IUCN

Terrestrial Biodiversity and the World Heritage List

Identifying broad gaps and potential candidate sites for inclusion in the natural World Heritage network

WCPA WORLD COMMISSION ON PROTECTED AREAS

BfN Federal Agency for Nature Conservation

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

MAVA FONDATION POUR LA NATURE

protected planet

UNEP WCMC

About IUCN

IUCN, International Union for Conservation of Nature, helps the world find pragmatic solutions to our most pressing environment and development challenges.

IUCN works on biodiversity, climate change, energy, human livelihoods and greening the world economy by supporting scientific research, managing field projects all over the world, and bringing governments, NGOs, the UN and companies together to develop policy, laws and best practice.

IUCN is the world's oldest and largest global environmental organization, with more than 1,000 government and NGO members and almost 11,000 volunteer experts in some 160 countries. IUCN's work is supported by over 1,000 staff in 45 offices and hundreds of partners in public, NGO and private sectors around the world.

About UNEP-WCMC

The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is the specialist biodiversity assessment centre of the United Nations Environment Programme (UNEP), the world's foremost intergovernmental environmental organisation. The Centre has been in operation for over 30 years, combining scientific research with practical policy advice.

About BfN and BMU

The German Federal Agency for Nature Conservation (Bundesamt für Naturschutz – BfN) is the German government's scientific authority with responsibility for national and international nature conservation. BfN is one of the government's departmental research agencies and reports to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The Agency provides the Ministry with professional and scientific assistance in all nature conservation and landscape management issues and in international cooperation activities. BfN furthers its objectives by carrying out related scientific research and is also in charge of a number of funding programmes.

About MAVA

The MAVA Foundation was established in 1994 and is a family-led, Swiss-based philanthropic foundation whose mission is to engage in strong partnerships to conserve biodiversity for future generations. Under the leadership of its President, André Hoffmann, the foundation strives to help protect and rebuild the earth's natural wealth, ensure sustainable use of natural resources and build strong conservation communities.

Terrestrial Biodiversity and the World Heritage List

Identifying broad gaps and potential candidate sites for inclusion in the natural World Heritage network

WCPA WORLD COMMISSION ON PROTECTED AREAS
BfN Federal Agency for Nature Conservation
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
MAVA FONDATION POUR LA NATURE
protected planet
UNEP WCMC

Funding

This study was supported by the German Federal Agency for Nature Conservation (BfN) with funds from the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Additional support was provided by the MAVA Foundation.

Disclaimers

The contents of this study do not necessarily reflect the views or policies of IUCN or contributory organizations. The designation of geographical entities in this book, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of IUCN or contributory organizations, concerning the legal status of any country, territory, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Published by: IUCN, Gland, Switzerland

Citation: Bertzky, B., Shi, Y., Hughes, A., Engels, B., Ali, M.K. and Badman, T. (2013) Terrestrial Biodiversity and the World Heritage List: Identifying broad gaps and potential candidate sites for inclusion in the natural World Heritage network. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK. xiv + 70pp.

ISBN: 978-2-8317-1589-6

Cover photo: Juriah Mosin / Shutterstock.com

Layout by: NatureBureau

Printed by: Duffield Printers Ltd

Produced by: IUCN and UNEP-WCMC

Available from: IUCN (International Union for Conservation of Nature)
World Heritage Programme
Rue Mauverney 28
1196 Gland
Switzerland
Tel +41 22 999 0000
Fax +41 22 999 0002
www.iucn.org

Contents

Online data annex
Key results from this study are also available online at:
www.unep-wcmc.org/biodiversity-wh_975.html

Acronyms and abbreviations

AZEs	Alliance for Zero Extinction sites
BWHS	Biodiversity World Heritage sites (sites inscribed under criterion (ix) and/or (x))
CBD	Convention on Biological Diversity
CPDs	Centres of Plant Diversity
EBAs	Endemic Bird Areas
FYR	Former Yugoslav Republic (Macedonia)
GIS	Geographic Information System
HBWAs	High-biodiversity wilderness areas
IBAs	Important Bird Areas
IUCN	International Union for Conservation of Nature
KBAs	Key Biodiversity Areas
NGOs	Non-governmental organizations
NWHS	Natural and mixed World Heritage sites (sites inscribed under one or more of the four natural World Heritage criteria (vii) to (x))
OUV	Outstanding Universal Value
PAs	Protected areas
TEOW	Terrestrial ecoregions of the world (as defined by Olson *et al*. 2001)
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
WDPA	World Database on Protected Areas
WH	World Heritage

Acknowledgements

We are very grateful for the invaluable input, support and reviews we received from the study's advisory group: Thomas Brooks, Neil Burgess, Lincoln Fishpool, Matthew Foster, Michael Hoffmann, Tilman Jaeger, Cyril Kormos, Peter Shadie, Wendy Strahm, James Thorsell and Stephen Woodley. We particularly thank Ana Rodrigues and Soizic Le Saout at the Centre d'Ecologie Fonctionnelle et Evolutive (CNRS UMR 5175, Montpellier, France) for the collaboration on the species irreplaceability analysis. We are also grateful for the input and support we received from Charles Besançon, Stuart Butchart, Vineet Katariya, Naomi Kingston, Remco van Merm and Christelle Perruchoud. We thank Barbara Creed for the layout and Danièle and Richard DeVitre for the translation of the report. This study would not have been possible without the thousands of individuals and organizations that have contributed to the development of the different datasets used here.

This study was supported by the German Federal Agency for Nature Conservation (BfN) with funds from the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU). Additional support was provided by the MAVA Foundation. IUCN and UNEP-WCMC thank the BfN, BMU and MAVA Foundation for their generous support.

All errors remain ours. The contents of this report are solely the responsibility of the authors and should not be interpreted as reflecting the views of any of the individuals or organizations that contributed to the report or any of its elements.

Foreword

The World Heritage Convention, adopted in 1972, seeks to encourage the identification and protection of cultural and natural heritage around the world considered to be of outstanding value to humanity. Today the Convention is one of the most important global conservation instruments and has almost universal adoption amongst the nations of the world.

The 962 World Heritage properties include places as unique and diverse as the pyramids of Egypt, the Great Wall of China, Machu Picchu, the Taj Mahal in India, Galápagos Islands, Grand Canyon, Great Barrier Reef, Kamchatka, Kilimanjaro and Mount Everest. The 217 properties that are listed for their outstanding natural values include many of the most famous protected areas. Together, they cover over 2.6 million square kilometres of land and sea, or 11% of the world's total protected area.

The World Heritage Convention thus has the potential to make an exceptional contribution to the conservation of the world's natural heritage. IUCN, the Advisory Body to the World Heritage Convention for natural heritage, has a central role to support these efforts. Key responsibilities of IUCN include the monitoring of the state of conservation of natural and mixed World Heritage properties, evaluation of natural heritage nominations to the World Heritage List and preparation of thematic studies that help identify and evaluate potential natural and mixed World Heritage properties.

Biodiversity, the variety of life on earth, is a critical element of the world's natural heritage. Species, ecosystems and genetic diversity underpin a wide range of ecosystem services that humans depend on. These services include clean water provision, food and fuel, building materials, medicines, agricultural pollination, nutrient cycling, climate regulation via carbon storage and sequestration, and protection from flooding and other natural disasters.

The World Heritage List includes 156 properties that are explicitly recognized for their outstanding biodiversity values. These properties are distributed across 72 countries on all continents except Antarctica and represent all the world's major ecosystems. However, it is widely recognized that there are still areas with outstanding biodiversity values around the world that are not yet part of this network of 'biodiversity World Heritage sites'.

To address this issue, IUCN and UNEP-WCMC have developed this global thematic study for World Heritage criteria (ix) and (x), with a focus on the terrestrial realm. The study updates previous analyses and identifies broad gaps in the network of biodiversity World Heritage sites as well as potentially outstanding biodiversity sites that may merit World Heritage listing. A complementary study is underway for the marine realm. These studies are the latest in a long series of global and regional studies that, over the years, have provided critical guidance for the development of the World Heritage List.

We hope that this study will support ongoing efforts to conserve the world's terrestrial biodiversity through the identification of critical areas and sites that should be considered for effective protection under the World Heritage Convention. It is not intended to be prescriptive, and readers are invited to note carefully the caveats and cautions within it. The development of successful World Heritage nominations will require more analysis than is contained in this study, and further advice and guidance on options and expectations of the Convention can be provided by IUCN. We recommend that anyone interested in following up this study with a possible idea for a World Heritage nomination contact IUCN for further information at the earliest possible opportunity.

This study would not have been possible without the generous support of the German Federal Agency for Nature Conservation (BfN), the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), and the MAVA Foundation. We warmly thank them for their support. We also thank the many reviewers, our partners in UNEP-WCMC, and in particular the lead authors of the study, Bastian Bertzky and Yichuan Shi, for their tireless and painstaking efforts on this work.

Tim Badman
Director, IUCN World Heritage Programme

Executive summary and recommendations

The World Heritage Convention identifies and helps conserve natural and cultural heritage of Outstanding Universal Value – and in doing so the Convention makes an important contribution to the conservation of the world's terrestrial and marine biodiversity. Together, the 217 natural and mixed World Heritage properties cover over 2.6 million square kilometres of land and sea, or 11% of the world's total protected area. At present 156 (72%) of these properties are specifically recognized by the Convention for their outstanding biodiversity values. These sites, inscribed under the biodiversity criteria (ix) and/or (x), are here referred to as biodiversity World Heritage sites (see Table 2.1 for an indicative overview of biodiversity values that can be recognized under the different natural World Heritage criteria).

This study provides a technical basis for the selection and prioritization of areas and sites with potentially outstanding biodiversity values for World Heritage nomination. It first assesses the current coverage of biogeographic regions and global biodiversity conservation priorities in the 156 biodiversity World Heritage sites and identifies broad gaps. It then identifies other protected areas with potentially outstanding biodiversity values that may merit World Heritage listing and evaluates how these can help to fill the broad gaps identified. This study thus provides an expanded update of an earlier IUCN / UNEP-WCMC gap analysis for the terrestrial realm. Together with other global and regional thematic studies, this study forms an important contribution to the implementation of the Global Strategy for a Representative, Balanced and Credible World Heritage List.

Current coverage and broad gaps

The 156 biodiversity World Heritage sites cover a total land area of 1.1 million km², i.e. nearly 0.8% of the global land surface, or 6.6% of the total extent of the world's terrestrial protected areas. Generally speaking, biodiversity World Heritage sites are very large protected areas, often involving multiple component parts in serial sites. The existing network of biodiversity World Heritage sites encompasses many outstanding protected areas that represent a wide range of global biodiversity conservation priorities. Biodiversity World Heritage sites 'represent':

- 31 (89%) of the 35 biodiversity hotspots and all five high-biodiversity wilderness areas;
- 97 (68%) of the 142 Global 200 terrestrial priority ecoregions;
- 72 (31%) of the 234 Centres of Plant Diversity; and
- 83 (38%) of 218 Endemic Bird Areas.

However, this study shows that a number of globally important priority areas for biodiversity conservation are not included in the existing network of biodiversity World Heritage sites. Broad 'gaps' in the coverage of global biodiversity conservation priorities include, for example, priority areas in the mountains of Central Asia, southwest Arabian Peninsula, and mountain, forest and desert areas in the southwest of both North America and South America (Figure 3.11). There appears to still be potential for new biodiversity World Heritage sites particularly in the four biodiversity hotspots and 46 Global 200 terrestrial priority ecoregions which are not yet represented in biodiversity World Heritage sites (see below recommendations, Tables 3.10 and 3.11 and Section 3.2.2.5).

Although not every priority area will necessarily support a site of Outstanding Universal Value as defined by the World Heritage Convention, such broad gaps can guide the search for new biodiversity World Heritage sites. However, since the available priority schemes do not necessarily provide a stringent enough standard for the selection of outstanding biodiversity sites for the World Heritage List (see also Section 3.2.2.5), this study takes a novel approach to the identification of potential candidate sites for the World Heritage List.

Potential candidate sites

This study uses three different approaches for identifying protected areas with potentially outstanding biodiversity values at the species level. First, the world's most irreplaceable protected areas for species conservation, including threatened species, are identified based on the IUCN / UNEP-WCMC World Database on Protected Areas and the IUCN Red List of Threatened Species. Second, the most irreplaceable protected Alliance for Zero Extinction sites are identified, here defined as the only protected sites where at least five highly threatened species survive. Finally, existing non-biodiversity World Heritage sites are screened for potentially important biodiversity values.

The three approaches yield a number of potential candidate sites for consideration under the biodiversity criteria (see below recommendations and Tables 4.1, 4.3 and 4.4). The novel species irreplaceability analysis used here also demonstrates the exceptional importance of many of the existing biodiversity

World Heritage sites. In fact, biodiversity World Heritage sites represent 30 (38%) of the 78 most irreplaceable protected areas (sites and clusters) for species conservation identified through this analysis (Figure 4.1 and Table 4.1). This suggests that the species irreplaceability analysis used here is a good initial measure to recommend possible candidate sites under the biodiversity criteria, in particular the 'species criterion (x)', of the World Heritage Convention. Several of the candidate sites, although not specifically identified for this, also fall into the broad gaps noted above (Table 4.5) and could thus be considered under the 'ecosystem criterion (ix)' too.

Recommendations

This global study provides not only a useful basis for a second phase of regional initiatives (see Section 4.6) but also a number of pointers to priorities for the nomination of terrestrial sites. States Parties, relevant stakeholders, IUCN and UNESCO are therefore invited to consider the findings of this study in the revision of Tentative Lists and in the preparation and evaluation of natural and mixed World Heritage nominations under the biodiversity criteria (ix) and (x). In particular the following recommendations should allow rapid progress within the next 5–10 years with the implementation of the Global Strategy for a Representative, Balanced and Credible World Heritage List with regard to the biodiversity criteria (in particular in relation to criterion (x)):

1. **Considering nomination, including through extensions of existing World Heritage sites and/or serial approaches where appropriate, of the world's most irreplaceable protected areas for species conservation, including threatened species.** Potential candidate sites are listed in Section 4.2. These sites represent outstanding species values and thus are especially relevant under criterion (x). Nevertheless they may also support important ecosystem values that could be considered under criterion (ix).

2. **Considering nomination of the most irreplaceable protected Alliance for Zero Extinction sites** which are of critical importance for the survival of several highly threatened species. Potential candidate sites are listed in Section 4.3. Again, these sites represent outstanding species values and thus are especially relevant under criterion (x), but they may also support important ecosystem values that could be considered under criterion (ix).

3. **Considering re-nomination of non-biodiversity World Heritage sites with potentially outstanding biodiversity values** under the biodiversity criteria so that their biodiversity values are formally recognized on the World Heritage List. Potential candidate sites are listed in Section 4.4. Although some of these sites may have been rejected under the biodiversity criteria in the past, this study suggests that these sites support important biodiversity values with relevance to criterion (ix) and/or (x).

4. **Identifying and considering nomination of outstanding areas that can help to fill the broad 'gaps' identified in this study**. Papua New Guinea remains a notable State Party-level gap (see Section 1.6), while broad biogeographic gaps include, for example, Oceania, temperate grasslands and cold deserts and semi-deserts (see Section 3.1). Important gaps in the coverage of global biodiversity conservation priorities include the four biodiversity hotspots (Table 3.10) and 46 Global 200 terrestrial priority ecoregions (Table 3.11) that are not yet represented in biodiversity World Heritage sites. These two priority schemes, together with the high-biodiversity wilderness areas, are the most useful approaches for identifying broad gaps in the coverage of global biodiversity conservation priorities for the World Heritage List. Outstanding areas within these broad gaps are likely to represent important ecosystem values (including ecological and/or biological processes) and thus are especially relevant under criterion (ix). Nevertheless they may also support important species values that could be considered under criterion (x).

A number of other recommendations emerge from this study:

5. **IUCN, in collaboration with UNEP-WCMC, may want to develop and disseminate updated guidance on the distinction between criteria (ix) and (x) to assist States Parties, other relevant stakeholders and UNESCO in the application of these criteria with regard to different biodiversity values** (see Section 2.1). This guidance would be useful in the revision of Tentative Lists and the preparation and evaluation of natural and mixed World Heritage nominations, including comparative analysis, and should also be used to update the corresponding World Heritage Resource Manual (Box 5.1) accordingly.

6. **Before States Parties embark on a full and costly nomination process, which can take several years, they should examine the feasibility of a possible nomination** (see Section 5.1). This includes, for example, a preliminary comparative analysis and careful consideration of the protection, management and integrity requirements of the World Heritage Convention. The preparatory work should involve all relevant stakeholders, including local communities within and surrounding the site, and consultation with IUCN and UNESCO. Feasibility studies should be undertaken even for sites listed as priorities in this and other thematic studies, to ensure that they have the potential to meet the requirements of the World Heritage Convention.

7. **The present study should be updated and expanded at latest in 2020 in order to review progress and provide further guidance for the future of the World Heritage Convention.** The next study should again be able to make use of improved data (e.g., by then, all the world's vertebrates, and a number of invertebrate and plant groups will have been comprehensively assessed for the IUCN Red List of Threatened Species) and/or new approaches and datasets that are currently being developed (e.g. the IUCN Red List of Threatened Ecosystems). The study should also provide global guidance on the application of criterion (ix) and thereby seek to expand the identification of candidate sites from the largely species-based approaches (most relevant to criterion (x)) used in the present study to ecosystem-based approaches (more relevant to criterion (ix)).

Finally, the findings of this study suggest that the integration of the World Heritage Convention with other biodiversity-related international conventions and agreements should be further improved. Although few in number, biodiversity World Heritage sites can make a globally significant contribution to biodiversity conservation and the Aichi Targets of the Convention on Biological Diversity, specifically Aichi Target 11 on protected areas and Targets 5 and 12 on reducing habitat and species loss. Improved integration could therefore include tracking and reporting the outstanding contribution of the World Heritage Convention to the Aichi Targets as well as the Programme of Work on Protected Areas of the Convention on Biological Diversity (CBD). Thematic studies, gap analyses and site selection processes under the World Heritage Convention could also be better connected to wider work on the development of effectively and equitably managed, comprehensive protected area networks as envisaged by the CBD.

1. Introduction

1.1 Purpose, scope and structure of the present study

The overarching purpose of this study is to assist in the preparation and evaluation of natural and mixed World Heritage nominations that have, from a global conservation perspective, a high potential to meet the 'biodiversity criteria' (ix) and/or (x) of the World Heritage Convention (see Section 1.4). The study is thus aimed at States Parties to the Convention, relevant stakeholders (e.g. protected area agencies, multilateral and bilateral donor agencies, and non-government organizations), the World Heritage Committee and the Committee's technical Advisory Bodies (see Section 1.2).

The study is based on the understanding that levels of biodiversity are not evenly distributed across the world and that the World Heritage List does not yet include all outstanding biodiversity sites (see also Section 1.6). **The study seeks to provide a technical basis for the selection and prioritization of areas and sites with potentially outstanding biodiversity values for World Heritage nomination under biodiversity criteria.**

The two principal aims of the study are therefore:

1. **To assess the current coverage of biogeographic regions and global biodiversity conservation priorities in biodiversity World Heritage sites and identify broad gaps (Chapter 3);**
2. **To identify potentially outstanding biodiversity sites that may merit World Heritage listing and to evaluate how these can help to fill the broad gaps identified (Chapter 4).**

In order to achieve these aims, the study uses best available data on the global distribution of natural and mixed World Heritage sites, biogeographic regions, global biodiversity conservation priorities, and species in three major taxonomic groups (amphibians, birds and mammals).

The study uses three different approaches to identify existing protected areas with potentially outstanding biodiversity values and to produce an indicative but non-exhaustive list of potential candidate sites for consideration under the biodiversity criteria. The list is not exhaustive because it was beyond the scope of this study to identify all sites around the world that may have potential Outstanding Universal Value under the biodiversity criteria. The list is indicative only for a number of reasons but especially because this study does not consider the stringent protection, management and integrity requirements of the World Heritage Convention. These and other limitations are stressed in Section 2.4 and throughout this study. **It is important to understand that the inclusion of a site on the list of potential candidate sites is therefore without prejudice to the success of any nomination that could be put forward, nor does it guarantee its future inclusion on the World Heritage List.**

The present study represents an expanded update of the 2004 study by Magin and Chape (2004). **The study is global in scope but focuses only on the terrestrial realm** and areas outside the Antarctic mainland. A separate study is underway for the marine realm. These studies contribute to the *Global Strategy for a Representative, Balanced and Credible World Heritage List* and complement existing theme studies on natural heritage (see also Section 1.5 and Annex 3).

This study is divided into five main chapters. Following this introductory Chapter 1, Chapter 2 outlines the methodological framework for the study, including the methodology and datasets used. Chapter 3 assesses the current coverage of biogeographic regions and global biodiversity conservation priorities in biodiversity World Heritage sites and identifies broad gaps. Chapter 4 identifies potentially outstanding biodiversity sites that may merit World Heritage listing and evaluates how these can help to fill the broad gaps identified in Chapter 3. Chapter 5 provides guidance on the process of nomination and evaluation that any of these sites would have to go through to be inscribed on the World Heritage List. The study's recommendations are included in the executive summary.

1.2 The World Heritage Convention

The *Convention concerning the Protection of the World Cultural and Natural Heritage* (the 'World Heritage Convention'), adopted in 1972, is one of the most important global conservation instruments and has almost universal adoption amongst the nations of the world. As of December 2012, 190 countries have joined the Convention. The Convention embodies a visionary idea – that some places are so important that their protection is not only the responsibility of a single nation, but is also the duty of the international community as a whole; and not only for this generation, but for all those to come.

The primary mission of the Convention is to identify and conserve the world's natural and cultural heritage

properties considered to be of 'Outstanding Universal Value' (OUV). As of December 2012, 962 properties in 157 States Parties are inscribed on the World Heritage List, including 745 cultural, 188 natural and 29 'mixed' (cultural and natural) properties. The 217 natural and mixed properties include many of the world's natural wonders such as the Great Barrier Reef (Australia), Galápagos Islands (Ecuador), Lake Baikal (Russian Federation), Ngorongoro Conservation Area (Tanzania) and Grand Canyon (United States).

The Convention is governed and implemented by the World Heritage Committee based on the Convention text adopted in 1972 and the *Operational Guidelines for the Implementation of the World Heritage Convention* (the 'Operational Guidelines'). Unlike the Convention text, the Operational Guidelines are regularly updated, and the most recent version dates from July 2012.

The Committee consists of representatives from 21 of the States Parties to the Convention, elected by the General Assembly of all States Parties, and meets once a year to evaluate the state of conservation of existing properties, decide on the inscription and deletion of properties on the World Heritage List and the List of World Heritage in Danger, and discuss other matters.

Box 1.1 IUCN – the Advisory Body on natural heritage

IUCN is an international, non-governmental organization that provides the World Heritage Committee with independent technical advice on natural heritage. IUCN's role under the Convention includes:

1. Supporting the implementation of the Convention.
2. Monitoring the state of conservation of natural and mixed World Heritage properties.
3. Evaluating natural heritage nominations to the World Heritage List.
4. Preparing thematic studies that help identify and evaluate potential natural and mixed World Heritage properties in their regional, global or thematic context.

IUCN was founded in 1948 and today has more than 1,200 member organizations, including over 200 government and 900 non-government organizations. IUCN's work is supported by more than 1,000 staff in 45 offices around the world and more than 10,000 members in IUCN's six expert commissions. IUCN's Headquarters are located in Gland, near Geneva, in Switzerland.

The Committee is supported by the UNESCO World Heritage Centre, the secretariat of the Convention, and three technical Advisory Bodies. The Advisory Bodies on cultural heritage are the International Council on Monuments and Sites (ICOMOS) and the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM). The Advisory Body on natural heritage is IUCN, the International Union for Conservation of Nature (see Box 1.1).

1.3 The concept of Outstanding Universal Value

Outstanding Universal Value (OUV) is the key requirement for inscription of a property on the World Heritage List and means "cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity" (§49 of the Operational Guidelines). As the Operational Guidelines further note, "the Convention is not intended to ensure the protection of all properties of great interest, importance or value, but only for a select list of the most outstanding of these from an international viewpoint".

To be deemed of OUV, a property must meet one or more of the ten World Heritage criteria (see Section 1.4), the corresponding conditions of integrity and/or authenticity, and protection and management requirements (Figure 1.1). While authenticity is only applied to cultural heritage, integrity is a measure of the wholeness and intactness of both natural and/or cultural heritage (see Section 2.4.2). Protection and management of World Heritage properties should ensure that their OUV, including the conditions of integrity and/or authenticity at the time of inscription, are sustained or enhanced over time. Properties must therefore have adequate protection and management in place to ensure their safeguarding (see also Section 2.4.2). **The present study is primarily an assessment concerning the pillar of the World Heritage criteria.**

The fundamental difference between natural and mixed World Heritage properties and other types of protected areas[1] such as Biosphere Reserves, Ramsar sites, national and provincial parks, is the use of OUV as a determinant for designation (Magin and Chape 2004). This relationship is expressed graphically in Figure 1.2. The graph shows the relationship of natural and mixed World Heritage properties to other types of protected areas in terms of global numbers (there are fewer World Heritage properties than other protected areas) and the application of the OUV threshold as the key determinant

[1] The Convention on Biological Diversity defines a protected area as a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives (Article 2 of the CBD). This corresponds very much to the IUCN definition: "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008).

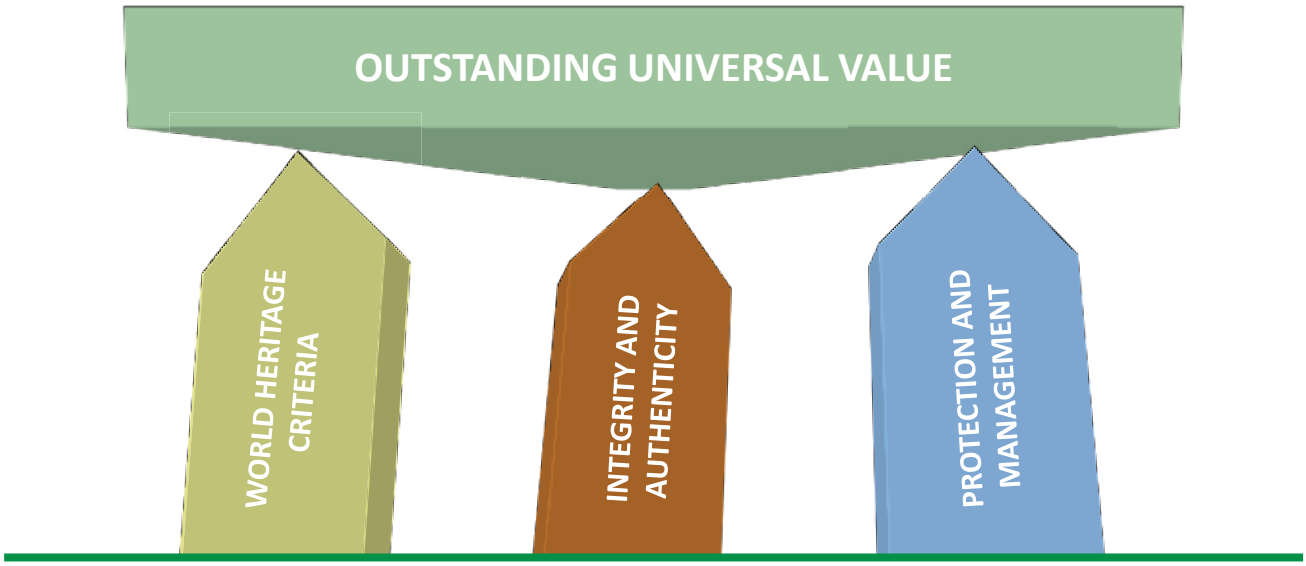


Figure 1.1 The three pillars of Outstanding Universal Value (OUV). To be deemed of OUV, a property must meet one or more of the World Heritage criteria, the corresponding conditions of integrity and/or authenticity, and protection and management requirements.

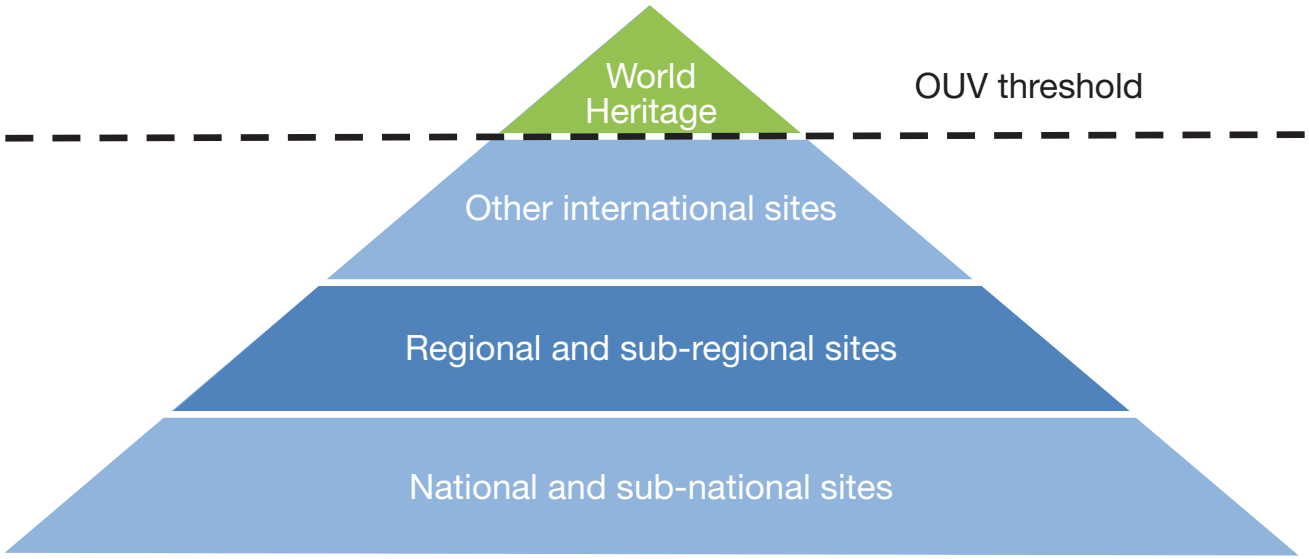


Figure 1.2 The relationship of natural and mixed World Heritage properties to other types of protected areas (adapted from Magin and Chape 2004). Only protected areas that meet the threshold of Outstanding Universal Value (OUV) are inscribed on the World Heritage List.

for inscribing protected areas on the World Heritage List (Magin and Chape 2004). It should be noted, however, that many natural and mixed World Heritage properties are also Biosphere Reserves and Ramsar sites.

1.4 The World Heritage criteria for natural heritage

The World Heritage Convention distinguishes between cultural and natural heritage. Natural heritage is defined in Article 2 of the Convention as follows:

- Natural features consisting of physical and biological formations or groups of such formations, which are of Outstanding Universal Value from the aesthetic or scientific point of view;
- Geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of Outstanding Universal Value from the point of view of science or conservation; and
- Natural sites or precisely delineated natural areas of Outstanding Universal Value from the point of view of science, conservation or natural beauty.

Four of the ten World Heritage criteria in the Operational Guidelines recognize properties with outstanding natural values. The criteria are regularly revised by the World Heritage Committee to reflect the evolution of the World Heritage concept itself and the wording of the natural criteria has slightly changed several times during the lifetime of the World Heritage Convention. According to the current Operational Guidelines, to be deemed of OUV, natural properties must:

(vii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;
(viii) be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;
(ix) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; or
(x) contain the most important and significant natural habitats for *in-situ* conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

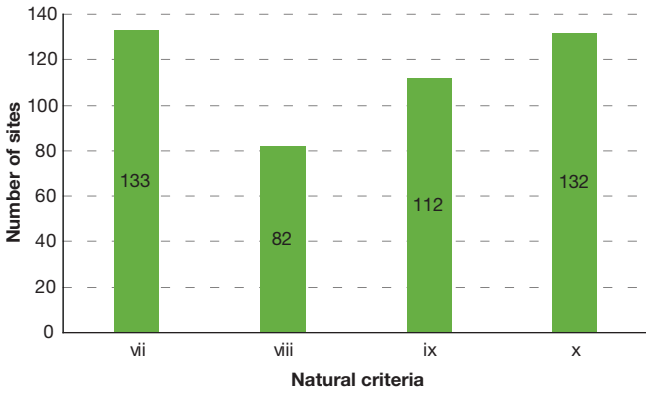


Figure 1.3 Frequency of use of different natural World Heritage criteria in the 217 natural and mixed World Heritage properties (see text for definition of criteria). Many of these sites are inscribed under multiple natural criteria, and mixed properties are also inscribed under one or more cultural criteria.

All 217 natural and mixed World Heritage properties are inscribed under at least one of these four criteria. Criteria (vii) and (x) have been used most frequently to inscribe natural properties, while criterion (viii) is met by 82 (38%) of the 217 properties (Figure 1.3). Together, the 217 natural and mixed World Heritage properties cover over 2.6 million square kilometres of land and sea, or 11% of the world's total protected area (Bertzky *et al.* 2012).

In the present study, natural or mixed World Heritage (WH) properties inscribed under the 'biodiversity criteria' (ix) and/or (x) are referred to as 'biodiversity WH sites'. Other natural and mixed WH properties are referred to as 'non-biodiversity WH sites'.

Although the WH Convention does not formally distinguish between biodiversity WH sites and other natural and mixed WH sites, **this distinction was considered useful for the purpose of this study because only the biodiversity WH sites are formally recognized by the Convention for their outstanding biodiversity values and thus trigger an intervention by the Convention if these values decline or disappear.** However, it should be noted that many other natural and mixed WH sites (and many cultural WH sites) support biodiversity values (see also Section 4.4).

At present there are 156 (72%) biodiversity WH sites[2] and 61 (28%) non-biodiversity WH sites among the 217 natural

[2] This includes the Australian Fossil Mammal Sites (Riversleigh / Naracoorte), inscribed under criteria (viii) and (ix), which was unusually recognized under (ix) based on fossil biodiversity values.

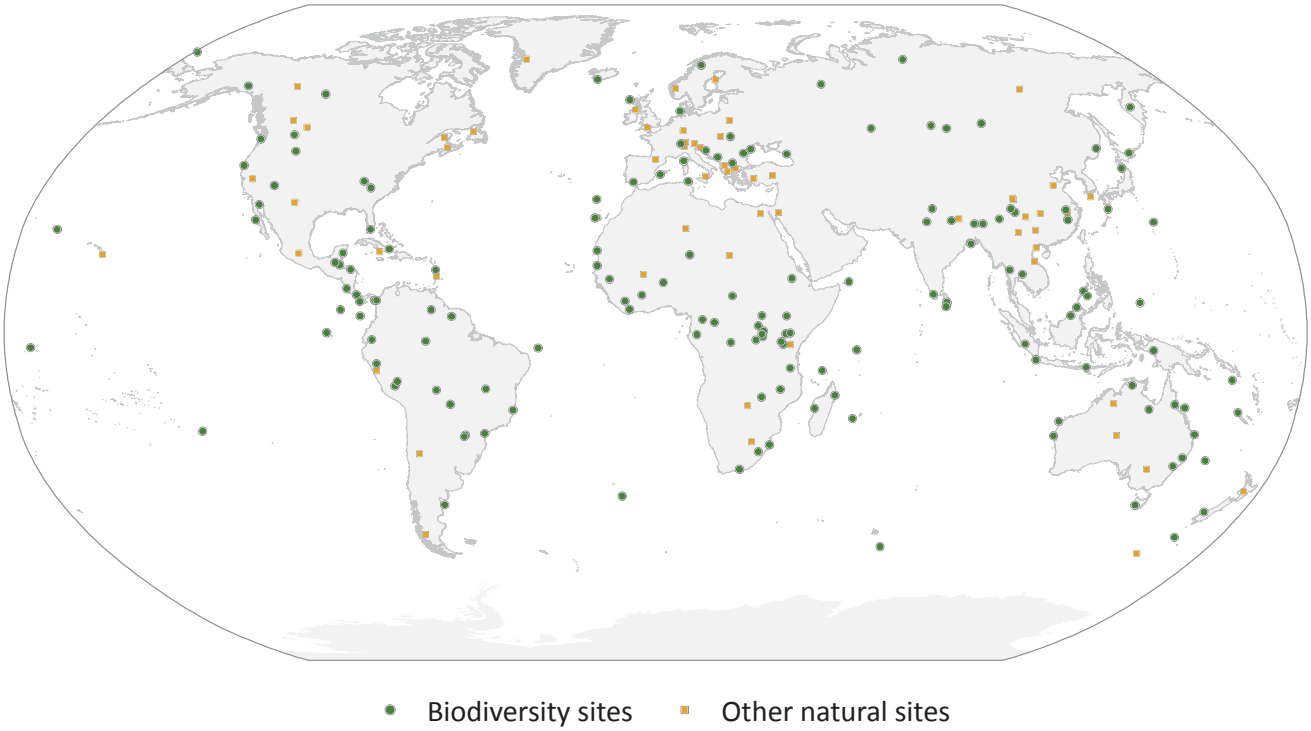


Figure 1.4 Global distribution of the 217 natural and mixed World Heritage properties. Green points indicate the 156 biodiversity sites inscribed under biodiversity criteria (ix) and/or (x) (see Annex 1 for a full list of these sites). Amber squares indicate the 61 natural and mixed World Heritage properties that are not inscribed under biodiversity criteria (see Annex 2 for a full list of these sites). For simplicity, all sites, including serial sites with multiple component parts, are represented as a single point or square on this map.

and mixed sites (Figure 1.4). A list of all the biodiversity sites is included in Annex 1, a list of the non-biodiversity sites in Annex 2.

Although adopted much later than the WH Convention, the Convention on Biological Diversity (Article 2 of the CBD) provides useful definitions for several key terms used in the two biodiversity WH criteria:

- "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.
- "Ecosystem" means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
- "Habitat" means the place or type of site where an organism or population naturally occurs.
- "*In-situ* conservation" means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings […].

1.5 Global Strategy for a Representative, Balanced and Credible World Heritage List

In 1994, the WH Committee launched the *Global Strategy for a Representative, Balanced and Credible World Heritage List* (the 'Global Strategy') with the aim of ensuring that the List reflects the world's diverse cultural and natural heritage of OUV. Crucial to the Global Strategy are efforts to encourage countries to become States Parties to the Convention, to prepare Tentative Lists of potential WH nominations and to prepare nominations of outstanding properties from regions and types of properties currently not well-represented on the WH List.

The global and regional thematic studies prepared by the Advisory Bodies (see also Annex 3) are an important contribution to the implementation of the Global Strategy. These studies help identify major gaps on the WH List, for example outstanding regions and types of properties that are not yet included on the List, and can guide States Parties, Advisory Bodies and the WH Committee in the preparation of Tentative Lists and the nomination and evaluation of properties that could fill such gaps.

To avoid misunderstandings of the Global Strategy, IUCN has repeatedly stressed that OUV remains the key requirement for inscription on the WH List, not representativeness (Badman *et al.* 2008). Unlike the Convention on Biological Diversity or UNESCO's Man and Biosphere Programme, the WH Convention seeks to establish only a select list of the most outstanding protected areas around the world, not an ecologically representative network of protected areas (Magin and Chape 2004). **Broad gaps in the current coverage of biogeographic regions and global biodiversity conservation priorities can however be useful in guiding the search for outstanding properties to those ecosystems whose distinctive biodiversity values are not yet included on the WH List.**

The next section uses the example of the so-called 'megadiversity countries' to illustrate existing imbalances and gaps on the WH List and set the scene for the more detailed assessments presented in Chapters 3 and 4.

1.6 Setting the scene: Does the World Heritage List cover the biodiversity values of the world's megadiversity countries?

Levels of biodiversity, the variety of all forms of life on earth, are not evenly distributed across the world, and the example of the so-called 'megadiversity countries' highlights that imbalances exist between the distribution of biodiversity on earth and the recognition of biodiversity values on the WH List. The 17 megadiversity countries[3], which together cover one third of the global land surface, are estimated to support two thirds of the world's species-level biodiversity (Mittermeier *et al.* 1997). These countries contain 87 (40%) of the 217 natural and mixed WH sites and 69 (44%) of the 156 biodiversity WH sites (Table 1.1). However, half of the biodiversity WH sites in these countries are concentrated in Australia (12), United States (10), Brazil (7) and India (6). Venezuela, on the other hand, has only one biodiversity WH site and Papua New Guinea none.

[3] Each megadiversity country holds at least 1% of the world's plant species as endemics (i.e. these plant species do not occur anywhere else).

Table 1.1 Total number of natural and mixed World Heritage sites (NWHS) and biodiversity World Heritage sites (BWHS) in each megadiversity country (Mittermeier *et al.* 1997). The table includes all sites including 'marine' sites. Countries are sorted by number of BWHS. Only the BWHS are formally recognized by the Convention for their outstanding biodiversity values and thus trigger an intervention by the Convention if these values decline or disappear.

Megadiversity country	Land area of country (million km²)	Number of NWHS	Number of BWHS	Percentage of NWHS that are BWHS
Australia	7.69	16	12	75%
United States	9.37	13	10	77%
Brazil	8.51	7	7	100%
India	3.29	6	6	100%
China	9.56	13	5	38%
Democratic Republic of the Congo	2.34	5	5	100%
Indonesia	1.92	4	4	100%
Mexico	1.97	4	3	75%
Peru	1.29	4	3	75%
South Africa	1.22	4	3	75%
Colombia	1.14	2	2	100%
Ecuador	0.28	2	2	100%
Madagascar	0.59	2	2	100%
Malaysia	0.33	2	2	100%
Philippines	0.30	2	2	100%
Venezuela	0.91	1	1	100%
Papua New Guinea	0.48	0	0	-

In general, larger megadiversity countries support more biodiversity WH sites, but Venezuela for example has fewer sites than one would expect. Relative to their land area, Papua New Guinea, China and Brazil have the fewest biodiversity WH sites (Figure 1.5), and China is also the megadiversity country with the lowest percentage of biodiversity WH sites among its natural and mixed WH sites (Table 1.1). In terms of area, Colombia, Papua New Guinea and the Philippines are the megadiversity countries with the lowest percentage area coverage of biodiversity WH sites (Figure 1.6). To summarize,

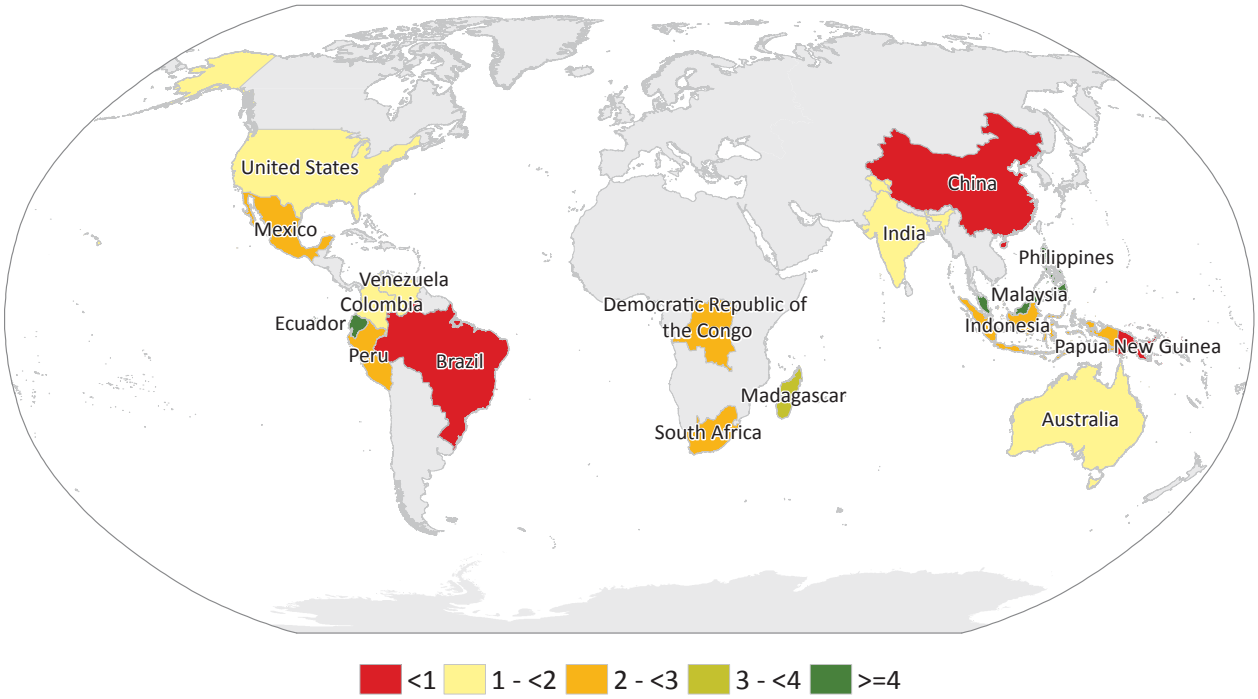


Figure 1.5 Density (sites per million km^2 land area) of biodiversity World Heritage sites in the 17 megadiversity countries as defined by Mittermeier *et al.* (1997).

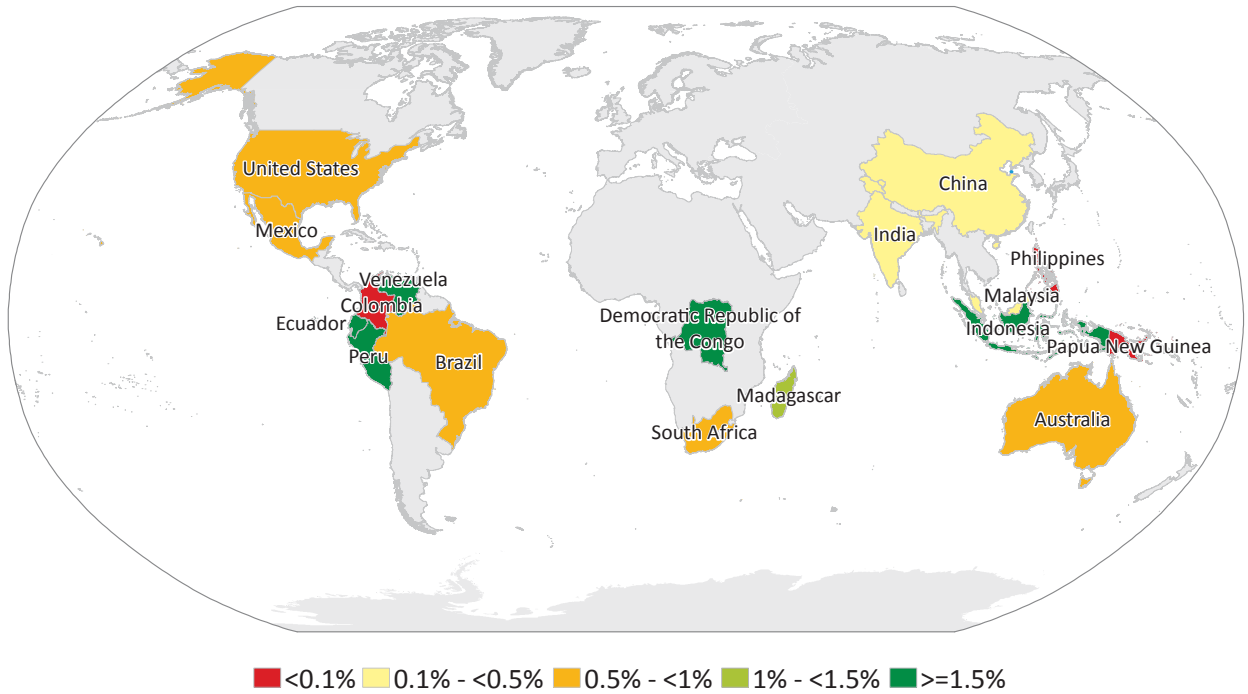


Figure 1.6 Percentage area coverage (land area only) of biodiversity World Heritage sites in the 17 megadiversity countries as defined by Mittermeier *et al.* (1997).

the vast biodiversity values of Papua New Guinea are not yet represented on the WH List, and those of Brazil, China, Colombia, the Philippines and Venezuela could be considered 'under-represented'.

This study assesses in more detail the distribution of biodiversity WH sites relative to the world's species-level biodiversity, identifies imbalances and gaps, and seeks to identify areas and sites with potentially outstanding biodiversity values for WH nomination under biodiversity criteria. However, since the distribution of biodiversity does not follow political boundaries, the remainder of this study will not use countries as units of analysis.

2. Conceptual and methodological framework for the study

2.1 Mapping biodiversity values against World Heritage criteria

> The Convention on Biological Diversity defines **biodiversity** as the variability among living organisms and the ecological complexes of which they are part, including diversity within species, between species and of ecosystems.

Many different approaches exist to measure and compare biodiversity. Common measures that are used to 'value' the relative importance of an area for biodiversity include, for example, species richness (number of species present) and endemism (number of species present that are restricted to the area or region).

The texts of the WH Convention and Operational Guidelines provide general guidance on how biodiversity values can be recognized under the Convention. However, it is not straightforward to map biodiversity values against the WH criteria, not least because the wording and application of the criteria has changed over time.

Biodiversity related values have been recognized under all four natural WH criteria (Table 2.1). The earth science criterion (viii) includes the fossil record of life on earth, from its earliest beginnings to the predecessors of today's animals and plants (see also Wells 1996 and Dingwall *et al.* 2005). The WH List includes more than a dozen outstanding fossil sites including the Burgess Shale (Canada), Chengjiang (China), Messel Pit (Germany), Riversleigh and Naracoorte (Australia) and Wadi Al-Hitan (Egypt).

Extant biodiversity values are recognized under criteria (vii), (ix) and (x). In the terrestrial realm, criterion (vii) has been applied to superlative ecological and/or biological phenomena such as the wildlife concentrations and migrations in the Ngorongoro Conservation Area and Serengeti National Park (Tanzania) and the overwintering concentration of up to a billion monarch butterflies in the Monarch Butterfly Biosphere Reserve (Mexico) (Table 2.1).

However, criteria (ix) and (x) are clearly the primary criteria for recognition of extant biodiversity values, and they have been applied to a wide range of biodiversity features including ecosystems, species and ecological and/or biological processes (Table 2.1). IUCN (2006a) and others have noted that these two criteria are closely linked and often used in combination with each other (in 88, or 56%, of the 156 biodiversity WH sites).

Table 2.1 maps some common biodiversity values against criteria (ix) and (x). However, **it is widely acknowledged that the criteria are not easily distinguished and have not always been consistently applied in WH nominations and evaluations.** Biodiversity measures such as species richness and endemism have thus been used to justify inscription of sites on the WH List under (ix) in one case and under (x) in another case (see also Section 3.2.1).

In an effort to provide some guidance on this issue, Table 2.1 uses a simple distinction between ecosystem and community related biodiversity values (including ecological and/or biological processes) under criterion (ix) and species and habitat related biodiversity values under criterion (x). The arguments used in the nominations and evaluations of the selected example sites, although in many cases inscribed under both (ix) and (x), support this distinction. **The remainder of this study focuses on the primary biodiversity criteria (ix) and (x).**

2.2 Defining biodiversity thresholds for Outstanding Universal Value

The Convention on Biological Diversity (CBD) is the primary multilateral environmental agreement concerned with the conservation of biodiversity. Its main objectives are the conservation and sustainable use of biodiversity, and the fair and equitable sharing of the benefits arising from the utilization of genetic resources. In 2010, the Parties to the CBD agreed a Strategic Plan for Biodiversity 2011–2020, which includes the 20 Aichi Targets, with the purpose of inspiring broad-based action in support of biodiversity by all countries and stakeholders.

Site-based conventions and agreements such as the WH Convention, Ramsar Convention and UNESCO's Man and Biosphere Programme make an important contribution to the Aichi Targets, in particular Aichi Target 11 on protected areas, and global biodiversity conservation in general (Bertzky *et al.* 2012). Among these, the WH Convention sets the highest standards for inscription, both in terms of the

Table 2.1 Overview of biodiversity values that can be recognized under natural World Heritage criteria. The existing World Heritage sites included in this table are considered good examples for the respective values in the terrestrial realm. However, many of these sites are also recognized under other natural criteria, and especially criteria (ix) and (x) are closely linked and often used in combination with each other. These criteria are not easily distinguished and have not always been as consistently applied as this table suggests.

Category	Value	Criterion (vii)	Criterion (viii)	Criterion (ix)	Criterion (x)
Biodiversity phenomena	Superlative ecological and/or biological phenomena (e.g. species migrations)	Monarch Butterfly Biosphere Reserve, Mexico; Serengeti National Park, Tanzania			
Fossil record	Fossil record of life on earth		Messel Pit Fossil Site, Germany		
Ecosystems and communities: sites representing outstanding examples of	Globally unique ecosystems or communities (high endemism at species and/or higher taxonomic levels)			Gondwana Rainforests of Australia; Galápagos Islands, Ecuador; Cape Floral Region, South Africa	
	Globally significant ongoing ecological and/or biological processes			Surtsey Island, Iceland; Ogasawara Islands, Japan	
	Globally threatened or rare ecosystems or communities			Laurisilva of Madeira, Portugal; Wrangel Island Reserve, Russian Federation; Redwood National and State Parks, United States	
	Vast and intact "wilderness" areas			Central Amazon Conservation Complex, Brazil; Central Suriname Nature Reserve, Suriname; Selous Game Reserve, Tanzania	
Species and habitats: sites of outstanding importance for	Globally threatened or rare species and their habitats				Atlantic Forest South-East Reserves, Brazil; Rainforests of the Atsinanana, Madagascar
	Restricted range (locally endemic) species and their habitats				Central Highlands of Sri Lanka; Socotra Archipelago, Yemen
	Overall species and/or habitat richness				Three Parallel Rivers of Yunnan, China; Manú National Park, Peru

required biodiversity values and the integrity, protection and management requirements of sites. **The guiding principle is that biodiversity WH sites must be of Outstanding Universal Value (OUV) and thus support and sustain outstanding biodiversity values. However, the WH Convention has never defined specific thresholds for what constitutes outstanding biodiversity values**, and this has provided both challenges and opportunities in the identification and evaluation of potential WH sites.

Combining the CBD's definition of biodiversity and the WH concept, one can argue that the WH List should seek to include the world's most important (and effective) sites for the conservation of ecosystems, species and genetic diversity. However, different studies have shown that the importance of sites has been defined and measured in many ways, and that thresholds of importance have varied with the specific biodiversity values and context under consideration (see for example Badman *et al.* 2008, Engels and Winkler 2008). For example, nominations for sites that support thousands of species and a wide range of ecosystems have in the past been rejected because they were not considered to be outstanding relative to other comparable sites, whereas other sites that support only a few species in a single ecosystem have been inscribed on the WH List as outstanding examples of their kind. So how can one operationalize the concept of OUV, at least with regard to the requirements of the WH criteria, in an objective way?

Systematic conservation planning helps to identify and prioritize key sites for biodiversity conservation based on the concepts of irreplaceability, vulnerability and representativeness (Margules and Pressey 2000). The two biodiversity WH criteria (and their corresponding conditions of integrity) also draw on these concepts for the selection of sites for the WH List. Among these concepts, **irreplaceability (or uniqueness or rarity) is arguably the most important concept for assessing the potential of a site to be considered of OUV** (Schmitt 2011), while representativeness is the least important concept in the context of the WH Convention (Badman *et al.* 2008). But what constitutes irreplaceability and what makes a site so irreplaceable that it has the potential to be inscribed on the WH List?

One of the most common measures for the irreplaceability of sites (and ecosystems more broadly) is species endemism, i.e. the number of species that do not occur anywhere else, but other measures such as the taxonomic uniqueness of species, or the diversity and/or uniqueness of ecosystems and communities have also been used to identify areas of high irreplaceability (Brooks *et al.* 2006 and 2010, Schmitt 2011). In a strict sense, any site that supports a species that occurs nowhere else is irreplaceable (Brooks *et al.* 2006); if the site is lost, the unique biodiversity found only at that site may be lost forever. However, in the WH context, single-species approaches have been considered inappropriate to justify OUV (IUCN 2006b), and nominations based on single species, such as the one for the Wild Ass Sanctuary (India), have in the past been rejected by the WH Committee. On the other hand, there are biodiversity WH sites which may have no endemic species at all and less than 100 species in total, such as Surtsey Island (Iceland), which was inscribed for ecological and/or biological processes. Thus the number of species or endemic species present is not necessarily a conclusive indicator of OUV under the biodiversity WH criteria. Notwithstanding these practical difficulties, **this study focuses on the concept of irreplaceability as the guiding principle for identifying broad gaps and potential candidate sites for the WH List**, and uses approaches that include species endemism at least as one of several measures of irreplaceability. While the concept of irreplaceability can also be applied at the level of genetic diversity, ecosystems and ecological and/or biological phenomena, **this study focuses primarily on approaches that apply the concept at the level of species**.

However, in line with the position of the WH Committee, this study does not propose specific thresholds (e.g. a minimum number of species or endemic species) for the selection of potential candidate sites. Instead **this study illustrates how specific biodiversity measures provide a means to place sites on a continuum of high to low irreplaceability and can thus be used to identify for example the 10, 50 or 100 most irreplaceable protected areas for species conservation globally**. These measures thus provide a basis for IUCN to work with States Parties and other stakeholders to refine this global study, including through the identification of suitable thresholds, at the regional level.

Ultimately it is up to the WH Committee to decide where to draw the line between sites that are of OUV (or outstanding irreplaceability) and sites that are not of OUV. This decision requires consideration of many factors including the amount of replication that the WH Committee wants to see on the WH List (e.g. by inscribing more of the same or similarly important sites as opposed to focusing on a finite list of only the single most important sites), the application of different thresholds to different types of sites, and the question where new sites should be accepted on their own or only as extensions or part of serial sites (see Section 2.4.3).

2.3 Methodology and datasets used in this study

2.3.1 Methodology

This study can be divided in two main parts. The analyses in Chapter 3 build on previous work (Magin and Chape 2004)

and assess the current coverage of biogeographic regions and global biodiversity conservation priorities in biodiversity WH sites and identify broad gaps. The analyses in Chapter 4 identify potentially outstanding biodiversity sites that may merit WH listing and evaluate how these potential candidate sites can help to fill the broad gaps identified.

The following sections provide an overview of the methodology and datasets used in this study. The spatial analyses described below were conducted using a Geographic Information System (GIS). Spatial data editing and pre-processing was carried out in Esri ArcGIS 10 SP3, while subsequent data processing and analyses were performed in PostGIS 1.5 / PostgreSQL 8.4 databases. All area calculations were computed from spatial data using the Mollweide equal area projection. Unless otherwise indicated, all analyses excluded the marine components of WH sites and other protected areas. More information on the methodology and datasets are available on request from IUCN and UNEP-WCMC (Contact: protectedareas@unep-wcmc.org).

2.3.1.1 Current coverage and broad gaps

This study uses a number of readily available datasets to assess the current coverage of biogeographic regions and biodiversity conservation priorities in biodiversity WH sites and identify broad gaps (Chapter 3). The choice of datasets was informed by previous thematic studies, gap analyses and current IUCN / UNEP-WCMC practice in the evaluation of biodiversity WH nominations (see also Section 5.3). The methods used to assess current coverage and identify broad gaps are briefly summarized below. Chapter 3 includes more information on the rationale and results of these analyses. Where necessary, Section 2.3.2 provides further information on the datasets used.

Megadiversity countries (Section 1.6)

The number and density (number of sites per million km^2) of WH sites in megadiversity countries was calculated using the information on the webpage of the WH Centre, while the percentage area coverage was calculated through GIS analysis.

Biogeography (Section 3.1)

Current coverage of biogeographic regions was assessed by overlaying the boundaries of WH sites from the IUCN / UNEP-WCMC World Database on Protected Areas (WDPA; see Section 2.3.2.1) with the two global biogeographic classification schemes developed by Udvardy (1975) and Olson *et al.* (2001). Section 3.1.1 provides more information on these schemes. The analysis calculated the number, density (number of sites per million km^2) and percentage area coverage of biodiversity WH sites in the realms and biomes of the terrestrial ecoregions of the world (TEOW) scheme (Olson *et al.* 2001). The analysis also calculated the number of biodiversity WH sites in the unique realm / biome combinations of the TEOW scheme. For comparisons with previous studies, the analysis also calculated the number of WH sites by Udvardy biome, and identified Udvardy biogeographical provinces without biodiversity WH sites. The results of the overlay analysis were used to identify and map broad biogeographic gaps, i.e. biogeographic units that are not yet represented or underrepresented (relative to other units) on the WH List.

Biodiversity conservation priorities (Section 3.2)

Current coverage of biodiversity conservation priorities was assessed by overlaying the boundaries of WH sites from the WDPA with a number of priority schemes. Section 3.2.1 and Table 3.5 therein provide more information on the global-scale and site-based schemes used in this study. Section 2.3.2 provides further information on some of the datasets used. The analysis calculated the number and percentage area coverage of biodiversity WH sites in each priority area in each global-scale scheme (Section 3.2.2). The results of the overlay analysis were used to identify, summarize and map broad gaps in the coverage of biodiversity conservation priorities, i.e. priority areas that are not yet represented on the WH List (Section 3.2.2.5). The analysis also calculated the number of priority sites in each site-based scheme (different subsets of Key Biodiversity Areas) overlapping with biodiversity WH sites (Section 3.2.3).

Unless otherwise indicated, all these analyses considered only biodiversity WH sites, i.e. those natural and mixed WH sites that are recognized under criterion (ix) and/or (x). Non-biodiversity WH sites should not be taken into account when assessing the current coverage of biogeographic regions and biodiversity conservation priorities because their biodiversity values (if any) are not formally recognized under the WH Convention. They could therefore wrongly suggest that a particular biogeographic unit or priority area is already represented on the WH List while formally it is not. WH sites overlapping with more than one biogeographic unit or priority area were counted against all units or areas affected.

2.3.1.2 Potential candidate sites

This study uses three different approaches to identify existing protected areas with potentially outstanding biodiversity values that are not yet recognized on the WH List but may merit inscription under criteria (ix) and/or (x) (Chapter 4). These approaches use data from the IUCN / UNEP-WCMC World Database on Protected Areas (WDPA), IUCN Red List of Threatened Species and Alliance for Zero Extinction (see Section 2.3.2). The methods used to identify potential candidate sites are briefly summarized below. Chapter 4 includes more information on the rationale and results of these analyses.

Species irreplaceability analysis for protected areas (Section 4.2)

To identify the most irreplaceable protected areas for species conservation globally, this study applies a new approach developed by Le Saout (2010) and Le Saout *et al.* (in prep.). The approach defines irreplaceability as an intrinsic spatial property of each protected area, an aggregated measure of the degree of dependence of each species on the site. It therefore provides an absolute value of irreplaceability for each protected area that is not dependent on the species composition of the protected area network as a whole. Furthermore, for any given taxonomic group, irreplaceability scores can be directly compared across sites worldwide.

This approach combines information from the WDPA (see Section 2.3.2.1; IUCN and UNEP-WCMC 2012) and the IUCN Red List of Threatened Species (see Section 2.3.2.2; IUCN 2012) in order to calculate for each protected area an irreplaceability score. The score is based on the fraction of each species' global range overlapping the boundaries of each protected area. The methodology is briefly summarized below; for more details, see Le Saout (2010) and Le Saout *et al.* (in prep.).

The irreplaceability score I for each site p was calculated as the sum of species-specific irreplaceability scores across i species. For each species i in each site p, the percentage x_{ip} of the species' range overlapping with the site was calculated. This value was then transformed into a weighted irreplaceability score w_{ip} of the site p for the species i through an irreplaceability function f and rescaling. For the transformation a sigmoid function (equation 1) with parameters (μ = 39; s = 9.5) was chosen to satisfy the following thresholds: for percentages x_{ip} below 10% coverage, the species makes a relatively small contribution to the site's irreplaceability score; for percentages above 80%, the species makes a relatively large contribution. The irreplaceability function f was then rescaled (equation 2) to ensure that weights vary between 0 (for a species whose range overlaps 0% with the site) and 1 (for a species whose range overlaps 100% with the site). All the species-specific weighted irreplaceability scores were then summed up to obtain the overall irreplaceability score I of each site p (equation 3). For guidance, an irreplaceability score of 1 is equivalent to one species being entirely confined to the corresponding site, but can also be obtained if multiple species have smaller percentages of their ranges in the site (see also detailed discussion and sensitivity tests in Le Saout 2010 and Le Saout *et al.* in prep.)

$$f(x_{ip}) = \frac{1}{1 + e^{-\left(\frac{x_{ip}-\mu}{s}\right)}} \qquad \text{(equation 1)}$$

$$w_{ip} = \frac{f(x_{ip}) - f(0)}{f(100) - f(0)} \qquad \text{(equation 2)}$$

$$I_p = \sum_i w_{ip} \qquad \text{(equation 3)}$$

The irreplaceability analysis presented here is based on 21,419 vertebrate species and 173,461 existing protected areas. The analysis considered only taxonomic groups that have been globally assessed for the IUCN Red List (amphibians, birds and mammals) and for which range maps were recorded in the 2012.2 version of the IUCN Red List (IUCN 2012). The range maps were filtered to ensure that only areas where a species is native or reintroduced (origin codes 1–2) and extant or probably extant (presence codes 1–2) were included in the analysis. In addition, for birds, only areas where a species is certain to occur at least in one season were included (seasonality codes 1–4). Out of the 21,419 species included in the analysis, 21,296 species contributed to the irreplaceability scores[4]: 6,240 amphibian species (of which 1,922 were classified as globally threatened), 9,916 bird species (1,311) and 5,263 mammal species (1,096).

The analysis also included all 173,461 existing protected areas for which a site boundary was recorded in the October 2012 version of the WDPA (IUCN and UNEP-WCMC 2012). This included protected areas of all designation types, management categories or governance types recorded in the WDPA, including all 217 existing natural and mixed WH sites and other internationally recognized protected areas such as Biosphere Reserves and Ramsar sites.

The species range maps and protected area boundaries were intersected in a GIS to calculate for each protected area separate irreplaceability scores for all amphibian, bird and mammal species. Two species irreplaceability scores were then aggregated for each protected area, one based on all species in the three taxonomic groups, the other one based only on the globally threatened species in these groups. Globally threatened species are classified as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) on the IUCN Red List. The irreplaceability scores for all protected areas analysed will be made available in the online data annex.

The 100 most irreplaceable individual protected areas for all species and the 100 most irreplaceable protected areas for the subset of all threatened species were selected from the 173,461 existing protected areas. The overlap and proximity of all 200

[4] The analysis failed for 123 bird species with very large ranges and thus these species did in the end not contribute to the irreplaceability scores of any protected areas. These species are, however, very unlikely to affect the irreplaceability calculations because very small fractions of their ranges are present in any individual protected area.

selected protected areas was calculated to identify duplicates (i.e. protected areas on both top 100 lists or overlapping protected areas of different designation types in the WDPA: e.g. Ciénaga de Zapata in Cuba is recorded as a national protected area, Biosphere Reserve and Ramsar site) and form clusters. Where duplicates were identified, only the protected area with the highest irreplaceability score was retained. Where any two or more of the selected protected areas were contiguous or within 50 km of each other, clusters were formed to include all the affected sites. The final list of the most irreplaceable protected areas includes 78 sites and clusters, including 30 existing biodiversity WH sites, and was reviewed manually to identify possible options (e.g. new nomination or extension of existing site) for all potential candidate sites and clusters (see last column in Table 4.1).

The results of the irreplaceability analysis were also used to identify the most irreplaceable natural and mixed WH sites that are not yet recognized under biodiversity criteria (see below and Section 4.4).

Protected Alliance for Zero Extinction sites (Section 4.3)

This analysis combines data on the boundaries and trigger species of the 587 known Alliance for Zero Extinction sites (Alliance for Zero Extinction 2012) with protected area boundaries from the WDPA (see Section 2.3.2.1). AZEs had to meet three conditions to qualify as potential candidate sites for the WH List in the next 5–10 years: They have to support five or more trigger species, be at least half covered by designated protected areas in the WDPA, but not be covered by existing biodiversity WH sites. The thresholds for trigger species and protected area coverage were selected arbitrarily. Different thresholds would change the list of potential candidate sites.

Non-biodiversity World Heritage sites (Section 4.4)

This analysis uses the results from the species irreplaceability analysis (see above) for the 61 natural and mixed WH sites that are not yet recognized under biodiversity criteria. The boundaries of non-biodiversity WH sites were taken from the WDPA (see Section 2.3.2.1). To qualify as potential candidate sites, non-biodiversity WH sites had to be among the world's 1,000 most irreplaceable protected areas for all species analysed and/or the subset of all threatened species analysed. A different threshold for irreplaceability would change the list of potential candidate sites.

Finally, the potential candidate sites identified in Chapter 4 were overlaid with broad gaps identified in Chapter 3 (biodiversity hotspots and Global 200 terrestrial priority ecoregions which are not yet represented in biodiversity WH sites), to assess the potential of the sites to help fill these gaps.

2.3.2 Datasets

The global datasets used in this study represent best available data on protected areas, including WH sites, species, biogeographic regions and biodiversity conservation priorities. However, the coverage and quality of these datasets varies greatly, and this is well documented in the literature and metadata on these datasets. Key issues are noted in relevant sections of this study, but for more detailed information, readers are referred to relevant documentation (see references in this study).

The next two sections briefly describe the two datasets that underpin the species irreplaceability analysis. Section 2.3.2.3 provides a quick overview of the other datasets used in this study and the small changes made to them for this study.

2.3.2.1 IUCN / UNEP-WCMC World Database on Protected Areas

Data on protected areas, including WH sites, was taken from the IUCN / UNEP-WCMC World Database on Protected Areas (WDPA). The CBD-mandated WDPA is the most comprehensive global dataset on marine and terrestrial protected areas. The WDPA is a joint product of UNEP and IUCN, prepared by UNEP-WCMC and the IUCN World Commission on Protected Areas (WCPA), working with governments and collaborating non-governmental organizations (NGOs).

The study used the October 2012 version of the WDPA (IUCN and UNEP-WCMC 2012), which contained site boundaries and other information for 173,461 existing protected areas, including all natural and mixed WH sites. The information in the WDPA varies in coverage and quality, but it was beyond the scope of this study to improve this information, except for the natural and mixed WH sites.

The WDPA records key information on all natural and mixed WH sites, including their name, size, year of inscription, WH criteria and approximate boundaries. The information originates from a wide range of sources including UNESCO, IUCN and UNEP-WCMC records, data reported to the WDPA, and the original WH nominations prepared by State Parties to the WH Convention.

The GIS analyses conducted for this study required good information especially on the boundaries of WH sites. However, by early 2011, the WDPA recorded over 20 of the WH sites as points only. In preparation of this study, approximate boundaries were created for these sites, and the polygons recorded for many other sites were improved. The example of Keoladeo National Park (India) demonstrates the improvements made to the data (Figure 2.1).

Figure 2.1 Boundary information for Keoladeo National Park (India) before and after improvements.

The improved data for WH sites was integrated into the WDPA and is accessible on ProtectedPlanet.net, the web interface of the WDPA: www.protectedplanet.net. The interactive website allows users, among other things, to search, explore and download protected area data and to learn more about the world's protected areas. The WDPA version used here includes the improved data.

A KML file with the WDPA boundaries of all natural and mixed WH sites is also available for use in Google Earth at: www.unep-wcmc.org/kml-file-of-world-heritage-sites_812.html

2.3.2.2 IUCN Red List of Threatened Species

The IUCN Red List of Threatened Species is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species (IUCN 2012). The 2012.2 version of the IUCN Red List used for this study included 65,518 species, including 20,219 globally threatened species, from a wide range of taxonomic groups (IUCN 2012).

The species irreplaceability analysis could only consider taxonomic groups that have been globally assessed for the IUCN Red List (amphibians, birds and mammals) and for which range maps were recorded in the IUCN Red List. Nonetheless, the 21,296 species, including 4,329 threatened species, that contributed to the irreplaceability scores (see Section 2.3.2.2) represent over 30% of all species and over 20% of all threatened species on the IUCN Red List.

The species range maps in the IUCN Red List have a number of limitations which may have affected the irreplaceability analysis. Most importantly, due to their low spatial resolution, the species ranges often include relatively large areas where the species are in fact absent (Rodrigues 2011). For this reason, the irreplaceability analysis used a sigmoid function that had been specifically selected to counter the effects of these so-called 'commission errors' (Le Saout 2010).

2.3.2.3 Other datasets used in this study

This study uses a number of datasets of biogeographic regions and biodiversity conservation priorities that are currently used by IUCN and UNEP-WCMC in the evaluation of biodiversity WH nominations. These include two biogeographic classification schemes for terrestrial environments (Udvardy 1975 and Olson *et al.* 2001) and datasets on megadiversity countries (Mittermeier *et al.* 1997), biodiversity hotspots, high-biodiversity wilderness areas, Global 200 terrestrial priority ecoregions, Centres of Plant Diversity and Endemic Bird Areas (see Table 3.5 in Section 3.2.1 for references).

Small changes were made to some of these datasets to correct known errors, include updates and/or combine datasets for this study. Small corrections were made to the spatial dataset on Centres of Plant Diversity (CPDs) to address discrepancies with the list of CPDs published in Davis *et al.* (1994, 1995 and 1997). The dataset on biodiversity hotspots (Myers *et al.* 2000 and Mittermeier *et al.* 2004) was updated to include the 35th biodiversity hotspot, the Forests of East Australia, identified by Williams *et al.* (2011). The dataset on biodiversity hotspots was then combined with the dataset on high-biodiversity wilderness areas (Mittermeier *et al.* 2002 and 2003) because they are identified based on the same irreplaceability criterion (see Sections 3.2.1 and 3.2.2.1).

Recent datasets on the different subsets of Key Biodiversity Areas were also obtained for this study: Alliance for Zero Extinction sites (Alliance for Zero Extinction 2012), Important Bird Areas (BirdLife International 2012) and non-avian Key Biodiversity Areas (BirdLife International, Conservation International and partners 2012). The geographic and taxonomic coverage and quality of these datasets varies as described in Butchart *et al.* (2012), Foster *et al.* (2012) and relevant sections of this study (see for example Section 3.2.3).

2.4 Key limitations of the study

2.4.1 Limitations of the methodology and datasets

The present study uses best available data to assess the current coverage of biogeographic regions and global biodiversity conservation priorities in biodiversity WH sites and identify potential candidate sites for the WH List. As noted above, the study focuses only on the terrestrial realm (a separate study for the marine realm is underway), and does not specifically deal with freshwater biodiversity. The study takes a global perspective and cannot replace more detailed regional studies.

The global datasets used here are relevant to the biodiversity criteria of the WH Convention and are currently being used by IUCN and UNEP-WCMC in the evaluation of new WH nominations. However, the analysis is by no means exhaustive, and additional biogeographic and/or biodiversity datasets could be considered. Since most of the datasets used here are undergoing continuous improvements with regard to their coverage and quality, **this study provides a snapshot perspective that may change with future improvements of the underlying datasets**.

The assessment of the current coverage is based on the available data on existing natural and mixed WH sites in the World Database on Protected Areas (WDPA). Future inscriptions will change the coverage statistics reported here and may close the broad gaps identified. Since **none of the biodiversity priority schemes used in this study was developed specifically with the WH criteria in mind**, it is not guaranteed that each broad gap identified here does in fact support a site of potential OUV. While the WH Committee has in the past rejected nominations from priority areas identified in these schemes for various reasons, it has also determined OUV for several WH sites under biodiversity criteria which are not identified as priorities in any of these schemes. These points show that inclusion in any of these schemes is neither a guarantee nor a prerequisite for WH listing.

The identification of potential candidate sites (Chapter 4) focuses primarily on species-based approaches as opposed to ecosystem-based or process-based approaches. One reason for this is that there are no comparable global datasets for ecosystems and/or processes yet. The identified candidate sites may thus be more relevant to criterion (x) than (ix), although a number of them also fall into the broader gaps identified in this study (see Section 4.5). **The study does not consider if candidate sites meet the stringent protection, management and integrity requirements of the WH Convention** (see Section 2.4.2).

The irreplaceability analysis (Section 4.2) is based on information on the distribution ranges and threat status of amphibian, bird and mammal species, i.e. the only three major taxonomic groups for which this information is currently available, and includes only existing protected areas for which a site boundary was available. Due to lack of comparable data, the analysis could not identify protected areas that are irreplaceable for other species groups such as reptiles, invertebrates and plant species, which may be particularly important in some ecosystem types (e.g. some islands). Changes in the information base have the potential to affect the results of the irreplaceability analysis. For example, **the list of the most irreplaceable protected areas may change with the inclusion of additional protected areas or other species groups in a future analysis**, although this would not change the irreplaceability scores of existing protected areas for the taxonomic groups analysed here. The analysis did not consider how serial or cluster approaches could boost the irreplaceability scores of protected areas (but see Section 2.4.3).

The inclusion of a site on the list of potential candidate sites in this study is therefore without prejudice to the success of any nomination that could be put forward, nor does it guarantee its future inclusion on the WH List. The list of sites presented here is indicative but by no means exhaustive. Alternative methodologies and datasets, including for other species groups, are likely to yield additional candidate sites. In a number of cases this study identifies priority regions (e.g. broad gaps) rather than specific sites. In such cases further study is needed to identify the most important sites in the region.

2.4.2 Consideration of protection, management and integrity requirements in this study

As noted in Section 1.2, **to be deemed of OUV, a property must not only meet one or more of the WH criteria but also the protection, management and integrity requirements of the WH Convention**. This section briefly summarizes these important requirements and explains if and how these are considered in this study.

Summary of protection and management requirements

The Operational Guidelines (§97) stipulate that properties on the WH List must have "adequate long-term legislative, regulatory, institutional and/or traditional protection and management to ensure their safeguarding". Key elements of this include adequately delineated boundaries, adequate protective designation, an appropriate management plan

or other documented management system, and effective implementation of protection and management activities that help to safeguard the property for present and future generations (for details see §96–118 of the Operational Guidelines).

Summary of integrity requirements

As noted above, in the context of the WH Convention, integrity is defined as a measure of the wholeness and intactness of a property. More specifically, to meet the conditions of integrity, a property must (§88 of the Operational Guidelines):

a) include all elements necessary to express its Outstanding Universal Value;
b) be of adequate size to ensure the complete representation of the features and processes which convey the property's significance; and
c) must not suffer from adverse effects of development and/or neglect.

The Operational Guidelines (§90) note that natural properties should be relatively intact but acknowledge that no natural area is totally pristine and that almost all natural areas to some extent involve human populations and/or human use of natural resources (see also Thorsell and Sigaty 1997a). Ecologically sustainable human activities, including those of indigenous and local communities, may therefore be perfectly consistent with natural WH status as long as they do not adversely affect the OUV of the property.

In addition to these general conditions, the Operational Guidelines also include for each natural WH criterion a more specific condition of integrity, which interprets the general conditions with regard to each criterion. The corresponding conditions for the biodiversity criteria (ix) and (x) can be found in §94–95 of the Operational Guidelines.

Consideration of protection, management and integrity requirements

The primary focus of global and regional thematic studies prepared by the Advisory Bodies is on the assessments of values and their potential to meet the WH criteria. The protection, management and integrity requirements, whose assessment requires first-hand knowledge of a property and its site-specific context, are usually not considered in these thematic studies. Instead the Advisory Bodies assess these requirements during their evaluation process, especially during the field visit, and based on input from experts that know the property under consideration (see Section 5.3).

Some previous thematic studies have, however, explicitly focused their identification of potential candidate sites on existing protected areas (Thorsell and Sigaty 1997b, Thorsell and Hamilton 2002). In short, protected areas are defined by IUCN as "clearly defined geographical spaces, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature […]" (Dudley 2008). In theory, existing protected areas could thus be considered to already fulfil, at the most basic level (e.g. in terms of their legal status and primary objectives), some of the protection and management requirements of the WH Convention. **Existing protected areas thus provide a useful starting point for the selection of potential candidate sites.**

The present study therefore also focuses its identification of potential candidate sites on existing protected areas, the global number of which has increased from a few thousand to over 170,000 protected areas since the WH Convention was adopted in 1972. Recognizing that existing biodiversity WH sites represent a wide range of protection, management and governance arrangements, the study considers all designated protected areas for which a delineated boundary is included in the World Database on Protected Areas (WDPA), whatever their designation type, management category or governance type (see Section 2.3). **However, it is important to understand that the study's focus on existing protected areas does in no way imply that any of the candidate sites identified here necessarily meet the stringent protection, management and integrity requirements of the WH Convention. As noted above, it is the prerogative of the Advisory Bodies and, ultimately, the WH Committee to establish this during the evaluation process.**

The present study also considers protected areas of all sizes in the identification of potential candidate sites. Although size is an important consideration for natural WH sites (see for example §88, §94 and §101 of the Operational Guidelines), this approach is considered appropriate here because there is no strict lower or upper limit for the size of biodiversity WH sites. In fact, the size of existing biodiversity sites varies greatly over several orders of magnitude, from less than 1 km^2 in the Vallée de Mai Nature Reserve (Seychelles) to more than 400,000 km^2 in the marine Phoenix Islands Protected Area (Kiribati) (Figure 2.2). The largest non-marine biodiversity site is Lake Baikal (Russian Federation; c. 88,000 km^2), while the largest purely terrestrial biodiversity site is the Aïr and Ténéré Natural Reserves (Niger; c. 77,000 km^2). Interestingly, on average, the 156 biodiversity WH sites (mean size 16,149 km^2 and median size 3,014 km^2) are considerably larger than other natural and mixed WH sites (2,859 km^2 and 471 km^2), and 92% of all existing biodiversity sites exceed 100 km^2, with 67% even exceeding 1,000 km^2. However, since **size may be an important consideration in the nomination and evaluation process of the candidate sites identified here**, the study includes size information for all these sites.

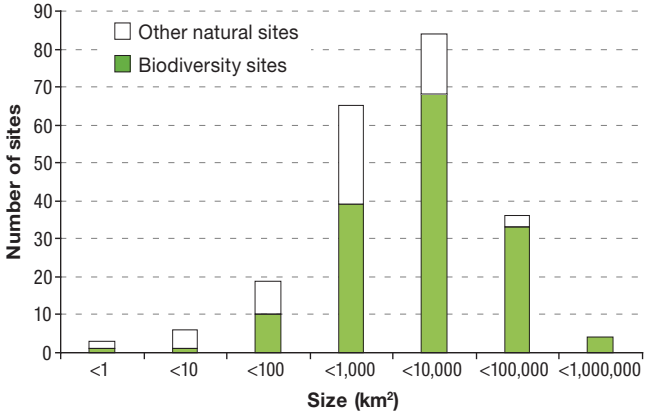


Figure 2.2 Size distribution of the 217 natural and mixed World Heritage sites. The graph is based on the site boundaries recorded in the World Database on Protected Areas (IUCN and UNEP-WCMC 2012). The average size of all natural and mixed sites is 12,413 km^2 (mean) and 1,574 km^2 (median). See text for the average size of the 156 biodiversity sites and 61 other natural sites.

2.4.3 Consideration of serial sites in this study

The WH List includes both single properties and serial properties. The Operational Guidelines define serial properties as properties that include two or more component parts which are not contiguous but reflect some functional linkages. The component parts can be located in a single country (serial national property) or in multiple countries (serial transnational property) (§138 of the Operational Guidelines). Serial properties can be nominated as a whole series during one nomination cycle, or in parts over several nomination cycles (§139 of the Operational Guidelines). Single properties can also become serial properties through the subsequent addition of component parts.

Most importantly, **serial approaches provide an opportunity to recognize OUV where a single property cannot sufficiently capture the key values, and thus would fail to meet the criteria and/or conditions of integrity** (Engels *et al.* 2009). In the case of serial properties, the WH Convention requires the series as a whole – and not necessarily its individual component parts – to be of OUV (§137 of the Operational Guidelines). However, the Operational Guidelines further note that "each component part should contribute to the OUV of the property as a whole in a substantial, scientific, readily defined and discernible way". Serial properties also require an effective overall management system for the coordinated management of all their individual component parts (§114 of the Operational Guidelines).

A serial approach was first applied successfully to a biodiversity WH site in 1986 when 17 rainforest protected areas in New South Wales were inscribed on the WH List as the Australian East Coast Temperate and Sub-Tropical Rain Forest Parks (now included in the larger Gondwana Rainforests of Australia). Today there are 31 serial biodiversity WH sites which involve up to 41 component parts (Gondwana Rainforests of Australia) and range in size from 7.9 km^2 (Gough and Inaccessible Islands, United Kingdom) to 3.8 million km^2 (Volcanoes of Kamchatka, Russian Federation). These properties cover a wide range of ecosystems including forests, mountains, lakes, islands and deserts. Serial approaches have also provided a particularly useful framework in highly fragmented biodiversity hotspots such as the Atlantic Forest (Brazil) and Western Ghats (India).

Serial approaches are particularly relevant in the biodiversity context where functional linkages, or connections, are not only common but often critical, and occur at multiple scales. Migratory species are a classic example of such connections as they depend on different habitats and migration routes through the different seasons (see also §95 of the Operational Guidelines). One of the reasons why the serial Monarch Butterfly Biosphere Reserve in Mexico was not inscribed under biodiversity criteria was in fact that the series did include only the butterfly's wintering areas, which alone cannot guarantee the survival of the species. Together with buffer zones (§103–107 of the Operational Guidelines), serial approaches can also improve the resistance and resilience of biodiversity WH sites to natural and anthropogenic pressures, including land use changes and climate changes.

This study includes existing serial sites in the assessment of the current coverage of biogeographic regions and global biodiversity conservation priorities. Moreover, **although this study has not been designed specifically to identify serial candidate sites, it seeks to facilitate the application of serial approaches to the candidate sites it identifies in Chapter 4** (see Sections 4.2 and 4.5). Serial biodiversity WH sites usually include multiple protected areas from the same ecoregion or ecosystem type (e.g. Cape Floral Region Protected Areas in South Africa or Rainforests of the Atsinanana in Madagascar). Consequently, **a serial approach should be considered wherever several candidate sites represent the same ecoregion or ecosystem type, and especially where these sites individually might be too small to meet the criteria and/or conditions of integrity on its own**.

3. Current coverage in biodiversity World Heritage sites

The aim of this part of the study is to assess the current coverage of biogeographic regions and global biodiversity conservation priorities in biodiversity WH sites and identify broad gaps.

3.1 Biogeography

3.1.1 Introduction

Biodiversity, the variety of life on earth, is distributed in distinct patterns around the world. Arctic desert and tundra stretch across the high northern latitudes, followed by vast boreal forests (also known as taiga) further south. Most of the remaining tropical rainforests straddle the equator, while the subtropics support enormous deserts and Mediterranean-type ecosystems. Africa supports the most diverse communities of large herbivores and carnivores, whereas two thirds of the world's marsupials are found in Australia, New Guinea and nearby islands. More generally, the flora and fauna of many island and mountain ecosystems is highly distinctive, with many endemic species.

Biogeography seeks to document and explain the distribution of species and ecosystems in geographic space and time. Biogeographic classification schemes such as the one developed by Udvardy (1975) provide a useful framework for assessing the overall biogeographic coverage of protected area systems and the natural WH network. Broad gaps in biogeographic coverage can be useful in guiding the search for outstanding properties to those ecosystems whose distinctive biodiversity values are not yet included on the WH List. However, unlike the Convention on Biological Diversity or UNESCO's Man and Biosphere Programme, the WH Convention is not concerned with establishing an ecologically representative network of protected areas. The aim of the WH Convention is instead identifying and conserving properties of Outstanding Universal Value (OUV).

Biogeographic classification schemes identify large areas with distinctive biodiversity values. The two most widely used global biogeographic classification schemes for terrestrial environments are those developed by Udvardy (1975) and Olson *et al.* (2001). The latter is also known as the terrestrial ecoregions of the world (TEOW) scheme. Both schemes employ a hierarchical system of geographical areas with eight biogeographical realms and 13–14 vegetated biomes that can be used to evaluate the biogeographic coverage of existing biodiversity WH sites. The differences between the two schemes are relatively small at the level of realms but more pronounced at the level of biomes. For example, Udvardy's scheme recognizes azonal biomes such as 'mixed island systems' and 'mixed mountain systems' separately, whereas the TEOW scheme seeks to include them in the corresponding zonal biomes (e.g. forests, grasslands and deserts).

The Udvardy scheme has a long history of use in the WH Convention and UNESCO's Man and the Biosphere Programme. However, the broader conservation community has increasingly adopted the more recent TEOW scheme, which has further refined the Udvardy scheme based on various global and regional classification schemes. At the lowest level, the TEOW scheme recognizes 827 ecoregions, more than a fourfold increase compared with Udvardy's 193 biogeographical provinces. The TEOW scheme therefore provides a higher-resolution map of life on earth (Olson *et al.* 2001) and is used, for example, to assess the biogeographic coverage of the global protected area system under the Convention on Biological Diversity (Jenkins and Joppa 2009, Bertzky *et al.* 2012).

The next sections review to what extent the eight biogeographic realms and 14 vegetated biomes in the TEOW scheme are covered by biodiversity WH sites. It identifies broad gaps in the coverage of realms and biomes, and combinations thereof, and can thus guide the search for outstanding properties in realms and biomes whose distinctive biodiversity values are not yet included on the WH List. In order to enable comparisons with previous studies that have used the Udvardy scheme, information is also provided on the number of biodiversity WH sites in the Udvardy biomes, and those Udvardy biogeographical provinces that are not yet represented in biodiversity WH sites.

3.1.2 Biogeographic realms and biomes

The biogeographic realms and biomes of the world, as defined by the TEOW scheme, provide a useful framework for assessing the overall biogeographic coverage of the natural WH

network, especially biodiversity WH sites, because they reflect the broad-scale distribution of biodiversity on earth (Figure 3.1). The eight biogeographic realms are continent or subcontinent-sized areas with unifying features of geography and fauna, flora and vegetation (Udvardy 1975, Olson *et al.* 2001). For example, the flora and fauna of the Afrotropic realm differs markedly from the Neotropic realm, although both realms contain comparable ecosystems such as tropical forests, grasslands and deserts. Such major ecosystem types have been classified into 14 vegetated biomes, large areas that share similar climatic and other abiotic and biotic conditions, and hence support similar ecosystems and communities of plants and animals (Udvardy 1975, Olson *et al.* 2001). Realms contain multiple biomes and biomes stretch across multiple realms (Figure 3.1): For example, the Boreal Forests / Taiga biome occurs in both the Nearctic and Palearctic realm, and the Tundra biome in the Nearctic, Palearctic, Australasia and Antarctic realms.

The 156 existing biodiversity WH sites (see Annex 1) are distributed across all eight biogeographic realms and the 14 vegetated biomes that support notable terrestrial biodiversity (this excludes the two biomes 'lakes' and 'rock and ice') in the TEOW scheme (Tables 3.1 and 3.2). The realms with the largest number of biodiversity WH sites are the Afrotropic (37 sites), Palearctic (36) and Neotropic (33) (Table 3.1). However, these are also some of the largest realms in terms of their land area, and thus more likely to support a larger number of sites.

Biogeographic coverage is therefore better measured by taking into account the total land area of each realm and all the biodiversity WH sites within it: Australasia (1.2%), Afrotropic (1.1%) and Neotropic (1.0%) are the realms with the highest percentage area coverage in biodiversity WH sites, while Oceania (0.4%) and Antarctic (less than 0.1% covered in Sub-Antarctic Islands WH sites; the WH Convention has not yet been applied to the Antarctic mainland which makes up most of the land area of the realm) have the lowest percentage area coverage among all realms.

The Tropical and Subtropical Moist Broadleaf Forests (71 sites) is the biome with by far the largest number of biodiversity WH sites, followed by the Tropical and Subtropical Grasslands, Savannas, and Shrublands (26) and Temperate Broadleaf and Mixed Forests (23) (Table 3.2). Considering the number of sites per biome area, the following biomes appear under-represented relative to other biomes: Boreal Forests / Taiga (0.5 sites per million km^2), Deserts and Xeric Shrublands (0.6), Tundra (0.8) and Temperate Grasslands, Savannas, and Shrublands (0.8). Considering the percentage area coverage of biomes in biodiversity WH sites, Temperate Grasslands, Savannas, and Shrublands (0.1%), Tropical and Subtropical Coniferous Forests (0.3%) and Mediterranean Forests, Woodlands, and Scrub (0.3%) are under-represented, while Mangroves (2.5%) and Temperate Coniferous Forests (1.7%) are over-represented relative to other biomes.

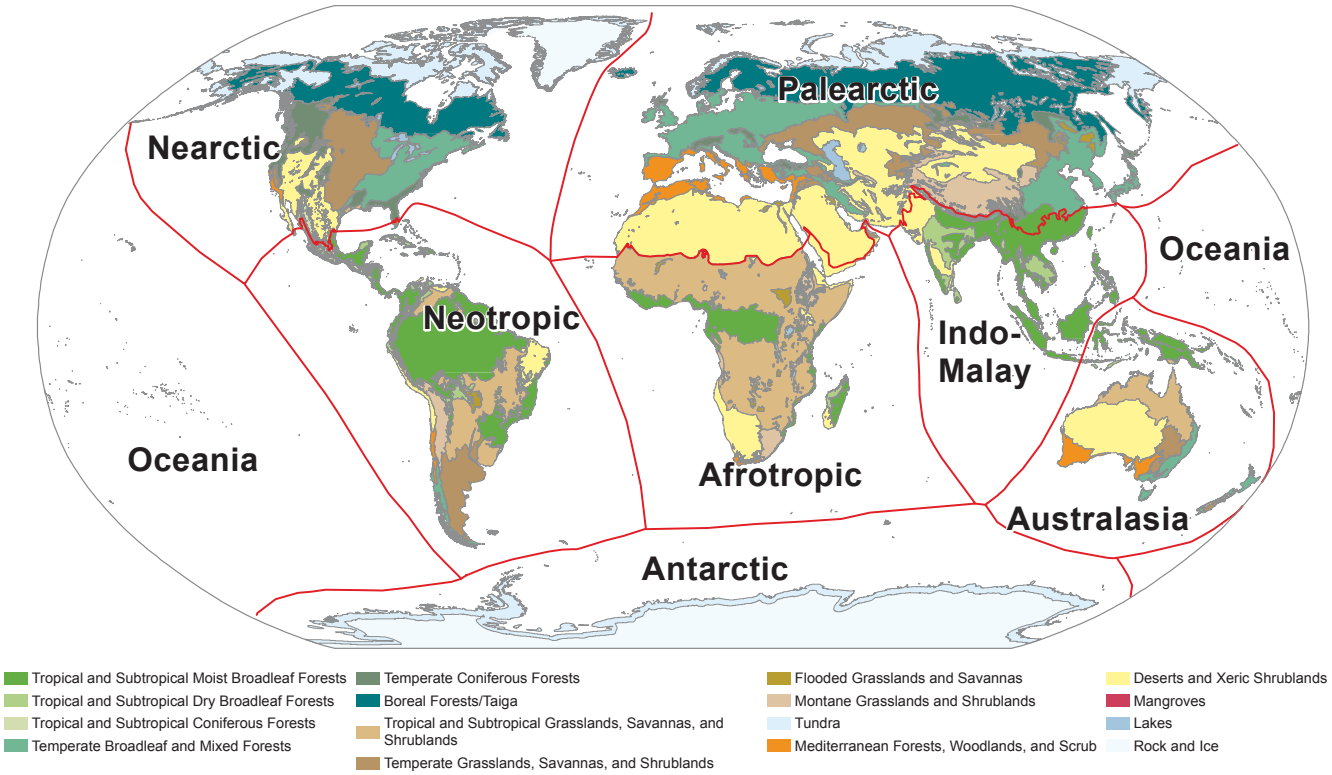


Figure 3.1 The eight biogeographic realms and 16 biomes of the world as defined by Olson *et al.* (2001). This study uses only the 14 vegetated biomes, which exclude lakes and rock and ice, to assess the biogeographic coverage of existing biodiversity World Heritage sites.

Table 3.1 Biodiversity World Heritage sites (BWHS) and biogeographic realms (based on the terrestrial ecoregions of the world scheme; Olson *et al.* 2001). Some sites stretch across more than one realm. Areas classified as lake or rock and ice are excluded. Note the World Heritage Convention has not yet been applied to the Antarctic mainland which makes up most of the land area of the Antarctic realm.

Realm	Realm land area (km²)	Percentage land area of all realms	Number of BWHS	Percentage sites of all BWHS	Density of BWHS (number of sites per realm land area in million km²)	Total land area in BWHS (km²)	Percentage land area of all BWHS	Percentage realm land area in BWHS
Afrotropic	21,630,400	16.0%	37	23.3%	1.7	246,726	23.0%	1.1%
Antarctic	3,286,208	2.4%	1	0.6%	0.3	389	0.0%	0.0%
Australasia	9,268,092	6.8%	17	10.7%	1.8	113,311	10.6%	1.2%
Indo-Malay	8,543,067	6.3%	19	11.9%	2.2	55,592	5.2%	0.7%
Nearctic	20,470,043	15.1%	11	6.9%	0.5	160,705	15.0%	0.8%
Neotropic	19,385,970	14.3%	33	20.8%	1.7	188,094	17.5%	1.0%
Oceania	47,155	0.03%	5	3.1%	106.0	191	0.0%	0.4%
Palearctic	52,859,641	39.0%	36	22.6%	0.7	308,562	28.7%	0.6%
Total	**135,490,575**	**100.0%**	**-**	**100.0%**	**-**	**1,073,569**	**100.0%**	**-**

Table 3.2 Biodiversity World Heritage sites (BWHS) and biomes (based on the terrestrial ecoregions of the world scheme; Olson *et al.* 2001). Some sites stretch across more than one biome. Areas classified as lake or rock and ice are excluded.

Biome	Biome land area (km²)	Percentage land area of all biomes	Number of BWHS	Percentage sites of all BWHS	Density of BWHS (number of sites per biome land area in million km²)	Total land area in BWHS (km²)	Percentage land area of all BWHS	Percentage biome land area in BWHS
Tropical and Subtropical Moist Broadleaf Forests	19,894,149	14.7%	71	30.6%	3.6	304,598	28.4%	1.5%
Tropical and Subtropical Dry Broadleaf Forests	3,025,997	2.2%	10	4.3%	3.3	19,866	1.9%	0.7%
Tropical and Subtropical Coniferous Forests	712,617	0.5%	3	1.3%	4.2	1,923	0.2%	0.3%
Temperate Broadleaf and Mixed Forests	12,835,688	9.5%	23	9.9%	1.8	56,150	5.2%	0.4%
Temperate Coniferous Forests	4,087,094	3.0%	16	6.9%	3.9	70,982	6.6%	1.7%
Boreal Forests/Taiga	15,077,946	11.1%	8	3.4%	0.5	130,401	12.1%	0.9%
Tropical and Subtropical Grasslands, Savannas, and Shrublands	20,295,424	15.0%	26	11.2%	1.3	169,448	15.8%	0.8%
Temperate Grasslands, Savannas, and Shrublands	10,104,080	7.5%	8	3.4%	0.8	11,704	1.1%	0.1%
Flooded Grasslands and Savannas	1,096,130	0.8%	4	1.7%	3.6	4,355	0.4%	0.4%
Montane Grasslands and Shrublands	5,203,411	3.8%	17	7.3%	3.3	34,679	3.2%	0.7%
Tundra	11,597,609	8.6%	9	3.9%	0.8	140,849	13.1%	1.2%
Mediterranean Forests, Woodlands, and Scrub	3,227,266	2.4%	8	3.4%	2.5	11,068	1.0%	0.3%
Deserts and Xeric Shrublands	27,984,645	20.7%	16	6.9%	0.6	108,875	10.1%	0.4%
Mangroves	348,519	0.3%	13	5.6%	37.3	8,671	0.8%	2.5%
Total	**135,490,575**	**100.0%**	**-**	**100.0%**	**-**	**1,073,569**	**100.0%**	**-**

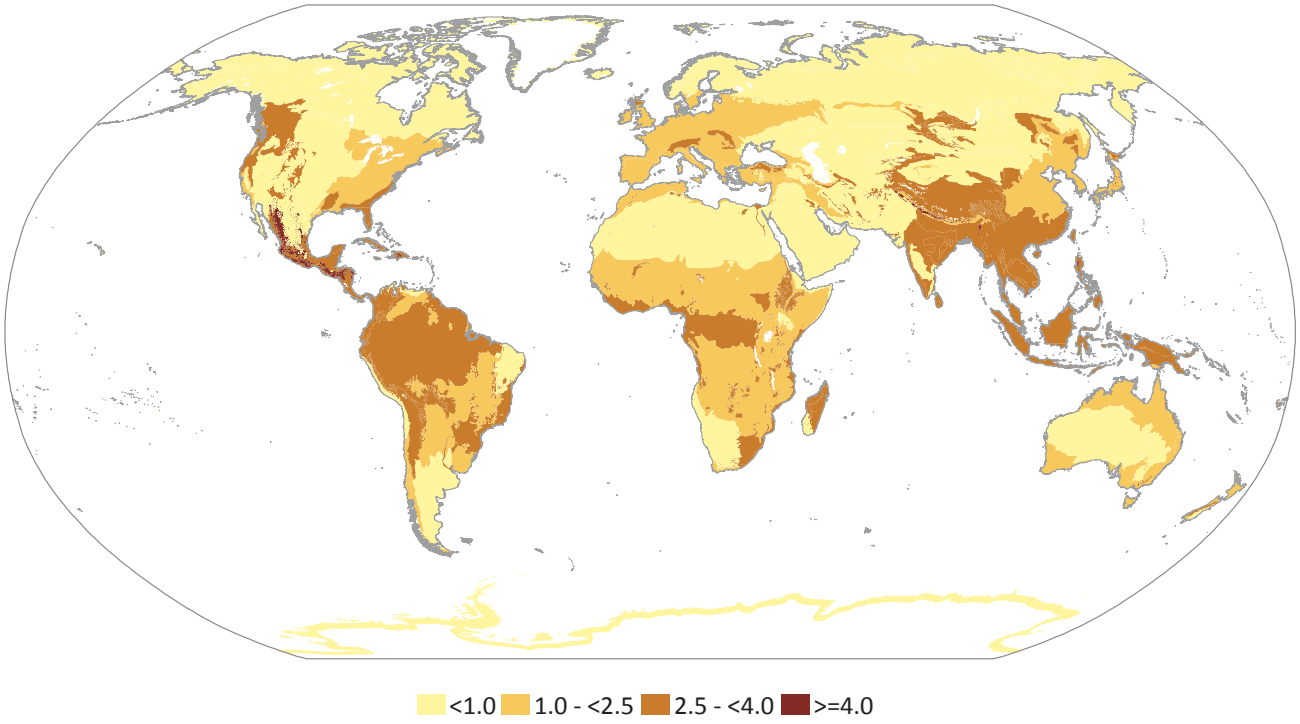


Figure 3.2 Density (sites per million km^2) of biodiversity World Heritage sites in the 14 vegetated biomes defined by Olson *et al.* (2001). Areas classified as lake or rock and ice (e.g. Greenland ice shield) are excluded.

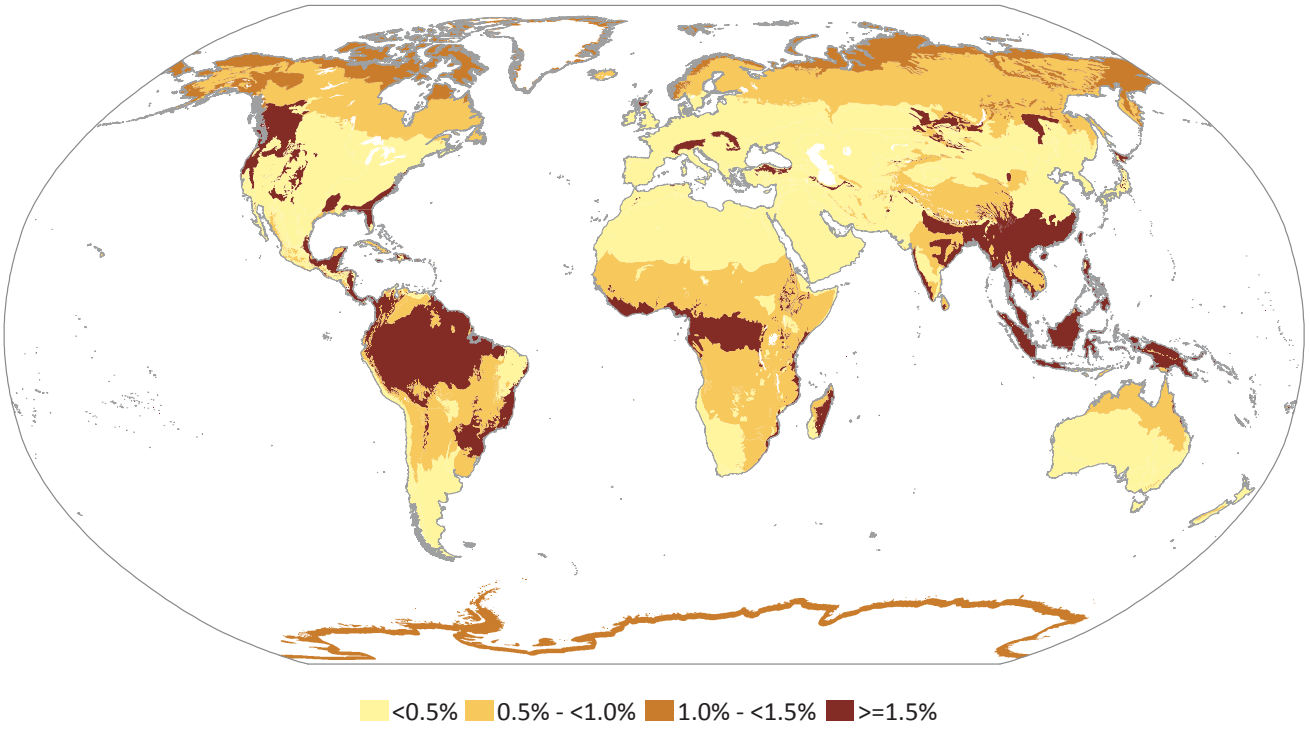


Figure 3.3 Percentage area coverage of biodiversity World Heritage sites in the 14 vegetated biomes defined by Olson *et al.* (2001). Areas classified as lake or rock and ice (e.g. Greenland ice shield) are excluded.

Global patterns in the density and percentage area coverage of biodiversity WH sites by biome reveal the influence of biome area and number and total area of biodiversity WH sites in each biome on measures of coverage (Figures 3.2 and 3.3). The density of biodiversity WH sites is comparably low, for example, in the Desert biome, the Temperate Grasslands biome and the Tundra and Boreal Forests / Taiga biomes in northern high latitudes (Figure 3.2). However, the percentage area coverage of biodiversity WH sites in the Tundra (1.2%) and Boreal Forests / Taiga (0.9%) biomes is far higher than in the Desert (0.4%) and Temperate Grasslands (0.1%) biomes (Figure 3.3), where existing biodiversity WH sites tend to be smaller. On the other hand, Tropical and Subtropical Coniferous Forests (4.2 sites per million km^2; 0.3%), Flooded Grasslands and Savannas (3.6; 0.4%) and Mediterranean Forests, Woodlands, and Scrub (2.5; 0.3%) have a comparably high density but low percentage area coverage of biodiversity WH sites.

To enable comparisons with previous studies, Table 3.3 shows the number of all natural and mixed WH sites and biodiversity WH sites by Udvardy biome. As noted above, the biomes of Udvardy (1975) are somewhat different from those of Olson *et al.* (2001) used above, with azonal biomes such as 'mixed island systems' and 'mixed mountain systems' treated as separate biomes.

Table 3.3 Number of natural and mixed World Heritage sites (NWHS) and biodiversity World Heritage sites (BWHS) by Udvardy biome (Udvardy 1975). Biomes are sorted by number of NWHS. Some sites stretch across more than one biome.

Udvardy biome	Number of NWHS	Number of BWHS	Percentage of NWHS that are BWHS
Tropical dry or deciduous forests and woodlands	37	34	92%
Mixed mountain systems	31	20	65%
Tropical humid forests	31	29	94%
Temperate broad-leaf forests and woodlands	27	14	52%
Warm deserts and semi-deserts	25	16	64%
Mixed island systems	24	20	83%
Subtropical or temperate rainforests	20	13	65%
Evergreen sclerophyllous forests, woodlands and scrubs	18	11	61%
Temperate needle-leaf forests and woodlands	13	6	46%
Tropical grasslands and savannas	7	6	86%
Temperate grasslands	5	3	60%
Lake systems	3	3	100%
Tundra and polar deserts	2	1	50%
Cold-winter deserts and semi-deserts	1	0	0%

All Udvardy biomes contain natural WH sites but cold-winter deserts do not yet have a biodiversity WH sites (Table 3.3). Cold-winter deserts, tundra / polar deserts, lake systems and temperate and tropical grasslands are still the least common Udvardy biomes found in natural WH sites (see also Table 3 in Magin and Chape 2004). Interestingly, over 80% of the natural WH sites representing Udvardy's lake systems, tropical forests and grasslands, and islands are recognized for their biodiversity values. In contrast, in tundra and temperate forests and grasslands, biodiversity WH sites make up 60% or less of the natural WH sites. The two tropical forest biomes (34 and 29 sites respectively), mixed mountain systems and mixed island systems (20 sites each) support two thirds of the 156 biodiversity WH sites.

3.1.3 Udvardy's biogeographical provinces

As previously noted, at a higher resolution, Udvardy's 193 biogeographical provinces have long been used by IUCN to compare existing and nominated properties. To enable comparisons with previous studies, Figure 3.4 shows the 85 Udvardy provinces without biodiversity WH sites (see online data annex for names and areas of these provinces). These provinces include for example areas in the Arabian, Gobi and Namib deserts; the Hindu Kush, Pamir and Tian Shan mountains; the Canadian and Russian tundra; the Mongolian-Manchurian steppe; and the Burman and Malayan rainforests. However, not all Udvardy provinces will necessarily support a site of Outstanding Universal Value as defined by the WH Convention.

3.1.4 Summary of biogeographic coverage and broad gaps

The 156 biodiversity WH sites are distributed across all eight biogeographic realms and all 14 vegetated biomes recognized by Olson *et al* (2001). They cover more than 1% of the land area in the Australasia, Afrotropic and Neotropic realms (Table 3.1) and in the Mangroves (2.5%), Temperate Coniferous Forests (1.7%), Tropical and Subtropical Moist Broadleaf Forests (1.5%) and Tundra (1.2%) biomes (Table 3.2). Leaving the special case of Antarctica aside, the lowest percentage area coverage is found in the Oceania (0.4%), Palearctic (0.6%) and Indo-Malayan (0.7%) realms and in the Temperate Grasslands, Savannas, and Shrublands (0.1%), Tropical and Subtropical Coniferous Forests (0.3%) and Mediterranean Forests, Woodlands, and Scrub (0.3%) biomes.

However, some biomes are well represented in biodiversity WH sites in some realms but not in others (Table 3.4). For

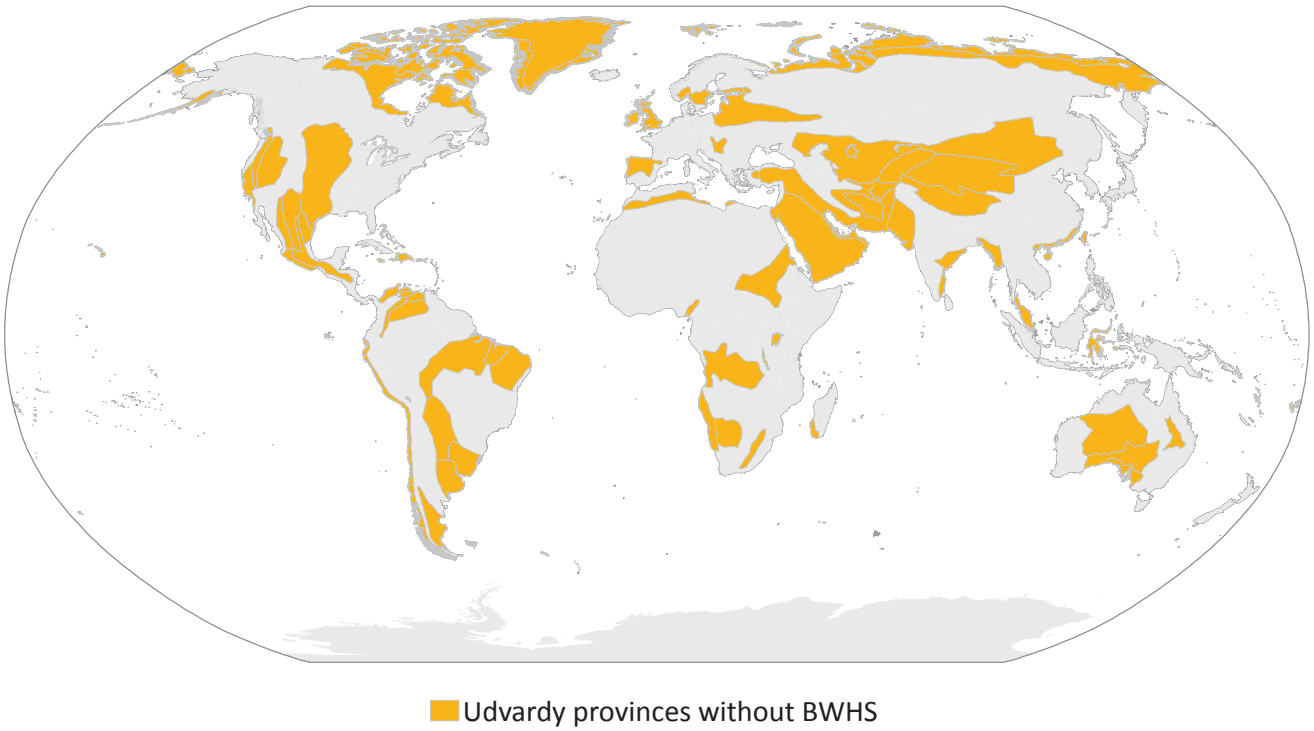


Figure 3.4 Biogeographical provinces (Udvardy 1975) without biodiversity World Heritage sites (BWHS). The names and areas of these provinces are included in the online data annex.

example, Boreal Forests / Taiga and Tundra are relatively well represented in the Palearctic realm (6 sites each) but not in the Nearctic realm (2 and 1 site(s) respectively), and Mangroves are very well represented in the Neotropic realm (9 sites) but not in the Afrotropic realm (1 site). Large areas of unique realm / biome combinations in the Nearctic, Neotropic, Australasia and Indo-Malay realms still have comparably few biodiversity WH sites (Figure 3.5). Table 3.4 and Figure 3.5 also highlight realm / biome combinations that are not yet present in biodiversity WH sites.

Although this analysis clearly shows that there are still large areas with distinctive biodiversity values in many parts of the world that are not yet represented in biodiversity WH sites, it should again be stressed that coverage in terms of 'representativeness' as such is not the key criterion of the WH Convention. Instead the WH Convention recognizes properties of Outstanding Universal Value, whether or not they are from under-represented or over-represented realms and biomes. Broad gaps in biogeographic coverage can however be useful in guiding the search for outstanding properties to realms and biomes whose distinctive biodiversity values are not yet included on the WH List.

Outstanding biodiversity values are not evenly distributed across the world: some ecosystems such as rainforests have long been known to harbour a disproportionate amount of the world's species for example. It may therefore not come as a surprise that the WH List includes more rainforest than desert properties. Nevertheless some rainforests are more important for endemic species than others, and there are also deserts that support exceptional biodiversity values. The next section therefore reviews the current coverage of global biodiversity conservation priorities in biodiversity WH sites.

3.2 Biodiversity conservation priorities

3.2.1 Introduction

Over the past 20 years, several major schemes for the spatial prioritization of biodiversity conservation have been developed, primarily with the goal to guide the allocation of conservation investments and interventions (Brooks *et al.* 2006 and 2010). All these schemes apply one or more of the following concepts to identify priority areas or sites for biodiversity conservation around the world: irreplaceability, vulnerability and representativeness (Brooks *et al.* 2006 and 2010, Margules and Pressey 2000, Schmitt 2011). Among these, irreplaceability (or uniqueness or rarity) is arguably the most relevant concept for the WH Convention, as it relates most strongly to the notion of Outstanding Universal Value (Schmitt 2011).

Table 3.4 Current coverage of biogeographic realm / biome combinations (Olson *et al.* 2001) by number of biodiversity World Heritage sites. Cells left blank indicate combinations that do not exist (e.g. Boreal Forests / Taiga and Tundra in Oceania). Cells highlighted in amber indicate existing combinations that are not yet present in biodiversity World Heritage sites.

Realm / Biome	Afro-tropic	Antarctic	Australasia	Indo-Malay	Nearctic	Neo-tropic	Oceania	Palearctic
Tropical and Subtropical Moist Broadleaf Forests	19		6	17		25	4	1
Tropical and Subtropical Dry Broadleaf Forests	1		2	3	1	4	0	
Tropical and Subtropical Coniferous Forests				1	0	2		
Temperate Broadleaf and Mixed Forests			7	0	2	0		14
Temperate Coniferous Forests				0	6			10
Boreal Forests/Taiga					2			6
Tropical and Subtropical Grasslands, Savannas, and Shrublands	17		4	1	0	3	1	
Temperate Grasslands, Savannas, and Shrublands	1		0		1	1		5
Flooded Grasslands and Savannas	1			0		3		0
Montane Grasslands and Shrublands	6		2	1		3		5
Tundra		1	1		1			6
Mediterranean Forests, Woodlands, and Scrub	1		2		0	0		5
Deserts and Xeric Shrublands	5		2	0	3	3		4
Mangroves	1		1	2		9		

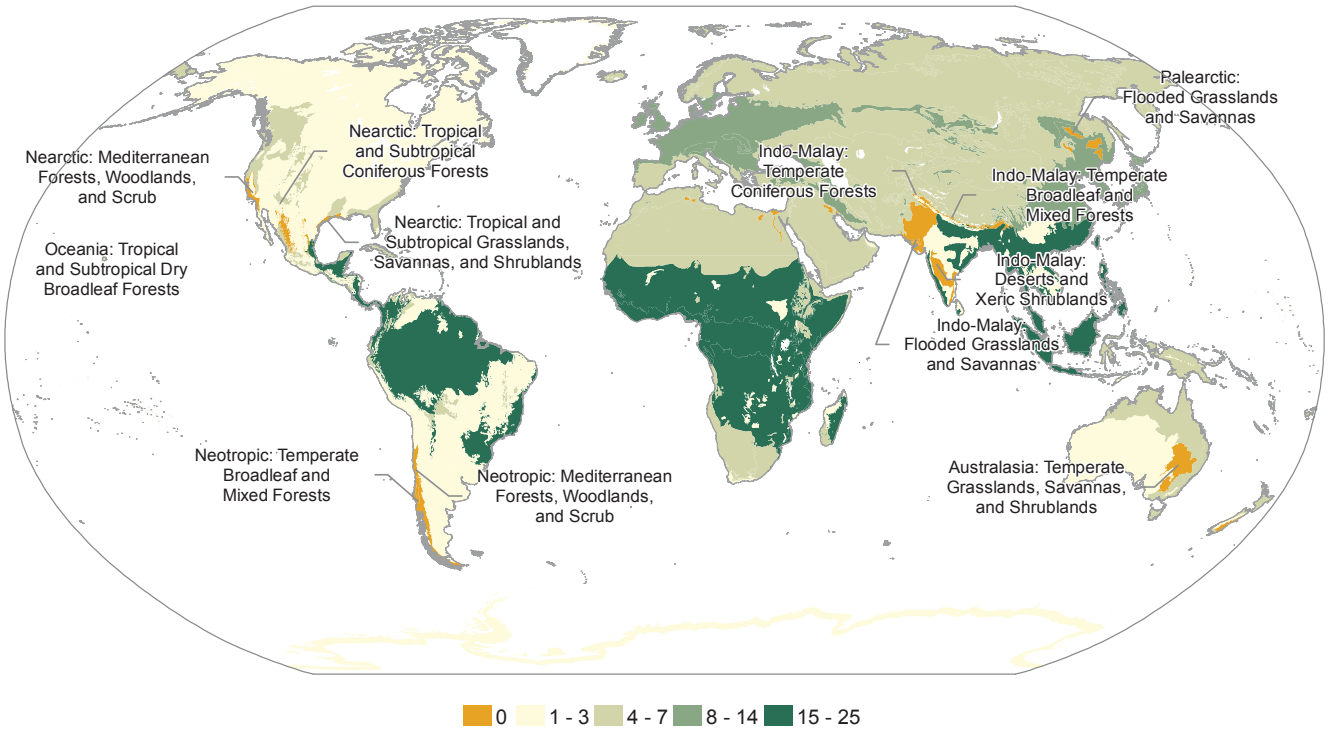


Figure 3.5 Current coverage of biogeographic realm / biome combinations (Olson *et al.* 2001) by number of biodiversity World Heritage sites. Areas shown in amber indicate combinations (see labels) that are not yet present in biodiversity World Heritage sites (see also Table 3.4).

This section therefore reviews to what extent existing biodiversity WH sites cover priority areas and sites identified in schemes that prioritize high irreplaceability. These schemes can be grouped into global-scale and site-based approaches (Table 3.5). The former tend to encompass large areas that cannot necessarily be managed or protected as a whole, while the latter are delineated explicitly as manageable conservation units such as protected areas, and thus tend to be much smaller (Schmitt 2011). While the global-scale approaches used here have been around for ten or more years and seen little development since then, most of the site-based approaches are still being developed and do not necessarily have complete global coverage yet.

Table 3.5 provides an overview and definitions of the high irreplaceability-focused schemes used in this study. The four global-scale schemes are:

1. Biodiversity hotspots and so-called 'high-biodiversity wilderness areas' (HBWAs) (Section 3.2.2.1). These are here combined into one scheme because they are identified based on the same irreplaceability criterion (i.e. they each hold ≥0.5% of the world's plants as endemics);
2. Global 200 terrestrial priority ecoregions (Section 3.2.2.2);
3. Centres of Plant Diversity (Section 3.2.2.3); and
4. Endemic Bird Areas (Section 3.2.2.4).

Although there is considerable spatial overlap between these four schemes, each scheme also includes large areas that are not included in any of the other schemes (Table 3.6).

The three site-based schemes are subsets of so-called 'Key Biodiversity Areas' (Section 3.2.3):

1. Alliance for Zero Extinction sites;
2. Important Bird Areas; and
3. Non-avian Key Biodiversity Areas.

For various reasons it is not straightforward to map the different priority schemes against the two biodiversity WH criteria. For example, the schemes are based on different biodiversity values (e.g. endemic or threatened species), which themselves are not easily mapped against the criteria (see also Section 2.1). Furthermore, none of the schemes has been developed specifically with the WH criteria in mind (and *vice versa*), and the application of the different schemes by IUCN and UNEP-WCMC has also changed over time (e.g. as new schemes became available).

Generally speaking, IUCN currently tends to apply the global-scale approaches in the evaluation – in particular the global comparative analysis (see Section 5.2) – of criterion (ix), while the site-based approaches tend to be applied in the evaluation of criterion (x). The rationale behind this is that the site-based approaches were specifically developed to identify important sites for the *in-situ* conservation of biodiversity, especially species of conservation concern (criterion (x)), whereas the global-scale approaches are more suitable to identify broader priority areas that encompass outstanding ecosystems and communities of plants and animals (criterion (ix)). In the past, however, when global data on site-based priorities did not yet exist, global-scale approaches were also frequently used under criterion (x). On the other hand, among site-based priorities, the Key Biodiversity Areas triggered by bioregionally restricted species are particularly relevant to criterion (ix) (see Section 3.2.3 and Foster *et al.* 2010).

A review of the application of the two biodiversity WH criteria in relation to the different biodiversity conservation prioritization schemes used in this study highlights the following points (see Tables 3.7, 3.8 and 3.9):

- As one would expect, compared with other natural and mixed WH sites, a much larger percentage of biodiversity WH sites overlaps with priority areas (Table 3.7). This is true for all priority schemes. These schemes thus provide some indication of the likelihood that natural WH sites are inscribed under the biodiversity criteria. However, a number of non-biodiversity WH sites also overlap with priority areas and thus potentially support important biodiversity values, although these values may not necessarily be of Outstanding Universal Value (see also Section 4.4).

- Among biodiversity WH sites, the global-scale priority schemes are equally prevalent among criterion (ix) and (x) sites (Table 3.8), which may indicate that they do not provide a clear indicator for either criterion or that clear indicators do not exist. This could also reflect the difficulties in distinguishing these two criteria noted in Section 2.1. In contrast, the site-based schemes (especially Alliance for Zero Extinction sites and non-avian Key Biodiversity Areas) are clearly more prevalent in the criterion (x) sites, indicating that overall they provide a useful indicator for criterion (x).

- The two global-scale schemes with the highest percentage overlap with biodiversity WH sites are a) the biodiversity hotspots combined with high-biodiversity wilderness areas (HBWAs) and b) the Global 200 terrestrial priority ecoregions (Tables 3.7, 3.8 and 3.9). This is not surprising as these two schemes also cover a much larger area than the other global-scale schemes (Table 3.5). Nonetheless, **these two schemes are here considered to be the most useful approaches for identifying broad gaps in the coverage of global-scale biodiversity conservation priorities for the WH List** (see also Magin and Chape 2004).

- Considering only biodiversity WH sites inscribed under one or the other criterion, almost all schemes – both global-scale

Table 3.5 Global-scale and site-based biodiversity conservation prioritization schemes used in this study (Brooks *et al.* 2006 and 2010, Schmitt 2011). The biodiversity hotspots and high-biodiversity wilderness areas are in this study combined into one scheme because they are identified based on the same irreplaceability criterion (i.e. they each hold ≥0.5% of the world's plants as endemics). Together with the Global 200 terrestrial priority ecoregions, they are the most useful approaches for identifying broad gaps in the coverage of global-scale biodiversity conservation priorities for the World Heritage List.

See results in section	Scheme	Scale	Number of areas or sites	Total land area covered (million km²)		Percentage of global land area		Definition	References
Global-scale approaches									
3.2.2.1	Biodiversity hotspots	Aggregations of ecoregions	35	23.6	35.4	15.9%	23.8%	Biogeographically similar aggregations of ecoregions holding ≥0.5% of the world's plants as endemics, and with ≥70% of primary habitat already lost	Myers *et al.* 2000, Mittermeier *et al.* 2004, Williams *et al.* 2011
	High-biodiversity wilderness areas	Aggregations of ecoregions	5	11.8		7.9%		Biogeographically similar aggregations of ecoregions holding ≥0.5% of the world's plants as endemics, and with ≥70% of primary habitat remaining and ≤5 people per km²	Mittermeier *et al.* 2002 and 2003
3.2.2.2	Global 200 terrestrial priority ecoregions	Aggregations of ecoregions	142	55.1		37.0%		Aggregations of ecoregions within biomes characterized by high species richness, endemism, taxonomic uniqueness, unusual phenomena, or global rarity of major habitat type	Olson and Dinerstein 1998 and 2002, Olson *et al.* 2000
3.2.2.3	Centres of Plant Diversity	Region or site	234	13.2		8.8%		Mainland areas holding >1,000 plant species, of which ≥10% are endemic either to the site or the region; or island areas containing ≥50 endemic species or ≥10% of flora endemic	Davis *et al.* 1994, 1995 and 1997
3.2.2.4	Endemic Bird Areas	Region or site	218	14.2		9.5%		Sole area where ≥2 bird species with global breeding ranges of <50,000 km² occur	Stattersfield *et al.* 1998
Site-based approaches									
3.2.3	Alliance for Zero Extinction sites	Site	587	0.6		0.4%		Site is sole area where an endangered (EN) or critically endangered (CR) species occurs (or contains >95% of the EN or CR species' global population for at least one life history segment)	Ricketts *et al.* 2005, Alliance for Zero Extinction 2012
	Important Bird Areas	Site	10,492	8.8		5.9%		Sites holds significant numbers of one or more globally threatened bird species, is one of a set of sites that together hold a suite of restricted-range bird species or biome-restricted bird species; and/or has exceptionally large numbers of migratory or congregatory bird species (see BirdLife International 2012 for full criteria and thresholds)	BirdLife International, Conservation International and partners 2012
	Non-avian Key Biodiversity Areas	Site	1,350	1.3		0.9%		Sites regularly holds significant numbers of one or more globally threatened species or a significant proportion of the global population of, for example, restricted-range species or congregatory species at any stage of the species' lifecycle (see Langhammer *et al.* 2007 for full criteria and thresholds)	Eken *et al.* 2004, Langhammer *et al.* 2007

Table 3.6 Spatial overlap (land area) between the different global-scale approaches used in this study. For example, 57% of the total area of Centres of Plant Diversity (CPDs) overlaps with biodiversity hotspots and high-biodiversity wilderness areas (HBWAs), while 21% of the total area of biodiversity hotspots and HBWAs also overlaps with CPDs.

Spatial overlap (land area)	Biodiversity hotspots and HBWAs	Global 200 terrestrial priority ecoregions	Centres of Plant Diversity	Endemic Bird Areas
Biodiversity hotspots and HBWAs		76%	21%	27%
Global 200 terrestrial priority ecoregions	49%		16%	19%
Centres of Plant Diversity	57%	65%		29%
Endemic Bird Areas	69%	74%	27%	

Table 3.7 Overlap of biodiversity WH sites and non-biodiversity WH sites with the different biodiversity conservation prioritization schemes used in this study.

	Biodiversity WH sites (156)		Other natural and mixed WH sites (61)	
	Number of sites	Percentage of total sites	Number of sites	Percentage of total sites
Global-scale approaches				
Biodiversity hotspots and high-biodiversity wilderness areas	104	67%	24	39%
Global 200 terrestrial priority ecoregions	113	72%	36	59%
Centres of Plant Diversity	74	47%	16	26%
Endemic Bird Areas	86	55%	18	30%
Site-based approaches				
Alliance for Zero Extinction sites	36	23%	0	0%
Important Bird Areas	130	83%	33	54%
Non-avian Key Biodiversity Areas	50	32%	2	3%

Table 3.8 Overlap of all biodiversity WH sites inscribed under criterion (ix) ***and/or*** (x) with the different biodiversity conservation prioritization schemes used in this study. This includes the 88 (56%) of the 156 biodiversity WH sites which are inscribed under both criteria.

	Inscribed under (ix) (112)		Inscribed under (x) (132)	
	Number of sites	Percentage of total sites	Number of sites	Percentage of total sites
Global-scale approaches				
Biodiversity hotspots and high-biodiversity wilderness areas	77	69%	92	70%
Global 200 terrestrial priority ecoregions	82	73%	96	73%
Centres of Plant Diversity	54	48%	65	49%
Endemic Bird Areas	61	54%	77	58%
Site-based approaches				
Alliance for Zero Extinction sites	24	21%	35	27%
Important Bird Areas	92	82%	113	86%
Non-avian Key Biodiversity Areas	32	29%	49	37%

Table 3.9 Overlap of biodiversity WH sites inscribed only under criterion (ix) ***or*** (x) with the different biodiversity conservation prioritization schemes used in this study. This excludes the 88 (56%) of the 156 biodiversity WH sites which are inscribed under both criteria.

	Inscribed under (ix) only (24)		Inscribed under (x) only (44)	
	Number of sites	Percentage of total sites	Number of sites	Percentage of total sites
Global-scale approaches				
Biodiversity hotspots and high-biodiversity wilderness areas	12	50%	27	61%
Global 200 terrestrial priority ecoregions	17	71%	31	70%
Centres of Plant Diversity	9	38%	20	45%
Endemic Bird Areas	9	38%	25	57%
Site-based approaches				
Alliance for Zero Extinction sites	1	4%	12	27%
Important Bird Areas	17	71%	38	86%
Non-avian Key Biodiversity Areas	1	4%	18	41%

and site-based – are much more prevalent in the criterion (x) sites (Table 3.9). The only exception is the Global 200 scheme, which has a comparably strong ecosystem / community component and is thus particularly relevant to criterion (ix).

- **In summary, this short review shows that the site-based approaches are particularly relevant to the evaluation of criterion (x), while the global-scale approaches are potentially relevant to both biodiversity criteria. However, none of these schemes has been developed specifically with the WH criteria in mind, and thus on their own they are of limited use for the selection of specific candidate sites for the WH List.**

The next sections provide a more detailed assessment of the current coverage of the different biodiversity conservation prioritization schemes by biodiversity WH sites and identify broad gaps with particular emphasis on the biodiversity hotspots, HBWAs and Global 200 terrestrial priority ecoregions.

3.2.2 Global-scale approaches

3.2.2.1 Biodiversity hotspots and high-biodiversity wilderness areas

Biodiversity hotspots and high-biodiversity wilderness areas (HBWAs) contain at least 1,500 species of vascular plants (i.e. >0.5% of the world's estimated 300,000 vascular plant species) as endemics (Myers *et al.* 2000, Mittermeier *et al.* 2002 and 2004). The difference between hotspots and HBWAs is that hotspots have already lost ≥70% of their primary vegetation while HBWAs retain ≥70% of their primary vegetation and are sparsely populated (≤5 people per km^2). To date, 35 hotspots and 5 HBWAs have been identified around the world (Figure 3.6). Together, these hotspots and HBWAs support over 50% of the world's vascular plant species and terrestrial vertebrate species (mammals, birds, reptiles and amphibians). They are therefore critical for the survival of the diversity of life on earth.

The 156 existing biodiversity WH sites are distributed across all five HBWAs and all but four of the 35 hotspots (Table 3.10). The hotspots with the largest number of biodiversity WH sites are Mesoamerica (10 sites) and Eastern Afromontane (9) but only 1.4% and 2.3% of the total area of these hotspots is in biodiversity WH sites. Coverage is therefore better measured by the percentage area of each hotspot and HBWA in biodiversity WH sites. The hotspots with the highest percentage area coverage in biodiversity WH sites are the Mountains of Southwest China, Forests of East Australia and New Zealand (all >9% of their total area). To put this into perspective: Assuming that biodiversity WH sites include mainly primary habitat and that, by definition, hotspots retain only 30% or less of their primary habitat, a hotspot with 9% of its total area in biodiversity WH sites has a third or more of its remaining primary habitat listed under the WH Convention.

Four hotspots are not yet represented in biodiversity WH sites: the Chilean Winter Rainfall and Valdivian Forests, Irano-Anatolian, Madrean Pine-Oak Woodlands and Mountains of Central Asia (Table 3.10 and Figure 3.7). Two nominations from the Mountains of Central Asia hotspot (Xinjiang Tianshan, China and Tajik National Park, Tajikistan) are currently being evaluated by IUCN for discussion at the WH Committee in 2013. The New Caledonia, Succulent Karoo, Philippines and Mediterranean Basin hotspots are very poorly covered (<0.1% of their total area) and another 15 hotspots and one HBWA have less than 1% of their total area in biodiversity WH sites (Table 3.10).

Table 3.10 Coverage of biodiversity hotspots and high-biodiversity wilderness areas (HBWAs) by biodiversity World Heritage sites (BWHS). Hotspots and HBWAs (bold) are ranked by the percentage land area in BWHS. Some BWHS stretch across more than one hotspot or HBWA.

Rank	Biodiversity hotspot or high-biodiversity wilderness area	Total land area (km^2)	Number of BWHS	Total land area in BWHS (km^2)	Percentage land area in BWHS
1	Mountains of Southwest China	263,034	3	26,009	9.9%
2	New Zealand	270,803	3	25,301	9.3%
3	Forests of East Australia	255,322	5	23,674	9.3%
4	Cape Floristic Region	78,731	1	5,391	6.9%
5	Tumbes-Choco-Magdalena	275,202	4	14,246	5.2%
6	Western Ghats and Sri Lanka	190,036	3	8,569	4.5%
7	**Congo Forests**	1,740,245	5	65,769	3.8%
8	**Miombo-Mopane Woodlands and Savannas**	1,202,222	2	44,133	3.7%
9	Coastal Forests of Eastern Africa	291,904	1	7,653	2.6%
10	Eastern Afromontane	1,020,095	9	23,051	2.3%
11	Sundaland	1,504,429	4	27,855	1.9%
12	**New Guinea**	2,613,225	1	45,290	1.7%
13	**Amazonia**	6,664,133	6	109,886	1.7%
14	Mesoamerica	1,132,551	10	15,566	1.4%
15	Southwest Australia	357,515	1	4,809	1.4%
16	Madagascar and the Indian Ocean Islands	601,829	5	7,548	1.3%
17	**North American Deserts**	1,411,534	3	12,816	0.9%
18	Tropical Andes	1,546,118	4	11,402	0.7%
19	Maputaland-Pondoland-Albany	273,018	2	1,898	0.7%
20	Atlantic Forest	1,236,663	5	8,034	0.7%
21	Guinean Forests of West Africa	621,705	2	3,676	0.6%
22	Indo-Burma	2,378,318	4	13,870	0.6%
23	Caucasus	533,852	1	2,878	0.5%
24	Cerrado	2,036,547	2	8,205	0.4%
25	Himalaya	743,370	5	2,777	0.4%
26	Caribbean Islands	230,073	2	746	0.3%
27	Polynesia-Micronesia	47,360	4	152	0.3%
28	East Melanesian Islands	99,630	1	302	0.3%
29	Japan	374,327	4	801	0.2%
30	California Floristic Province	294,462	1	570	0.2%
31	Horn of Africa	1,663,111	1	2,887	0.2%
32	Wallacea	339,258	1	559	0.2%
33	Mediterranean Basin	2,089,974	6	907	<0.1%
34	Philippines	297,846	1	58	<0.1%
35	Succulent Karoo	102,921	1	15	<0.1%
36	New Caledonia	19,014	1	<1	<0.1%
37	Chilean Winter Rainfall and Valdivian Forests	398,035	0	0	0.0%
38	Irano-Anatolian	901,789	0	0	0.0%
39	Madrean Pine-Oak Woodlands	462,299	0	0	0.0%
40	Mountains of Central Asia	865,298	0	0	0.0%

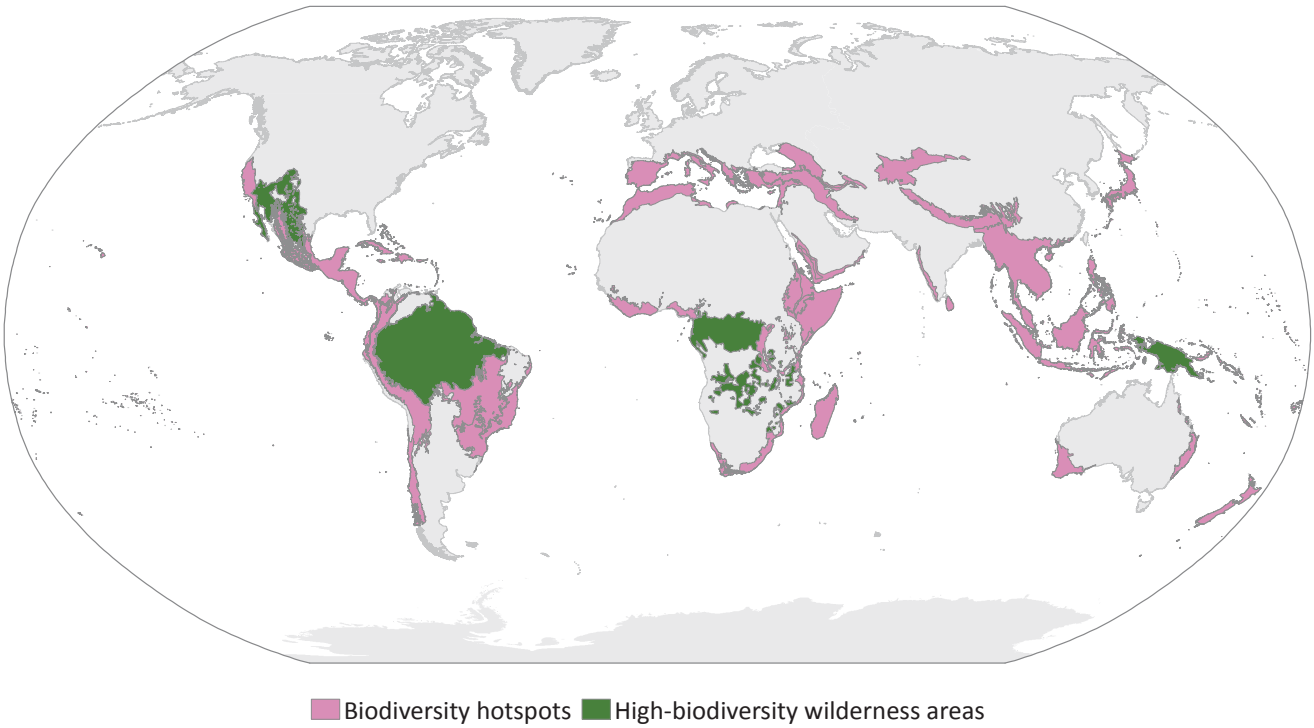


Figure 3.6 Biodiversity hotspots (35 areas that hold ≥0.5% of the world's plants as endemics and have already lost ≥70% of their primary vegetation) and high-biodiversity wilderness areas (five areas that hold ≥0.5% of the world's plants as endemics, retain ≥70% of their primary vegetation and are sparsely populated) of the world (Mittermeier *et al.* 2002 and 2004, Williams *et al.* 2011).

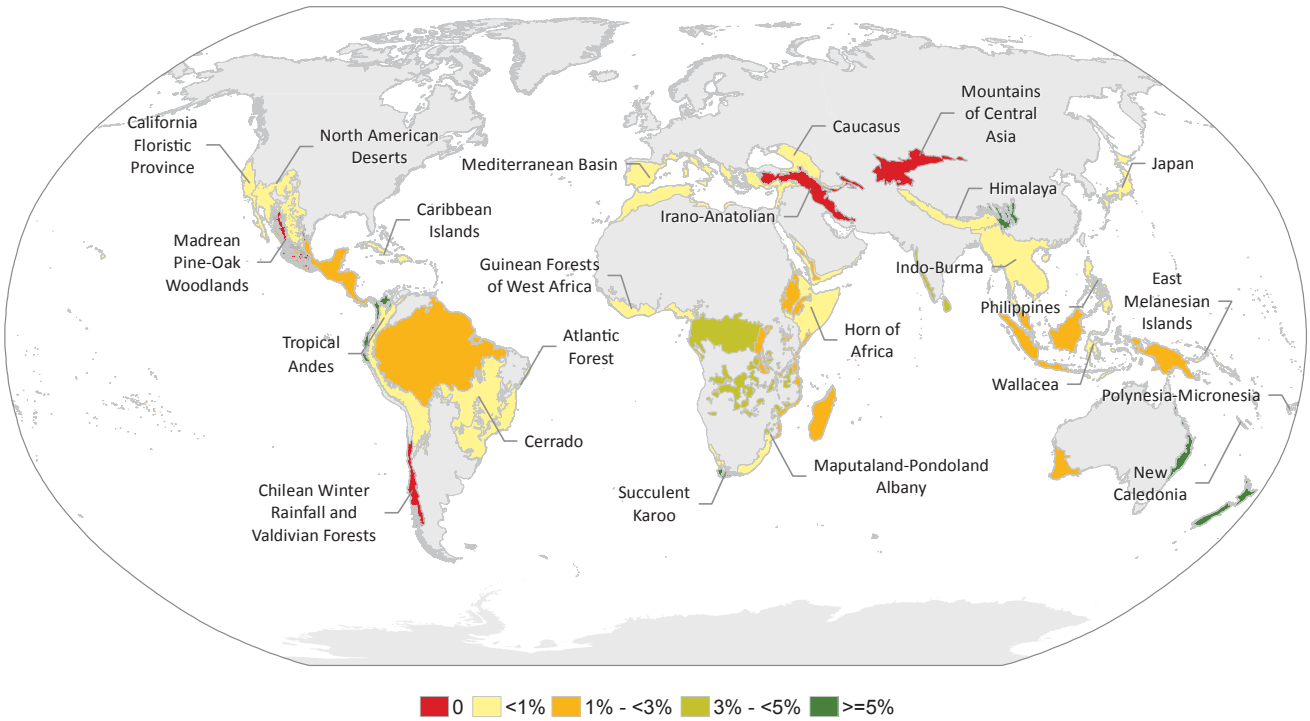


Figure 3.7 Percentage area coverage of biodiversity World Heritage sites in biodiversity hotspots and high-biodiversity wilderness areas (HBWAs). Hotspots and HBWAs with no (red) or less than 1% (yellow) of their total area in biodiversity World Heritage sites are labelled.

3.2.2.2 Global 200 terrestrial priority ecoregions

Global 200 priority ecoregions are ecoregions, or ecoregion complexes, which are characterized by high species richness and/or endemism, unique higher taxa, unusual ecological or evolutionary phenomena, or global rarity of major habitat types (Olson and Dinerstein 1998 and 2002). WWF has identified 238 Global 200 priority ecoregions, including 142 terrestrial, 53 freshwater and 43 marine priority ecoregions. Many terrestrial priority ecoregions overlap to varying degree with other global biodiversity conservation priorities such as biodiversity hotspots and HBWAs (see Table 3.6 in Section 3.2.1). However, they also include large areas – especially outside the tropics – that are not included in any of the other schemes considered here.

The 156 existing biodiversity WH sites are distributed across 97 of the 142 terrestrial priority ecoregions (Figure 3.8). While the total area of the Galapagos Island Scrub ecoregion and 75% of the total area of the Socotra Island Desert ecoregion is contained within biodiversity WH sites, no other ecoregion has more than 50% coverage in biodiversity WH sites. Most ecoregions (83 of 97) have less than 10% of their area within biodiversity WH sites. Large priority ecoregions with no or less than 1% coverage can be found in both the Americas, along the edges of the African continent and the Arabian Peninsula, in the Mediterranean Basin, Central, East and South East Asia, Siberia and central and western Australia (Figure 3.8).

The 46 priority ecoregions without any biodiversity WH site are found on all continents except Europe (Figure 3.8 and Table 3.11).

3.2.2.3 Centres of Plant Diversity

Centres of Plant Diversity (CPDs) are globally important areas for the conservation of plants. To qualify as a CPD, a mainland area must contain >1,000 plant species, of which ≥10% are endemic either to the area or region, and an island area must contain ≥50 endemic plant species or ≥10% of its flora must be endemic (Davis *et al.* 1994). IUCN and WWF have identified 234 CPDs around the world (Davis *et al.* 1994, 1995 and 1997). Due to their more specific focus, CPDs can add supplementary value to the above analyses based on biodiversity hotspots, HBWAs and Global 200 terrestrial priority ecoregions (Magin and Chape 2004). However, they are less useful to identify broad gaps in the coverage of global-scale biodiversity conservation priorities for the WH List.

The 156 existing biodiversity WH sites represent 72 of the 234 CPDs (Figure 3.9). The Galapagos Islands CPD is completely contained within a single biodiversity WH site, and another 20 CPDs have more than 50% of their area within biodiversity WH sites. However, 31 of the 72 CPDs have less than 10% of their area within biodiversity WH sites and 159 CPDs are not represented in any biodiversity WH site at present (see online data annex for list of 'gap' CPDs).

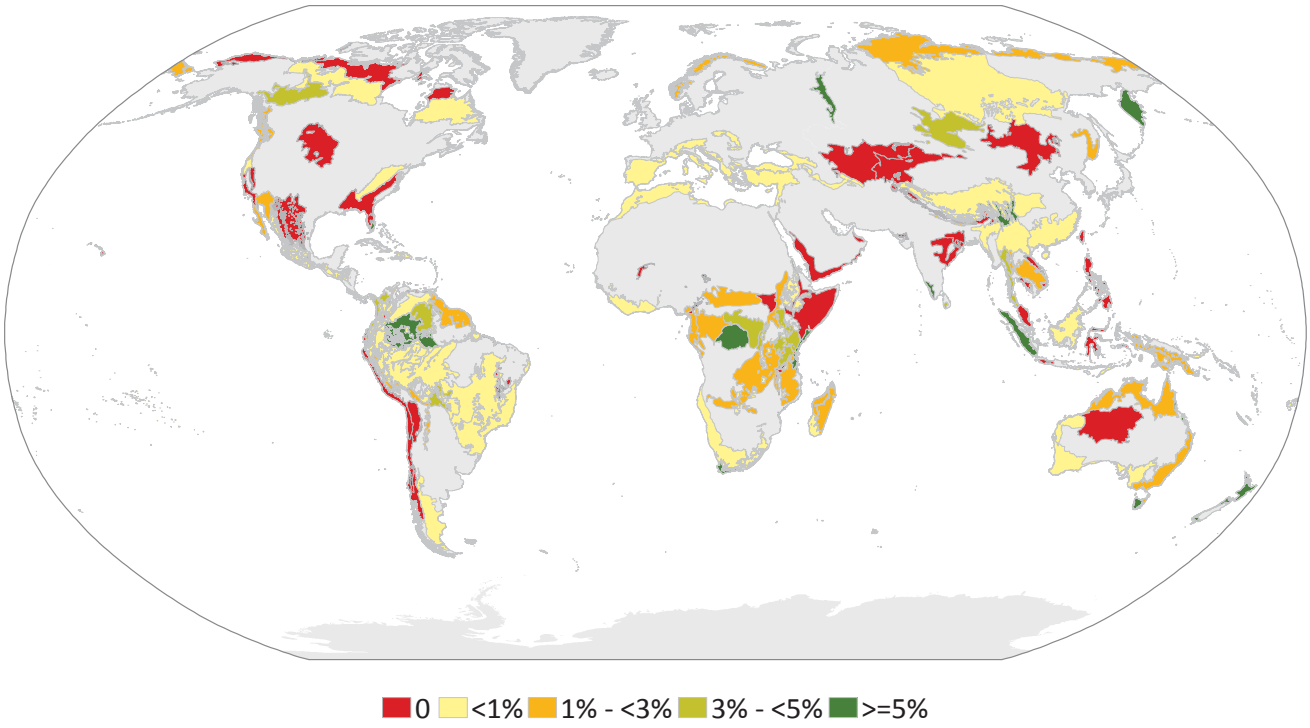


Figure 3.8 Percentage area coverage of biodiversity World Heritage sites in the 142 Global 200 terrestrial priority ecoregions as defined by Olson and Dinerstein (2002).

Table 3.11 The 46 Global 200 terrestrial priority ecoregions (Olson and Dinerstein 2002) lacking any biodiversity World Heritage sites. Ecoregions are sorted by realm.

Realm	Global 200 terrestrial biodiversity ecoregions	Total land area (km²)
Afrotropic	Arabian Highlands Woodlands and Shrublands	471,143
Afrotropic	Cameroon Highlands Forests	39,277
Afrotropic	East African Mangroves	16,108
Afrotropic	Eastern Arc Montane Forests	23,710
Afrotropic	Gulf of Guinea Mangroves	30,996
Afrotropic	Horn of Africa Acacia Savannas	1,056,171
Afrotropic	Madagascar Mangroves	5,217
Afrotropic	Southern Rift Montane Woodlands	33,571
Afrotropic	Sudd-Sahelian Flooded Grasslands and Savannas	245,119
Australasia	Great Sandy-Tanami-Central Ranges Desert	1,263,321
Australasia	Moluccas Moist Forests	46,330
Australasia	Sulawesi Moist Forests	192,565
Indo-Malay	Annamite Range Moist Forests	93,899
Indo-Malay	Cardamom Mountains Moist Forests	44,345
Indo-Malay	Chhota-Nagpur Dry Forests	122,693
Indo-Malay	Eastern Deccan Plateau Moist Forests	341,898
Indo-Malay	Eastern Himalayan Broadleaf and Conifer Forests	167,905
Indo-Malay	Greater Sundas Mangroves	37,529
Indo-Malay	Peninsular Malaysia Lowland and Montane Forests	142,988
Indo-Malay	Philippines Moist Forests	279,625
Indo-Malay	Rann of Kutch Flooded Grasslands	27,965
Indo-Malay	Taiwan Montane Forests	36,056
Indo-Malay	Western Himalayan Temperate Forests	95,750
Indo-Malay	Western Java Montane Forests	26,342
Nearctic	Alaskan North Slope Coastal Tundra	227,783
Nearctic	California Chaparral and Woodlands	121,535
Nearctic	Canadian Low Arctic Tundra	798,399
Nearctic	Northern Prairies	701,086
Nearctic	Sierra Nevada Coniferous Forests	52,951
Nearctic	Southeastern Conifer and Broadleaf Forests	585,715
Neotropic	Amazon-Orinoco-Southern Caribbean Mangroves	41,162
Neotropic	Atacama-Sechura Deserts	290,723
Neotropic	Atlantic Dry Forests	115,359
Neotropic	Central Andean Dry Puna	256,198
Neotropic	Chihuahuan-Tehuacán Deserts	646,098
Neotropic	Chilean Matorral	148,840
Neotropic	Coastal Venezuela Montane Forests	14,372
Neotropic	Sierra Madre Oriental and Occidental Pine-Oak Forests	290,076
Neotropic	South American Pacific Mangroves	13,551
Neotropic	Tumbesian-Andean Valleys Dry Forests	103,415
Neotropic	Valdivian Temperate Rain Forests / Juan Fernández	248,798
Oceania	Hawaii Dry Forest	10,031
Oceania	Hawaii Moist Forest	6,752
Palearctic	Central Asian Deserts	1,320,706
Palearctic	Daurian/Mongolian Steppe	1,098,720
Palearctic	Middle Asian Montane Woodlands and Steppe	880,384

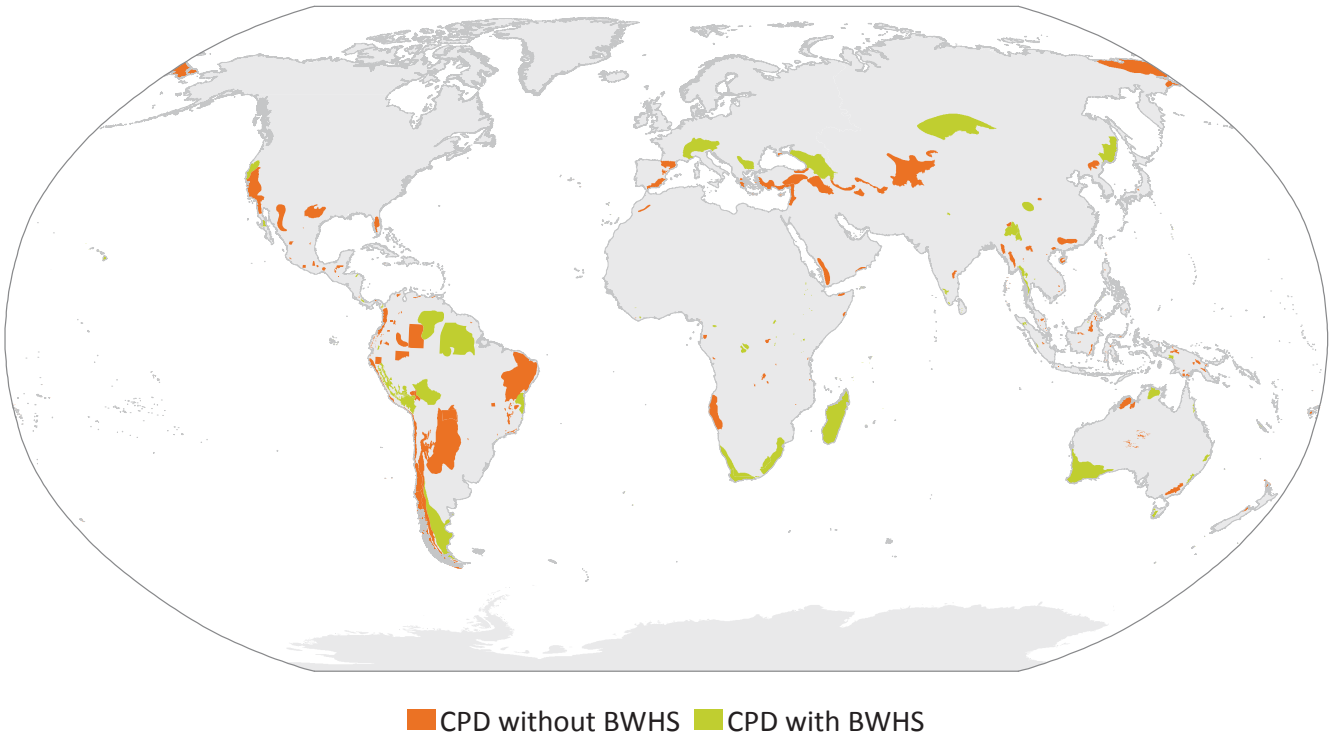


Figure 3.9 Centres of Plant Diversity (234) as defined by Davis *et al.* (1994, 1995 and 1997) with and without biodiversity World Heritage sites (BWHS).

Large CPDs without biodiversity WH sites can be found, for example, in the mountain ranges stretching from Turkey in the west to Middle Asia (Kazakhstan, Kirgizstan, Tajikistan, Turkmenistan and Uzbekistan), the Chukotskiy Peninsula in Russia's extreme northeast, southern parts of North America, and the whole of South America (Figure 3.9).

3.2.2.4 Endemic Bird Areas

Endemic Bird Areas (EBAs) are globally important areas for the conservation of birds. To qualify as an EBA, an area must encompass the entire breeding range of ≥2 bird species with global breeding ranges of <50,000 km^2 (Stattersfield *et al.* 1998). Each EBA is therefore critical for the survival of at least two endemic bird species but many EBAs support more endemic species. The Solomon group in the Pacific, for example, supports 62 bird species that are entirely confined to this EBA. BirdLife International has identified 218 EBAs around the world (Stattersfield *et al.* 1998). Again, as with CPDs, EBAs are less useful to identify broad gaps in the coverage of global-scale biodiversity conservation priorities for the WH List due to their more specific focus (Magin and Chape 2004).

The 156 existing biodiversity WH sites represent 83 of the 218 EBAs (Figure 3.10). Seven island EBAs (Auckland, Cocos, Galapagos, Gough, Henderson, Laysan and Lord Howe) are completely contained within biodiversity WH sites, and another four island EBAs (Aldabra, Fernando de Noronha, Ogasawara and Socotra) have more than 50% of their area within biodiversity WH sites. However, 58 of the 83 EBAs have less than 10% of their area within biodiversity WH sites and 135 EBAs are not represented in any biodiversity WH sites, including two of the only three EBAs with more than 50 endemic bird species: the Solomon group in the Pacific and Chocó in Colombia and Ecuador (see online data annex for list of 'gap' EBAs). In addition to a number of island EBAs, there are still large EBAs without biodiversity WH sites in the Americas, Western, East and South East Asia, southwest Australia and the North Island of New Zealand (Figure 3.10).

3.2.2.5 Summary of current coverage and broad gaps

Since 1978, the network of biodiversity WH sites has expanded to 156 sites, covering a total land area of 1.1 million km^2 (equivalent to the size of Bolivia). Biodiversity WH sites now 'represent':

- 31 (89%) of the 35 biodiversity hotspots and all five high-biodiversity wilderness areas;
- 97 (68%) of the 142 Global 200 terrestrial priority ecoregions;
- 72 (31%) of the 234 Centres of Plant Diversity; and
- 83 (38%) of 218 Endemic Bird Areas.

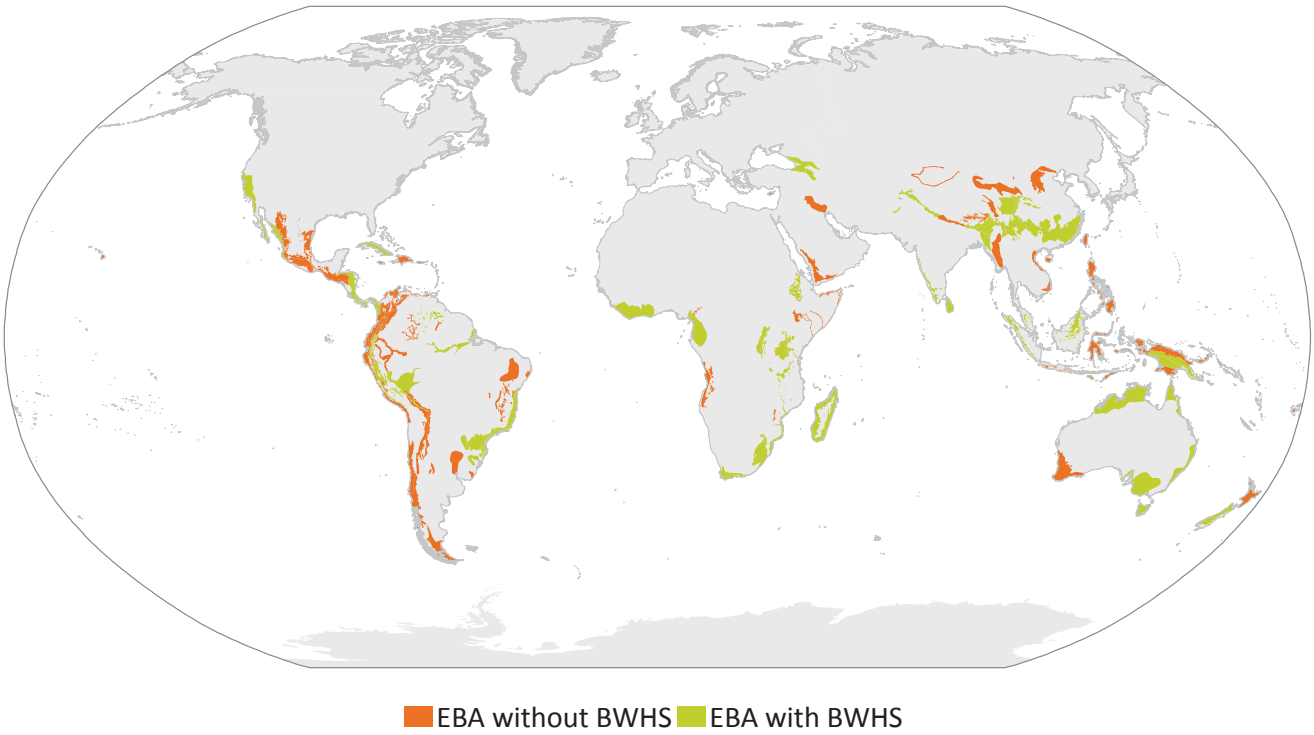


Figure 3.10 Endemic Bird Areas (218) as defined by Stattersfield *et al.* (1998) with and without biodiversity World Heritage sites (BWHS).

Biodiversity WH sites provide comparably good coverage – best measured in terms of the percentage coverage of a priority area – of a number of biodiversity hotspots, high-biodiversity wilderness areas (HBWAs) and Global 200 terrestrial priority ecoregions. The hotspots of the Mountains of Southwest China, Forests of East Australia, New Zealand, Cape Floristic Region (southern Africa) and Tumbes-Choco-Magdalena (northwestern South America) have all more than 5% of their total area in biodiversity WH sites. The Western Ghats and Sri Lanka hotspot and the two African HBWAs – the Congo Forests and the Miombo-Mopane Woodlands and Savannas – are also relatively well represented with around 4% coverage each. Global 200 terrestrial priority ecoregions with over 30% of their total area in biodiversity WH sites are the Galapagos Island Scrub (100%), Socotra Island Desert (75%), East African Moorlands (38%) and Central Range Subalpine Grasslands in Australasia (32%).

However, a range of notable gaps remains, even with regard to these global-scale biodiversity conservation priorities. Four biodiversity hotspots are not yet represented in biodiversity WH sites:

1. Chilean Winter Rainfall and Valdivian Forests (Argentina and Chile);
2. Irano-Anatolian (Armenia, Azerbaijan, Georgia, Iran, Iraq, Turkey and Turkmenistan) – the Göreme National Park WH site in Turkey falls into this hotspot but is not listed under biodiversity criteria;
3. Madrean Pine-Oak Woodlands (Mexico and United States) – the Monarch Butterfly Biosphere Reserve WH site in Mexico falls into this hotspot but is not listed under biodiversity criteria (see Section 2.4.3 for explanation); and
4. Mountains of Central Asia (Afghanistan, China, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) – two nominations from this hotspot (Xinjiang Tianshan, China and Tajik National Park, Tajikistan) are currently being evaluated by IUCN for discussion at the WH Committee in 2013.

Another 19 hotspots and one high-biodiversity wilderness area have less than 1% of their area in biodiversity WH sites. Hotspots with less than 0.1% coverage are New Caledonia, Succulent Karoo, Philippines and Mediterranean Basin.

Moreover, 46 Global 200 terrestrial priority ecoregions on all continents, 159 Centres of Plant Diversity, and 136 Endemic Bird Areas do not have a biodiversity WH site.

Figure 3.11 summarizes the broad gaps in the coverage of biodiversity conservation priorities. Due to the spatial overlap between the different global-scale approaches used in this study (see Table 3.6 in Section 3.2.1), some areas are identified as gaps in more than one approach. For example, the mountains

of Central Asia, southwest Arabian Peninsula, and mountain, forest and desert areas in the southwest of both North America and South America are all recognized as priorities in several approaches but are not yet represented in biodiversity WH sites.

The analysis shows that there are still many priority areas with important biodiversity values around the world that are not yet represented in biodiversity WH sites. Although none of the global-scale priority schemes was developed specifically to identify properties of Outstanding Universal Value as defined by the WH Convention, they continue to provide critical guidance for the identification, nomination and evaluation of important biodiversity sites.

The analysis above was primarily aimed at identifying broad gaps in the coverage of the global-scale schemes. However, it should be noted that many of the priority areas are too large (or too fragmented) to be fully represented by a single or small biodiversity WH site, in which case multiple sites and/or serial sites are required (see also Section 2.4.3). A biodiversity hotspot that has already one or more biodiversity WH sites may therefore still contain other properties of Outstanding Universal Value that deserve recognition. **The site-based schemes discussed in the next section can help identify specific priority sites within the broader gaps and beyond.** In addition, the current coverage of many priority areas could be improved through the targeted extension of existing WH sites, including through serial and/or transnational extensions, or the formal recognition of important biodiversity values in WH sites that are not yet inscribed under the biodiversity criteria (see Section 4.4).

However, it is important to understand the limitations of both the global-scale and site-based schemes when it comes to identifying biodiversity WH sites, and that they do not necessarily provide a stringent enough standard for the selection of outstanding biodiversity sites for the WH List. Hence, not every protected area in a biodiversity hotspot, Global 200 ecoregion, Centre of Plant Diversity, or Endemic Bird Area may meet the WH criteria (ix) and/or (x). Perhaps more importantly, none of these schemes indicates whether or not a site meets the protection, management and integrity requirements of the WH Convention (see Section 2.4.2).

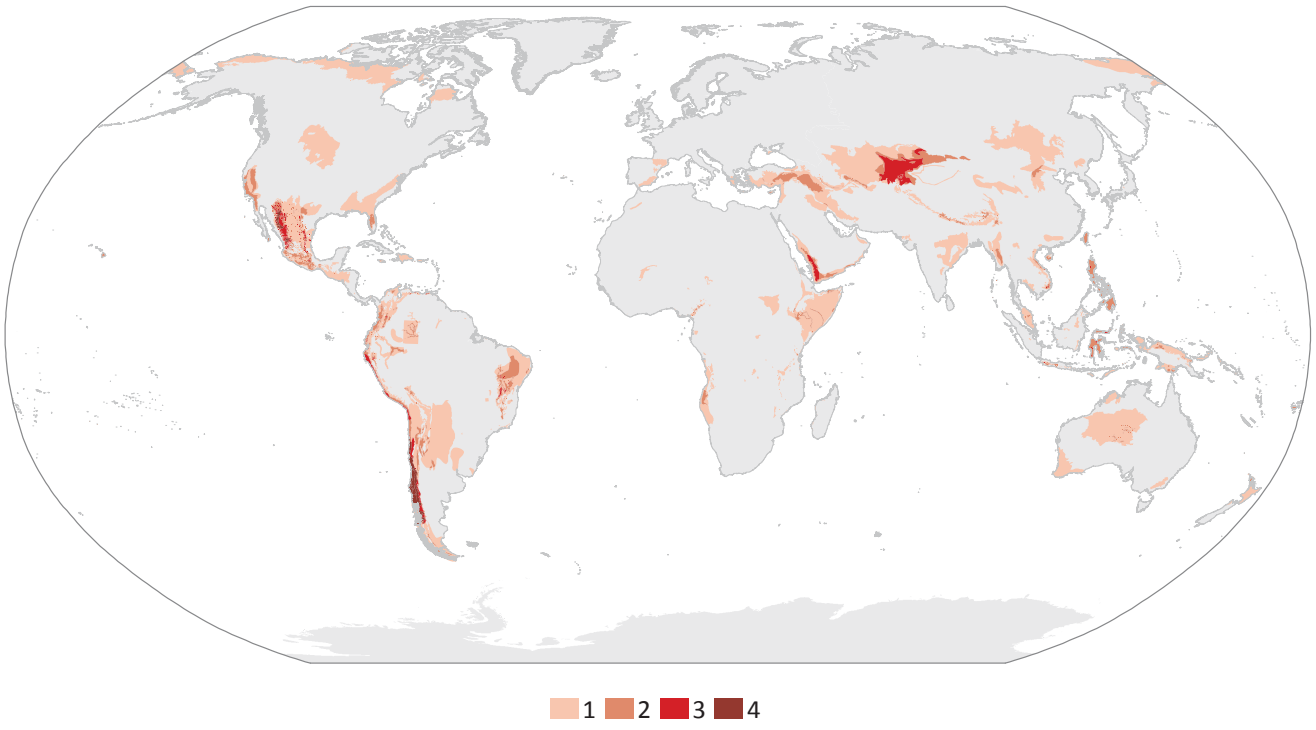


Figure 3.11 Summary of broad gaps in the coverage of biodiversity conservation priorities. The map shows priority areas from the four global-scale approaches used in this study (biodiversity hotspots and high-biodiversity wilderness areas, Global 200 terrestrial priority ecoregions, Centres of Plant Diversity, and Endemic Bird Areas) that are not yet represented in biodiversity World Heritage sites. The map has been created by overlaying all the gap areas shown in red in Figures 3.7, 3.8, 3.9 and 3.10. A value of two indicates that the area is a World Heritage gap in two of the four approaches, while a value of four indicates that the area is a gap according to all four approaches.

3.2.3 Site-based approaches

Key Biodiversity Areas (KBAs) are sites that contribute significantly to the global persistence of biodiversity. They are identified using globally standardized criteria and thresholds, based on the needs of biodiversity requiring safeguards at the site scale (Langhammer *et al.* 2007). These criteria are based on the framework of vulnerability and irreplaceability widely used in systematic conservation planning. KBAs can thus help identify specific priority sites within the broader gaps identified above.

KBAs help set national and regional priorities within the global context (Langhammer *et al.* 2007). The KBA approach thus helps to overcome some of the shortcomings of the global-scale approaches used above. For example, it facilitates the identification of globally significant sites in all countries worldwide, both inside and outside the broad priority regions (e.g. biodiversity hotspots). Unlike many of the broad priority regions, KBAs are also delineated based on existing management units (e.g. protected areas).

To qualify as a KBA, an area must contain significant populations of globally threatened, restricted range, congregatory or bioregionally restricted species (Langhammer *et al.* 2007). As Foster *et al.* (2010) noted, the KBA criteria reflect biodiversity values that can be recognized under WH criteria (ix) and (x). KBAs that support a significant number of species restricted to a particular bioregion (or ecoregion) could be considered as outstanding examples of ecosystems and communities of plants and animals (criterion (ix)). KBAs that support significant populations of globally threatened, restricted range and congregatory species could be considered as important habitats for the *in-situ* conservation of biodiversity (criterion (x)) (Foster *et al.* 2010).

Different subsets of KBAs have been identified (Figure 3.12). These include for example Alliance for Zero Extinction sites (AZEs) and Important Bird Areas (IBAs). AZEs and IBAs are the only two subsets identified globally to date. AZEs hold ≥95% of the global population of Critically Endangered or Endangered animal or plant species (Ricketts *et al.* 2005), while IBAs are important sites for the conservation of the world's birds (Butchart *et al.* 2012). KBAs for other taxonomic groups (e.g. mammals, amphibians, reptiles, plants; henceforth 'non-avian KBAs') have also been identified in at least 68 countries but not yet globally. A brief update is provided here of the analysis by Foster *et al.* (2010) on the current coverage of AZEs, IBAs and non-avian KBAs within biodiversity WH sites.

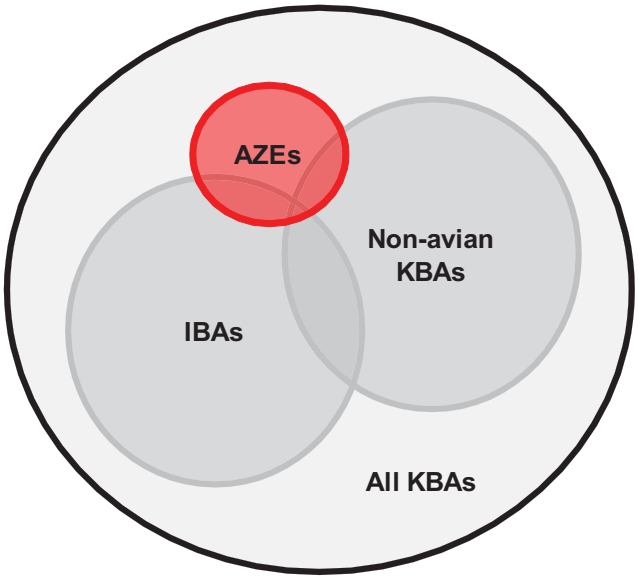


Figure 3.12 Key Biodiversity Areas (KBAs) are sites of global significance for biodiversity conservation (adapted from Foster *et al.* 2010). Alliance for Zero Extinction sites (AZEs), Important Bird Areas (IBAs) and non-avian KBAs each form a subset of KBAs based on more specific criteria. AZEs are highlighted in red because they are the last known places where highly threatened species survive and are thus the highest priority subset of all KBAs.

- **Current coverage of AZEs**: 36 of the 156 biodiversity WH sites cover, fully or partially, 65 (11%) of the 587 AZEs in the dataset (Table 3.12 and Figure 3.13). Several large and/or serial WH sites contain more than one AZE. Six biodiversity WH sites contain three or more AZEs: Islands and Protected Areas of the Gulf of California (8), Galápagos Islands (5), Rainforests of the Atsinanana (5), Western Ghats (4), Wet Tropics of Queensland (4) and Central Highlands of Sri Lanka (3). In addition, six biodiversity WH sites contain two AZEs each and 24 biodiversity WH sites contain one AZE each. With the exception of Mount Kenya National Park/Natural Forest (inscribed only under (vii) and (ix)), all biodiversity WH sites that contain AZEs are inscribed under (x), the most appropriate WH criterion for the recognition of AZEs. There are no AZEs in any of the non-biodiversity WH sites.

- **Current coverage of IBAs**: 130 of the 156 biodiversity WH sites overlap with 418 (4%) of the 10,492 confirmed IBAs in the dataset (Table 3.12 and Figure 3.13). The highest number of IBAs is found in The Wadden Sea (31), Western Ghats (29), Socotra Archipelago (22) and Great Barrier Reef (21). Another 21 biodiversity WH sites cover 5–10 IBAs and 48 biodiversity WH sites cover 2–4 IBAs. The vast majority (113 sites or 87%) of the 130 biodiversity WH sites that contain IBAs are inscribed under (x). However, there are also 54 IBAs that overlap with 33 non-biodiversity WH sites. The Dolomites, for example, contain four IBAs.

- **Current coverage of non-avian KBAs**: 50 of the 156 biodiversity WH sites overlap with 104 (8%) of the 1,350 confirmed non-avian KBAs in the dataset (Table 3.12 and Figure 3.13). The highest number of non-avian KBAs is found in the Rainforests of the Atsinanana (14), Islands and Protected Areas of the Gulf of California (8) and Virunga National Park (6). Another 18 biodiversity WH sites also cover more than one non-avian KBA. Again with the exception of Mount Kenya National Park/Natural Forest (see above), all biodiversity WH sites that contain non-avian KBAs are recognized under (x). There are only two non-biodiversity WH sites that contain non-avian KBAs: Kilimanjaro National Park and Pitons Management Area (one non-avian KBA each).

There are a number of important points arising from this brief analysis of the current coverage of different subsets of KBAs:

- Biodiversity WH sites cover, fully or partially, 11% of the AZEs, 4% of the IBAs and 8% of the non-avian KBAs identified to date.

- Overall there is a high degree of congruence between biodiversity WH sites and the different subsets of KBAs analysed here. Only 22 (14%) of the 156 biodiversity WH sites have not been identified as AZEs, IBAs or no-avian KBAs in the corresponding datasets.

- With the exception of Mount Kenya National Park/Natural Forest, all biodiversity WH sites with AZEs and non-avian KBAs are already inscribed under WH criterion (x). Thus, Mount Kenya National Park/Natural Forest could be considered for additional inscription under (x).

- The vast majority (87%) of the biodiversity WH sites with IBAs are recognized under (x). The 13% recognized under (ix) may however cover IBAs that were identified primarily because of their importance for bioregionally restricted species (see above and Foster *et al.* 2010). IBAs are the only subset of KBAs analysed here to which this KBA criterion has been applied widely.

- There are natural and mixed WH sites with important biodiversity values that are not recognized under the biodiversity criteria of the WH Convention (see also Foster *et al.* 2010). Some of these sites, for example the seven sites identified in Section 4.4, may support outstanding biodiversity values and thus warrant consideration under the biodiversity criteria.

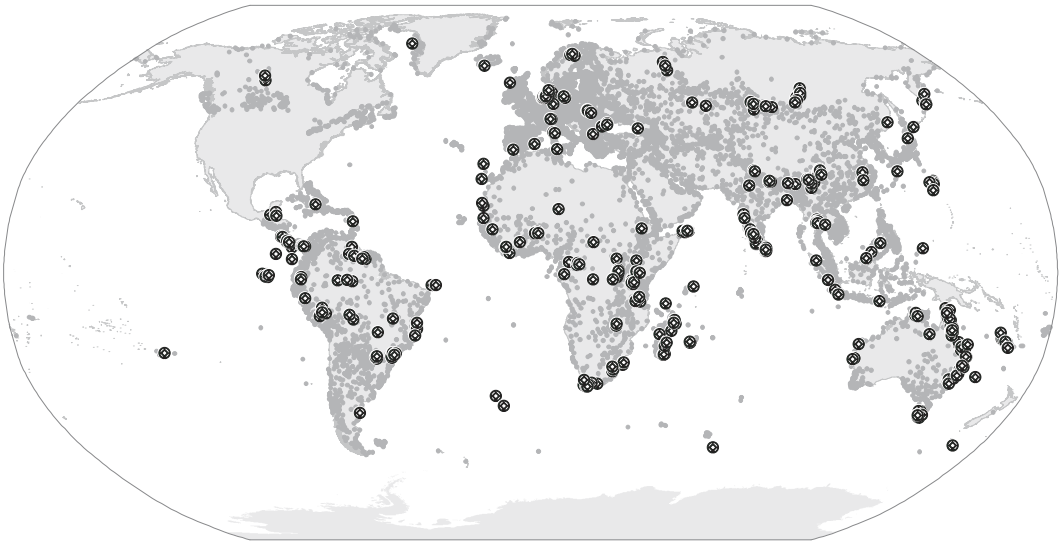
In the next chapter three different approaches are used to identify existing protected areas with potentially outstanding biodiversity values that are not yet recognized on the WH List but may merit inscription under criteria (ix) and/or (x).

Table 3.12 Current coverage of Alliance for Zero Extinction sites (AZEs), Important Bird Areas (IBAs) and non-avian Key Biodiversity Areas (KBAs) in biodiversity World Heritage sites (BWHS).

	Total number of sites analysed	Sites fully or partially contained within BWHS (percentage of all sites)	Number of the 156 BWHS overlapping with sites in this scheme
AZEs	587	65 (11%)	36
IBAs	10,492	418 (4%)	130
Non-avian KBAs	1,350	104 (8%)	50
Total	**12,429**	**587**	**-**

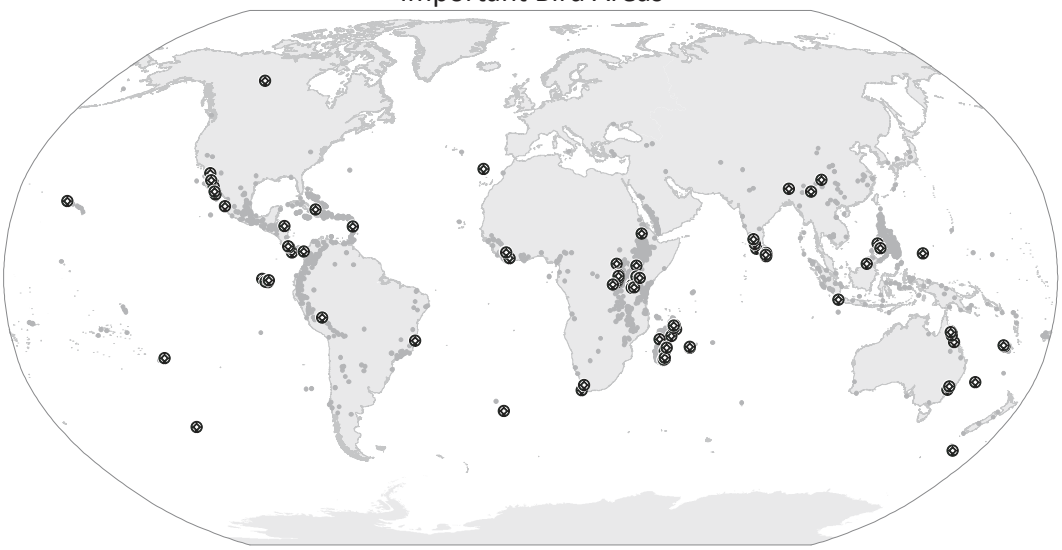
Alliance for Zero Extinction sites

65 (11%) of 587 AZEs are fully or partially within BWHS.



Important Bird Areas

418 (4%) of 10,492 IBAs are fully or partially within BWHS.



Non-avian Key Biodiversity Areas

104 (8%) of 1,350 non-avian KBAs are fully or partially within BWHS.

Figure 3.13 Known Alliance for Zero Extinction sites (top), Important Bird Areas (centre) and non-avian Key Biodiversity Areas (bottom), inside (black) and outside (grey) biodiversity World Heritage sites (BWHS).

4. Priority sites for species conservation that may merit consideration for World Heritage listing

The aim of this part of the study is to identify potentially outstanding biodiversity sites that may merit WH listing and to evaluate how these can help to fill the broad gaps identified above.

4.1 Introduction

Many different approaches exist to identify important areas and sites for biodiversity. However, as noted above, none of these has been developed specifically to identify properties of Outstanding Universal Value (OUV) as defined by the WH Convention. The development of a specific site selection approach for the WH Convention is not straightforward because 1) the biodiversity criteria encompass a wide range of biodiversity features including ecosystems, species and ecological and/or biological processes (see also Section 2.1) and 2) the WH Convention, unlike for example the Ramsar Convention, has not defined specific thresholds for OUV with regard to biodiversity values and features (see also Section 2.2). Notwithstanding these difficulties, the present study attempts to identify potential candidate sites for the WH List based on best available data, and thus differs from previous studies that have either relied on expert opinion (e.g. IUCN CNPPA 1982) or did not attempt to identify specific candidate sites (e.g. Magin and Chape 2004).

The present study uses three different approaches to identify **existing protected areas** with potentially outstanding biodiversity values that are not yet recognized on the WH List but may merit inscription under criteria (ix) and/or (x). By focusing on designated areas that are already subject to some degree of protection and management, the analysis seeks to take into account, at the most basic level, some of the protection and management requirements of the WH Convention (see also Section 2.4.2). Although many currently unprotected areas may have the potential to become WH sites in the future, **this study seeks to identify candidate sites for consideration in the next 5–10 years**. The focus on existing protected areas thus avoids the selection of sites that would first have to undergo the often lengthy process of protected area establishment before they could be considered for the WH List.

The three approaches are:

1. Species irreplaceability analysis: This approach identifies the world's most irreplaceable protected areas for species conservation based on the IUCN / UNEP-WCMC World Database on Protected Areas and the IUCN Red List of Threatened Species (Section 4.2).
2. Rapid screening of Alliance for Zero Extinction sites (AZEs): This approach identifies the most irreplaceable (in terms of number of 'trigger species') AZEs that are protected but not yet covered by biodiversity WH sites (Section 4.3).
3. Rapid screening of non-biodiversity WH sites: This approach identifies, based on the species irreplaceability analysis, existing WH sites with potentially important biodiversity values that are not yet recognized under biodiversity criteria (Section 4.4).

These approaches focus on species values and are thus especially relevant to criterion (x). It is envisaged that, once relevant global datasets become available, similar approaches will in the future be applied to ecosystem values and criterion (ix). However, it should be noted that many of the candidate sites identified for species values are likely to also support important ecosystem values, and thus may have the potential to meet both biodiversity criteria.

The first and second approach used here specifically target sites that "contain the most important and significant natural habitats for *in-situ* conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation", as required by criterion (x). The third approach seeks to ensure that the WH List formally recognizes important biodiversity values of natural and mixed WH sites that may have been overlooked when these sites were nominated, evaluated or inscribed. It thus targets 'low hanging fruit' for a more credible WH List with regard to biodiversity values. Section 4.5 briefly reviews the potential of the identified candidate sites to help fill broad gaps in the coverage of biodiversity conservation priorities.

4.2 Protected areas with potentially outstanding biodiversity values

This study first uses a new approach, developed by Le Saout (2010) and Le Saout *et al.* (in prep.), to identify the most

irreplaceable protected areas for species conservation globally. This approach is highly relevant to the identification of potential biodiversity WH sites because it:

1. applies the concept of irreplaceability, which recognizes some areas as unique and/or exceptionally important for biodiversity conservation, at the global level. This concept is strongly related to the notion of Outstanding Universal Value (see also Section 2.2);
2. seeks to identify, based on available data, the most irreplaceable sites globally for species conservation, including threatened species. The approach is thus particularly relevant to WH criterion (x) (see also Section 2.1); and
3. focuses the search for such sites on designated protected areas – i.e. sites that are already subject to some degree of protection and/or management and thus are more likely to meet the protection and management requirements of the WH Convention than unprotected areas (see also Section 2.4.2).

As described in Section 2.3, this approach combines information from the IUCN Red List of Threatened Species and the IUCN / UNEP-WCMC World Database on Protected Areas (WDPA) in order to assign each protected area a species-based irreplaceability score. The score is based on the fraction of each species' global range overlapping the boundaries of each protected area.

Species irreplaceability scores were calculated for 173,461 existing protected areas for which a site boundary was recorded in the October 2012 version of the WDPA (IUCN and UNEP-WCMC 2012). The scores are based on 6,240 amphibian species (1,922 globally threatened), 9,916 bird species (1,311) and 5,263 mammal species (1,096) for which range maps were recorded in the 2012.2 version of the IUCN Red List (IUCN 2012).

Two species irreplaceability scores were calculated for each protected area, one based on all species in the assessed groups, the other one based only on the globally threatened species in these groups. Globally threatened species are classified as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) on the IUCN Red List. The irreplaceability scores for all protected areas analysed will be made available in the online data annex.

Only the 100 most irreplaceable protected areas for all species and the 100 most irreplaceable protected areas for the subset of threatened species were selected as a basis for the final list. The final list includes only 78 areas because many of the selected areas are on both top 100 lists. Moreover, where any two or more of the selected protected areas were contiguous or within 50 km of each other, clusters were formed to include all the affected sites (see Section 2.3).

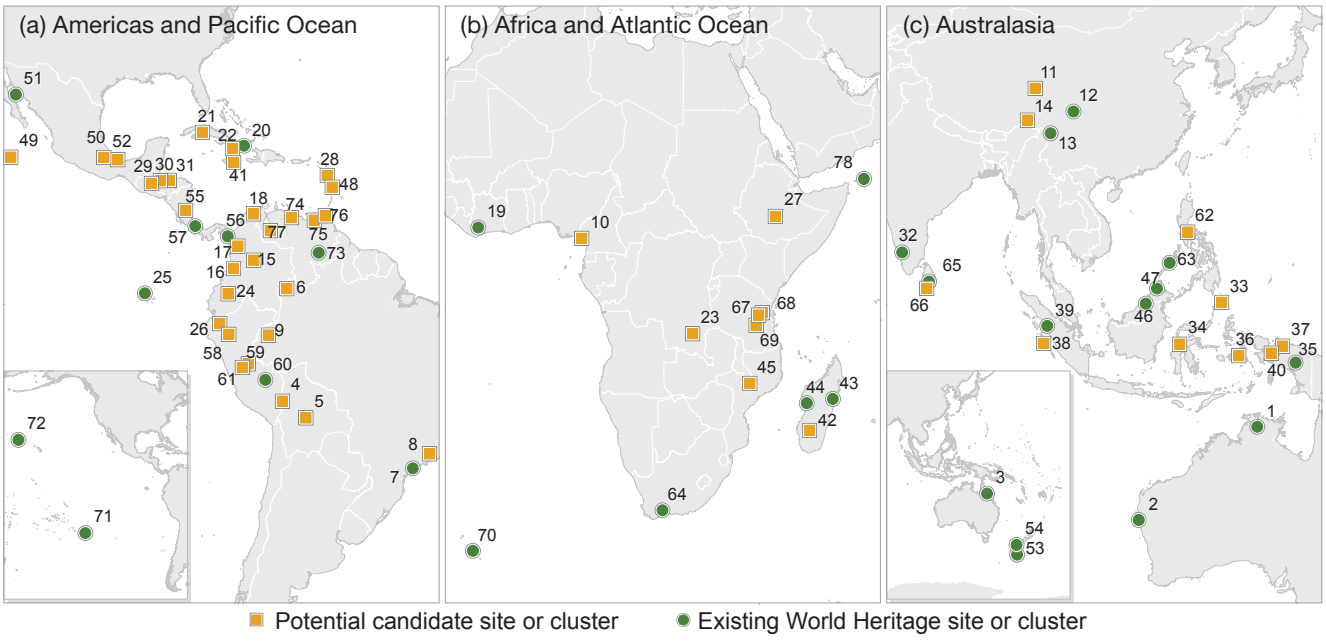


Figure 4.1 The 78 most irreplaceable protected areas (sites or clusters) for the conservation of the world's amphibian, bird and mammal species. Numbers correspond to Table 4.1. The selection of sites and clusters is based on the 100 most irreplaceable protected areas for all species and the 100 most irreplaceable protected areas for the subset of threatened species (see text and Table 4.1 for details).

List of the 78 most irreplaceable protected areas

The species irreplaceability analysis identified the 78 most irreplaceable protected areas (sites or clusters) for the conservation of the world's amphibian, bird and mammal species (see Figure 4.1 and Table 4.1). The vast majority of these areas is in the tropics of the Americas, followed by Australasia and Africa. The countries with the most areas in the list are Indonesia (8), Venezuela (5), Brazil, China, Colombia, Mexico and Peru (4 each), all recognized as megadiversity countries (see Section 1.6). **The list includes a number of existing biodiversity WH sites, some of which have potential for extensions, as well as potential candidate sites for new biodiversity nominations.**

The following sections provide more details on the existing biodiversity WH sites on the list, including those that may merit extension, and the potential candidate sites for new biodiversity nominations. The last column in Table 4.1 summarizes the possible options for WH nominations arising from this analysis. However, it should be noted that these are indicative only and do not take into account the protection, management and integrity requirements of the WH Convention. It is recommended that anyone interested in following up with any

Table 4.1 The 78 most irreplaceable protected areas (sites or clusters) for the conservation of the world's amphibian, bird and mammal species. Protected areas (PAs) are sorted by country. The list is based on the 100 most irreplaceable protected areas for all species (tick in top 100 PAs for all species) and the 100 most irreplaceable protected areas for the subset of threatened species (tick in top 100 PAs for threatened species). Many of the selected areas are on both top 100 lists and, where any two or more of the selected protected areas were contiguous or within 50 km of each other, clusters were formed to include all the affected sites. **The possible options for World Heritage nomination in the last column are indicative only and do not take into account the protection, management and integrity requirements of the World Heritage Convention. It is recommended that anyone interested in following up with any of these options contact IUCN for further information at the earliest possible opportunity.**

No. on map	Country	Name of protected area (site or cluster; existing World Heritage sites in bold)	Area (km²)	Top 100 PAs for all species	Top 100 PAs for threatened species	World Heritage site	World Heritage criteria	Possible option for World Heritage nomination (indicative)
1	Australia	**Kakadu National Park**	19,239	✓	✓	✓	(i)(vi)(vii)(ix)(x)	
2	Australia	**Shark Bay, Western Australia**	22,100	✓	✓	✓	(vii)(viii)(ix)(x)	
3	Australia	**Wet Tropics of Queensland**	8,988	✓	✓	✓	(vii)(viii)(ix)(x)	
4	Bolivia	Apolobamba	4,881	✓	✓			Consider nomination
5	Bolivia	Carrasco	6,953	✓	✓			Consider nomination
6	Brazil	Alto Rio Negro	80,570	✓	-			Consider nomination
7	Brazil	**Atlantic Forest Southeast Reserves** / Serra do Mar Cluster	8,013	✓	-	✓	(vii)(ix)(x)	Consider serial extension
8	Brazil	Serra da Mantiqueira / Itatiaia Cluster	4,488	✓	-			Consider serial extension to Atlantic Forest Southeast Reserves World Heritage site
9	Brazil	Vale do Javari	85,904	✓	-			Consider nomination
10	Cameroon	Mont Cameroun	586	✓	✓			Consider nomination
11	China	Sanjiangyuan	303,608	✓	-			Consider nomination
12	China	**Sichuan Giant Panda Sanctuaries - Wolong, Mt Siguniang and Jiajin Mountains**	9,861	✓	-	✓	(x)	
13	China	**Three Parallel Rivers of Yunnan Protected Areas**	21,134	✓	-	✓	(vii)(viii)(ix)(x)	
14	China	Yaluzangbudaxiagu	9,003	✓	-			Consider nomination
15	Colombia	Chingaza	788	-	✓			Consider nomination
16	Colombia	Los Farallones De Cali	2,079	-	✓			Consider nomination
17	Colombia	Páramo Urrao	301	✓	-			Consider nomination

Table 4.1, cont'd.

No. on map	Country	Name of protected area (site or cluster) (existing World Heritage sites in bold)	Area (km²)	Top 100 PAs for all species	Top 100 PAs for threatened species	World Heritage site	World Heritage criteria	Possible option for World Heritage nomination (indicative)
18	Colombia	Sierra Nevada de Santa Marta	4,050	✓	✓			Consider nomination
19	Côte D'Ivoire	**Taï National Park**	4,363	✓	✓	✓	(vii)(x)	
20	Cuba	**Alejandro de Humboldt National Park** / Cuchillas del Toa Cluster	2,073	✓	✓	✓	(ix)(x)	Consider extension
21	Cuba	Ciénaga de Zapata	6,503	✓	✓			Consider nomination
22	Cuba	La Bayamesa	243	-	✓			Consider nomination
23	Democratic Republic of the Congo	Upemba	13,527	✓	-			Consider nomination
24	Ecuador	Cayambe-Coca / Sumaco Napo Galeras Cluster	5,687	✓	✓			Consider nomination
25	Ecuador	**Galápagos Islands**	146,752	✓	✓	✓	(vii)(viii)(ix)(x)	
26	Ecuador	Podocarpus	1,473	-	✓			Consider nomination
27	Ethiopia	Bale Mountains / Arsi Cluster	25,090	✓	✓			Consider nomination
28	Guadeloupe (France)	Parc National de la Guadeloupe	2,256	✓	✓			Consider nomination
29	Guatemala	Sierra de las Minas	2,457	✓	✓			Consider nomination
30	Honduras	Cusuco	178	-	✓			Consider nomination
31	Honduras	Pico Bonito	562	✓	✓			Consider nomination
32	India	**Western Ghats** / Anamalai Cluster	9,358	✓	✓	✓	(ix)(x)	Consider extension
33	Indonesia	Karakelang Utara dan Selatan	397	-	✓			Consider nomination
34	Indonesia	Lore Lindu	2,339	✓	-			Consider nomination
35	Indonesia	**Lorentz National Park** / Foja / Jayawijaya Cluster	49,356	✓	✓	✓	(viii)(ix)(x)	Consider serial extension
36	Indonesia	Manusela	2,353	✓	✓			Consider nomination
37	Indonesia	Pulau Yapen Tengah	780	✓	-			Consider nomination
38	Indonesia	Siberut	1,950	✓	✓			Consider nomination
39	Indonesia	**Tropical Rainforest Heritage of Sumatra** / The Leuser Ecosystem Cluster	45,571	✓	✓	✓	(vii)(ix)(x)	Consider extension
40	Indonesia	Wondiwoi	977	✓	-			Consider nomination
41	Jamaica	Blue and John Crow Mountains	536	✓	✓			Consider nomination (re-nomination pending)
42	Madagascar	Isalo	871	✓	✓			Consider nomination
43	Madagascar	**Rainforests of the Atsinanana**	4,811	✓	✓	✓	(ix)(x)	
44	Madagascar	**Tsingy de Bemaraha Strict Nature Reserve**	1,575	-	✓	✓	(vii)(x)	
45	Malawi	Mulanje	585	-	✓			Consider nomination
46	Malaysia	**Gunung Mulu National Park**	555	-	✓	✓	(vii)(viii)(ix)(x)	
47	Malaysia	**Kinabalu Park**	770	✓	✓	✓	(ix)(x)	
48	Martinique (France)	Martinique	647	-	✓			Consider nomination
49	Mexico	Archipiélago de Revillagigedo	6,412	-	✓			Consider nomination
50	Mexico	Cañón de Río Blanco	491	-	✓			Consider nomination
51	Mexico	**Islands and Protected Areas of the Gulf of California**	23,196	✓	✓	✓	(vii)(ix)(x)	
52	Mexico	Los Tuxtlas	1,557	✓	✓			Consider nomination
53	New Zealand	**New Zealand Sub-Antarctic Islands**	14,722	✓	✓	✓	(ix)(x)	
54	New Zealand	**Te Wahipounamu – South West New Zealand**	25,139	-	✓	✓	(vii)(viii)(ix)(x)	

Table 4.1, cont'd.

No. on map	Country	Name of protected area (site or cluster) (existing World Heritage sites in bold)	Area (km²)	Top 100 PAs for all species	Top 100 PAs for threatened species	World Heritage site	World Heritage criteria	Possible option for World Heritage nomination (indicative)
55	Nicaragua	Sureste de Nicaragua	18,426	✓	-			Consider nomination
56	Panama	**Darien National Park**	6,121	✓	✓	✓	(vii)(ix)(x)	
57	Panama; Costa Rica	**Talamanca Range-La Amistad Reserves / La Amistad National Park** / Tapantí-Macizo Cerro la Muerte / Escudo de Veraguas / Palo Seco Cluster	7,112	✓	✓	✓	(vii)(viii)(ix)(x)	Consider (serial) extension
58	Peru	Alto Mayo	1,787	✓	-			Consider nomination
59	Peru	El Sira	6,208	✓	✓			Consider serial nomination with 61
60	Peru	**Manú National Park**	17,051	✓	-	✓	(ix)(x)	
61	Peru	Yanachaga-Chemillén	1,114	✓	-			Consider serial nomination with 59
62	Philippines	Mounts Banahaw – San Cristobal	114	✓	✓			Consider nomination
63	Philippines	**Puerto-Princesa Subterranean River National Park** / Palawan Cluster	11,849	✓	✓	✓	(vii)(x)	Consider (serial) extension
64	South Africa	**Cape Floral Region Protected Areas**	5,601	✓	-	✓	(ix)(x)	
65	Sri Lanka	**Central Highlands of Sri Lanka**	537	✓	✓	✓	(ix)(x)	
66	Sri Lanka	Kanneliya	62	-	✓			Consider serial extension to Sinharaja Forest Reserve World Heritage site
67	Tanzania	Milindo	86	-	✓			Consider serial nomination with 68 and 69
68	Tanzania	Nguru South	198	-	✓			Consider serial nomination with 67 and 69
69	Tanzania	West Kilombero Scarp / Udzungwa Mountains Cluster	2,975	-	✓			Consider serial nomination with 67 and 68
70	United Kingdom	**Gough and Inaccessible Islands**	3,918	-	✓	✓	(vii)(x)	
71	United Kingdom	**Henderson Island**	41	-	✓	✓	(vii)(x)	
72	United States	**Papahānaumokuākea**	386,697	-	✓	✓	(iii)(vi)(viii) (ix)(x)	
73	Venezuela	**Canaima National Park** / Imataca / San Pedro / Sur del Estado Bolívar / El Caura / Alto Orinoco-Casiquiare / Formaciones de Tepuyes Cluster	219,405	✓	✓	✓	(vii)(viii)(ix)(x)	Consider (serial) extension
74	Venezuela	Henri Pittier	882	✓	-			Consider serial nomination with 75 and 76
75	Venezuela	Macizo Montañoso del Turimiquire	4,518	✓	✓			Consider serial nomination with 74 and 76
76	Venezuela	Península de Paria	589	✓	-			Consider serial nomination with 74 and 75
77	Venezuela	Río Capaz / Sureste del Lago de Maracaibo Sto. Domingo-Motatán Guaramacal Cluster	9,236	✓	✓			Consider nomination
78	Yemen	**Socotra Archipelago**	4,108	✓	✓	✓	(x)	

of these options contact IUCN for further information at the earliest possible opportunity.

Existing biodiversity WH sites

Existing biodiversity WH sites represent, fully or partially, 30 (38%) of the 78 most irreplaceable sites and clusters. All the 30 biodiversity WH sites on the final list are inscribed under criterion (x), and 23 (77%) of the 30 sites are also inscribed under criterion (ix). **This suggests that the species irreplaceability analysis is a good initial measure to recommend possible candidate sites under the biodiversity criteria, in particular criterion (x), of the WH Convention**.

The most irreplaceable biodiversity WH sites identified in the analysis are shown in Table 4.2: Canaima National Park (Venezuela) is the most irreplaceable WH site for all amphibian, bird and mammal species, while the Western Ghats (India) are the most irreplaceable WH site for threatened amphibian, bird and mammal species. However, the analysis identified several other protected areas that are contiguous or close to existing biodiversity WH sites, including Canaima National Park and the Western Ghats, which could potentially be considered for extension.

Existing biodiversity WH sites that may merit extension

The irreplaceability analysis suggests that the following biodiversity WH sites could potentially be considered for extension, including through serial approaches, to better reflect the exceptional species values in the larger area surrounding them (numbers refer to Figure 4.1 and Table 4.1):

- Atlantic Forest Southeast Reserves, Brazil (7) – also potential serial extension with the separate Serra da Mantiqueira / Itatiaia Cluster (8);
- Alejandro de Humboldt National Park, Cuba (20);
- Western Ghats, India (32);
- Lorentz National Park, Indonesia (35);
- Tropical Rainforest Heritage of Sumatra, Indonesia (39);
- Talamanca Range-La Amistad Reserves / La Amistad National Park, Panama and Costa Rica (57);
- Puerto-Princesa Subterranean River National Park, Philippines (63) – the existing site covers less than 1% of the total area of the globally outstanding Palawan Game Refuge and Bird Sanctuary that covers the whole of Palawan Island;
- Sinharaja Forest Reserve, Sri Lanka (itself not on the list of the most irreplaceable protected areas) – potential serial extension with the Kanneliya Forest Reserve (66); and

Table 4.2 The most irreplaceable natural and mixed World Heritage sites currently included on the World Heritage List. These sites are all inscribed under biodiversity criteria. Sites are sorted by irreplaceability score for all species. The irreplaceability rank indicates the relative importance of a site (based on its irreplaceability score) among the 173,461 protected areas analysed. The table shows all natural and mixed World Heritage sites that are among the 10 most irreplaceable protected areas for all species or all threatened species analysed (see Annex 1 for corresponding information for all biodiversity World Heritage sites).

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Venezuela	Canaima National Park	(vii)(viii)(ix)(x)	29,019	41.16	8.33	3	16
Australia	Wet Tropics of Queensland	(vii)(viii)(ix)(x)	8,988	32.49	10.51	6	8
Panama; Costa Rica	Talamanca Range-La Amistad Reserves / La Amistad National Park	(vii)(viii)(ix)(x)	4,073	29.21	8.93	7	14
Ecuador	Galápagos Islands	(vii)(viii)(ix)(x)	146,679	24.39	11.02	15	5
India	Western Ghats	(ix)(x)	8,165	24.03	14.58	17	2
Madagascar	Rainforests of the Atsinanana	(ix)(x)	4,811	20.18	10.58	20	7
Mexico	Islands and Protected Areas of the Gulf of California	(vii)(ix)(x)	22,834	13.17	12.04	28	4

- Canaima National Park, Venezuela (73) – the larger cluster includes several globally outstanding protected areas that could be considered for extension.

Potential candidate sites for new biodiversity nominations

The list of the 78 most irreplaceable protected areas includes 48 sites and clusters that are not yet covered by existing biodiversity WH sites (see Table 4.1). Two of these could be considered for serial extension of existing biodiversity WH sites (see above): the Serra da Mantiqueira / Itatiaia Cluster in Brazil (8) and the Kanneliya Forest Reserve in Sri Lanka (66).

The remaining 46 sites and clusters could be considered potential candidate sites for new biodiversity nominations. A number of these have previously been noted in WH studies and/or already been considered for WH nomination. The IUCN CNPPA (1982) inventory of the world's greatest natural areas included, for example, the national parks of Mount Cameroon (Cameroon; 10), Sierra Nevada de Santa Marta (Colombia; 18), Siberut Island (Indonesia; 38) and Henri Pittier (Venezuela; 74). A more recent assessment of possible biodiversity priorities for the WH List in Africa identified the Bale Mountains National Park in Ethiopia (27) and the Eastern Arc mountain forests in Tanzania (67–69) as potential candidate sites (Bertzky and Kenney 2011). Two of the three sites in Tanzania, the Nguru South Forest Reserve (68) and West Kilombero Scarp / Udzungwa Mountains cluster (69), were already part of a nomination for the Eastern Arc mountain forests, but the nomination was withdrawn by the State Party in 2011 before it could be evaluated. A mixed nomination for the Blue and John Crow Mountains National Park in Jamaica (41) was deferred by the WH Committee in 2011 to allow the State Party to consider options for a revised natural nomination.

The list of potential candidate sites in Table 4.1 is indicative only and could change if additional protected areas or other species groups were included. Key limitations of the methodology and datasets are highlighted in Sections 2.3 and 2.4. **Above all it should be stressed again that the irreplaceability analysis did not take into account the stringent protection, management and integrity requirements of the WH Convention.**

Finally, as noted in Section 2.4.3, serial approaches should be considered wherever several candidate sites represent the same ecoregion or ecosystem type. A rapid screening of the sites and clusters suggests that this applies to the two sites in Peru (59 and 61), which could even be considered as potential serial extensions to Manú National Park (60), the three sites in the Eastern Arc mountain forests of Tanzania (67–69) and the three sites in the coastal mountain forests of Venezuela (74–76) (see also Section 4.5).

4.3 Protected Alliance for Zero Extinction sites with potentially outstanding biodiversity values

Alliance for Zero Extinction sites (AZEs) are the basis for the second approach used here to identify potential candidate sites for the WH List. As explained above, AZEs hold ≥95% of the global population of Critically Endangered or Endangered animal or plant species, and they are thus the highest priority subset of Key Biodiversity Areas (Ricketts *et al.* 2005). In short, they are the last known places where highly threatened species survive, but at present only 22% of all AZEs are completely covered by protected areas (Butchart *et al.* 2012). Terrestrial AZE sites have been identified globally for mammals, birds, amphibians, selected reptile clades (Crocodylia, Iguanidae and Testudines) and conifers (Butchart *et al.* 2012).

The rapid screening applied here identifies the most irreplaceable AZEs that are protected but not yet covered by biodiversity WH sites. As noted in Section 3.2.3, 65 (11%) of the 587 AZEs identified so far fall within 36 (23%) of the 156 biodiversity WH sites. With one exception (Mount Kenya National Park/Natural Forest), all biodiversity WH sites that contain AZEs are inscribed under (x), the most appropriate WH criterion for the recognition of AZEs. Section 3.2.3 also noted that there are no AZEs in any of the non-biodiversity WH sites.

AZEs can thus be used to identify potential candidate sites especially under criterion (x). From a WH perspective, it is important to understand that AZEs are of critical importance for the survival of their trigger species, and many of the 587 AZEs identified so far are 'triggered' not only by one but several highly threatened species. In addition, most AZEs also support other threatened and/or endemic species. The number of trigger species can be used as a simple indicator of the importance of each site. Here only AZEs with five or more trigger species that are at least half covered by designated protected areas were considered as potential candidate sites for the WH List in the next 5–10 years.

This rapid screening found nine protected AZEs with five or more trigger species (Table 4.3). They are all located in the Americas and Africa, with two sites each in Cuba, Tanzania and Venezuela. Several of these sites (or their corresponding protected areas) also feature highly in the species irreplaceability analyses (see Section 4.2): e.g. the Sierra Nevada de Santa Marta in Colombia, Ciénaga de Zapata in Cuba, Bale Mountains in Ethiopia, Los Tuxtlas in Mexico and Udzungwa Mountains in Tanzania. Both the Udzungwa and Uluguru Mountains in Tanzania were part of the nomination for the Eastern Arc mountain forests that was withdrawn by the State Party in 2011 before it could be evaluated.

However, the list of potential candidate sites in Table 4.3 is indicative only and would change if one were to extend the taxonomic coverage of the AZE approach to include more species groups, or apply different thresholds for trigger species and protected area coverage.

4.4 Non-biodiversity World Heritage sites with potentially outstanding biodiversity values

The third approach to identifying potential candidate sites targets existing WH sites. Of the 217 natural and mixed WH sites, 61 have not been inscribed under the biodiversity criteria (ix) and (x) (see Annex 2). This is either because the State Party did not nominate the site under these criteria, or the WH Committee did not consider the nominated site to be of Outstanding Universal Value under these criteria and the corresponding integrity conditions (e.g. the site was too small).

However, since a number of these sites are located in areas known to be important for biodiversity (see Section 3.2.3 and Foster *et al.* 2010), the 61 sites were rapidly screened against the results from the species irreplaceability analysis (see Section 4.2) in order to identify potential candidates for recognition of biodiversity values. Cultural WH sites and especially the subset of cultural landscapes – which are specifically recognized for the interaction between humankind and its natural environment – may also include potentially important biodiversity values but were not included in the irreplaceability analysis because there is no global dataset with their site boundaries.

Table 4.3 Protected Alliance for Zero Extinction sites (AZEs) with five or more trigger species that are not covered by biodiversity World Heritage sites. AZEs are here considered 'protected' if ≥50% of their area is covered by designated protected areas in the World Database on Protected Areas.

Country	Alliance for Zero Extinction site	Area (km²)	Protected area coverage	Trigger species
Colombia	Sierra Nevada de Santa Marta National Natural Park and surrounding areas	5,098	88%	12
Venezuela	Sierra La Culata and Sierra Nevada National Parks and surrounding areas	5,291	60%	9
Mexico	Los Tuxtlas	1,559	99%	8
Cuba	Ciénaga de Zapata	5,319	97%	5
Cuba	Turquino-Bayamesa	486	95%	5
Ethiopia	Bale Mountains	1,579	100%	5
Tanzania	Udzungwa Mountains	3,354	97%	5
Tanzania	Uluguru Mountains	305	96%	5
Venezuela	Cordillera de Caripe	4,801	100%	5

Table 4.4 The most irreplaceable natural and mixed World Heritage sites that are not yet recognized under biodiversity criteria. Sites are sorted by irreplaceability score for all species. The irreplaceability rank indicates the relative importance of a site (based on its irreplaceability score) among the 173,461 protected areas analysed. The table shows all non-biodiversity World Heritage sites that are among the 1,000 most irreplaceable protected areas for all species or all threatened species analysed (see Annex 2 for corresponding information for all non-biodiversity World Heritage sites).

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Tanzania	Kilimanjaro National Park	(vii)	755	3.06	1.01	197	314
Peru	Huascarán National Park	(vii)(viii)	3,418	1.34	0.67	458	459
Vietnam	Phong Nha-Ke Bang National Park	(viii)	904	1.27	0.03	487	1,245
United States	Yosemite National Park	(vii)(viii)	3,030	0.68	0.38	808	549
United States	Hawaii Volcanoes National Park	(viii)	848	0.34	0.32	993	579
Cuba	Desembarco del Granma National Park	(vii)(viii)	327	0.28	0.25	1,072	607
Belarus; Poland	Belovezhskaya Pushcha / Bialowieza Forest	(vii)	926	0.07	0.07	2,027	896

Table 4.4 shows the most irreplaceable natural and mixed WH sites that are not yet recognized under biodiversity criteria. According to the irreplaceability analysis, these sites are among the world's 1,000 most irreplaceable protected areas for all species analysed and/or the subset of all threatened species analysed. Kilimanjaro National Park was already highlighted in Section 3.2.3 as one of only two non-biodiversity WH sites that are recognized as non-avian Key Biodiversity Area. Moreover, all the sites in Table 4.4 are recognized as Important Bird Areas (IBAs), except of the two sites in the United States where information on IBAs was missing in the global dataset.

These results suggest that the seven sites shown in Table 4.4 could be considered, or reconsidered, under biodiversity criteria to improve the coverage of globally significant biodiversity values on the WH List. Since these sites are already inscribed on the WH List for other, non-biodiversity values, they are 'low hanging fruit' for a more credible WH List with regard to biodiversity values. However, it should be noted that several of these sites have been previously nominated under biodiversity criteria without success. Normally this would preclude them from being re-nominated under the same criteria except in exceptional circumstances such as new discoveries or new scientific information on the sites (§158 of the Operational Guidelines). The irreplaceability analysis presented here could potentially provide a basis for revisiting the previous decisions on these sites.

However, if a State Party wanted to consider re-nominating any of these sites under biodiversity criteria, a global comparative analysis would still be required, demonstrating the site's relative importance compared with relevant biodiversity WH sites and other protected areas. This analysis should seek to specifically address the issues raised in previous WH Committee decisions concerning the biodiversity values of the site. Consideration would also have to be given to the site's potential to meet the protection, management and integrity requirements. For example, a re-nomination of Phong Nha-Ke Bang National Park under criterion (x) was referred by the WH Committee in 2011 to allow the State Party to address integrity, protection and management issues affecting the property.

4.5 How the identified candidate sites can help fill broad gaps

This study has identified a number of protected areas, protected Alliance for Zero Extinction sites and non-biodiversity WH sites as candidate sites for nomination (or re-nomination) under the biodiversity criteria (see Sections 4.2, 4.3 and 4.4.). This section briefly reviews the potential of these candidate sites to help fill broad gaps in the coverage of global biodiversity conservation priorities, focusing on biodiversity hotspots and Global 200 terrestrial priority ecoregions which are not yet represented in biodiversity WH sites (see Sections 3.2.2.1 and 3.2.2.2).

Although not specifically selected to fill broad gaps, the candidate sites identified in this study fall into one of the four hotspots and 11 of the 46 Global 200 ecoregions that are not currently recognized on the WH List (Table 4.5). Inscription of the Cañón de Río Blanco National Park (Mexico) under biodiversity criteria would add the Madrean Pine-Oak Woodlands hotspot to the WH List (Table 4.5 and Figure 4.2). Recognition of three non-biodiversity WH sites – Hawaii Volcanoes National Park (United States), Yosemite National Park (United States) and Phong-Nha-Ke Bang National Park (Vietnam) – under biodiversity criteria would add four Global 200 ecoregions to the WH List (Table 4.5 and Figure 4.3). An additional seven Global 200 ecoregions could be represented by other candidate sites or clusters.

Where several candidate sites or clusters fall into the same broad gap, a serial approach should be considered. This applies especially to the candidate sites in the Coastal Venezuela Montane Forests and the Eastern Arc Montane Forests (Tanzania).

However, even if all the candidate sites or clusters identified in this study were inscribed under biodiversity criteria, there would still be three biodiversity hotspots and 35 Global 200 terrestrial priority ecoregions without a biodiversity WH site (Figures 4.2 and 4.3).

4.6 Concluding remarks on site selection and suggestions for follow up

The key requirement of the WH Convention is that properties can only be inscribed on the WH List if they are of Outstanding Universal Value (OUV). In order to improve its credibility and standing, **the WH Convention needs to continue to maintain the highest standards in identifying and conserving outstanding natural heritage sites**, particularly with regard to biodiversity values, given the environmental challenges facing the 21st century and the importance of conserving functioning ecosystems for future generations.

The species irreplaceability analysis used here suggests that many of the 156 existing biodiversity WH sites are indeed among the world's most outstanding places for the conservation of species-level biodiversity (see irreplaceability ranks in Annex 1). It also demonstrates that analyses using global datasets such as the IUCN / UNEP-WCMC World Database on Protected Areas and the IUCN Red List of Threatened Species can help identify protected areas with potentially outstanding biodiversity values that may merit WH listing.

Table 4.5 Candidate sites and clusters that fall into biodiversity hotspots or Global 200 terrestrial priority ecoregions which are not yet represented in biodiversity World Heritage sites. Inscription of these sites or clusters under biodiversity criteria would ensure representation of one of the four hotspots (Madrean Pine-Oak Woodlands) and 11 of the 46 Global 200 ecoregions that are not currently recognized on the World Heritage List.

Broad gap	Name of candidate site or cluster (existing World Heritage sites in bold)	Country	Type of candidate site or cluster	Size (km^2)
Biodiversity hotspot				
Madrean Pine-Oak Woodlands	Cañón de Río Blanco	Mexico	Irreplaceable protected area	491
Global 200 terrestrial priority ecoregion				
Annamite Range Moist Forests	**Phong Nha-Ke Bang National Park**	Vietnam	Non-biodiversity World Heritage site	904
Cameroon Highlands Forests	Mont Cameroun	Cameroon	Irreplaceable protected area	586
Coastal Venezuela Montane Forests	Henri Pittier	Venezuela	Irreplaceable protected area	882
	Macizo Montañoso del Turimiquire	Venezuela	Irreplaceable protected area	4,518
	Península de Paria	Venezuela	Irreplaceable protected area	589
	Cordillera de Caripe	Venezuela	Protected AZE site	4,801
Eastern Arc Montane Forests	Milindo	Tanzania	Irreplaceable protected area	86
	Nguru South	Tanzania	Irreplaceable protected area	198
	West Kilombero Scarp / Udzungwa Mountains Cluster	Tanzania	Irreplaceable protected area	2,975
	Udzungwa Mountains	Tanzania	Protected AZE site	3,354
	Uluguru Mountains	Tanzania	Protected AZE site	305
Eastern Himalayan Broadleaf and Conifer Forests	Yaluzangbudaxiagu	China	Irreplaceable protected area	9,003
Hawaii Dry Forest	**Hawaii Volcanoes National Park**	United States	Non-biodiversity World Heritage site	848
Hawaii Moist Forest				
Moluccas Moist Forests	Manusela	Indonesia	Irreplaceable protected area	2,353
Philippines Moist Forests	Mounts Banahaw – San Cristobal	Philippines	Irreplaceable protected area	114
Sierra Nevada Coniferous Forests	**Yosemite National Park**	United States	Non-biodiversity World Heritage site	3,030
Sulawesi Moist Forests	Karakelang Utara dan Selatan	Indonesia	Irreplaceable protected area	397
	Lore Lindu	Indonesia	Irreplaceable protected area	2,339

Future studies will be able to use improved data (e.g. an updated and expanded version of the IUCN Red List of Threatened Species) and/or new approaches and datasets, such as the forthcoming IUCN Red List of Threatened Ecosystems, to further refine and expand the list of potential candidate sites presented here. Equally, further analysis is needed to identify the potential for WH sites in areas that are not currently protected, but hold globally significant biodiversity values. This could potentially be achieved by expanding the irreplaceability analysis presented here to cover all land areas, protected or not (see for example the analysis for forest-dependent birds by Buchanan *et al.* 2011).

However, the essential caveat and caution of this study is that the list of potential candidate sites included here is only indicative and not exhaustive, and that inclusion of any site on the list is without prejudice to the success of any nomination that could be forward and does not guarantee its future inclusion on the WH List (see also Section 2.4). This is because of the limitations of the methodology and datasets used (see Section 2.4.1) and because this study does not indicate whether or not a site meets the stringent protection, management and integrity requirements of the WH Convention (see Section 2.4.2). **For these reasons any reader considering this study as a basis for developing a WH nomination is advised to contact IUCN at the earliest possible opportunity to seek more detailed advice and guidance as early as possible and well before a nomination is submitted ('upstream advice').**

A key issue to also consider is the degree of coverage within global-scale conservation priorities that are already represented on the WH List. In this regard there is a need for further work,

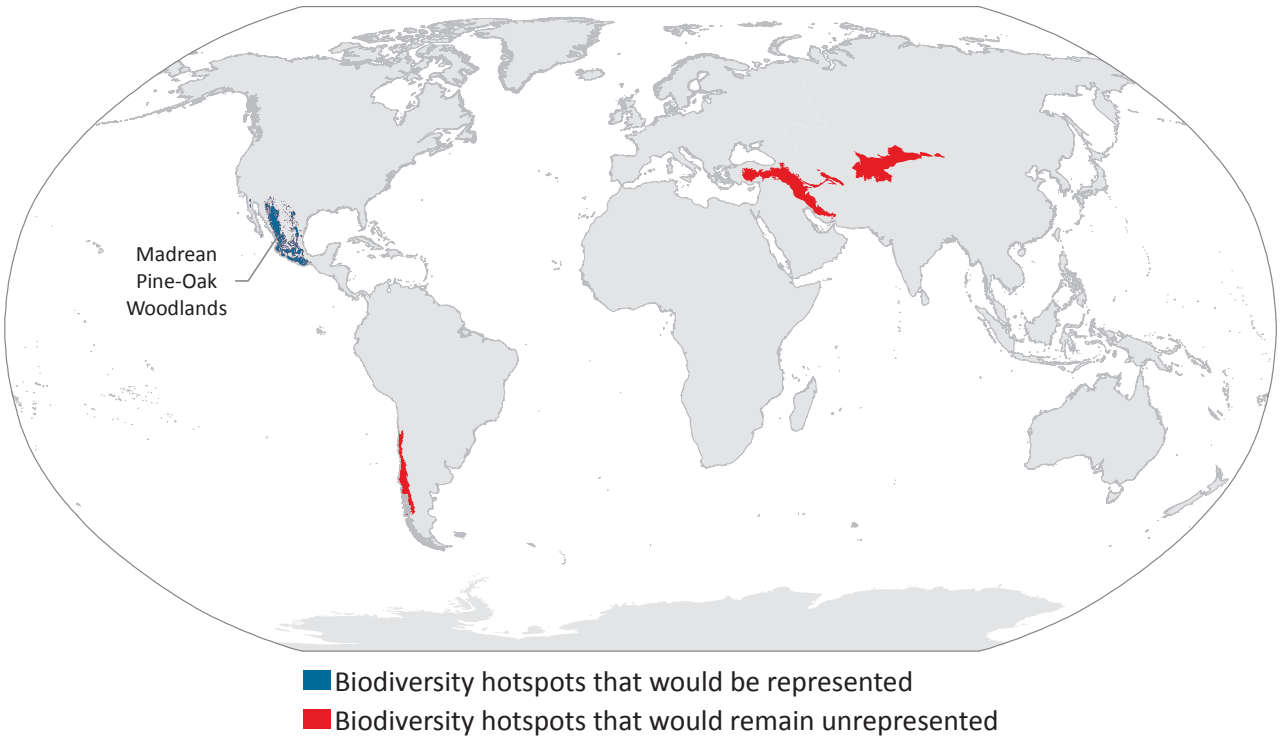


Figure 4.2 Map showing the four biodiversity hotspots without biodiversity World Heritage sites (see Figure 3.7 for all biodiversity hotspots). The Madrean Pine-Oak Woodlands hotspot (blue, labelled) could potentially be represented on the World Heritage List through inscription of the Cañón de Río Blanco National Park in Mexico under biodiversity criteria. However, the remaining hotspots without biodiversity sites (red) do not overlap with any of the candidate sites identified in this study.

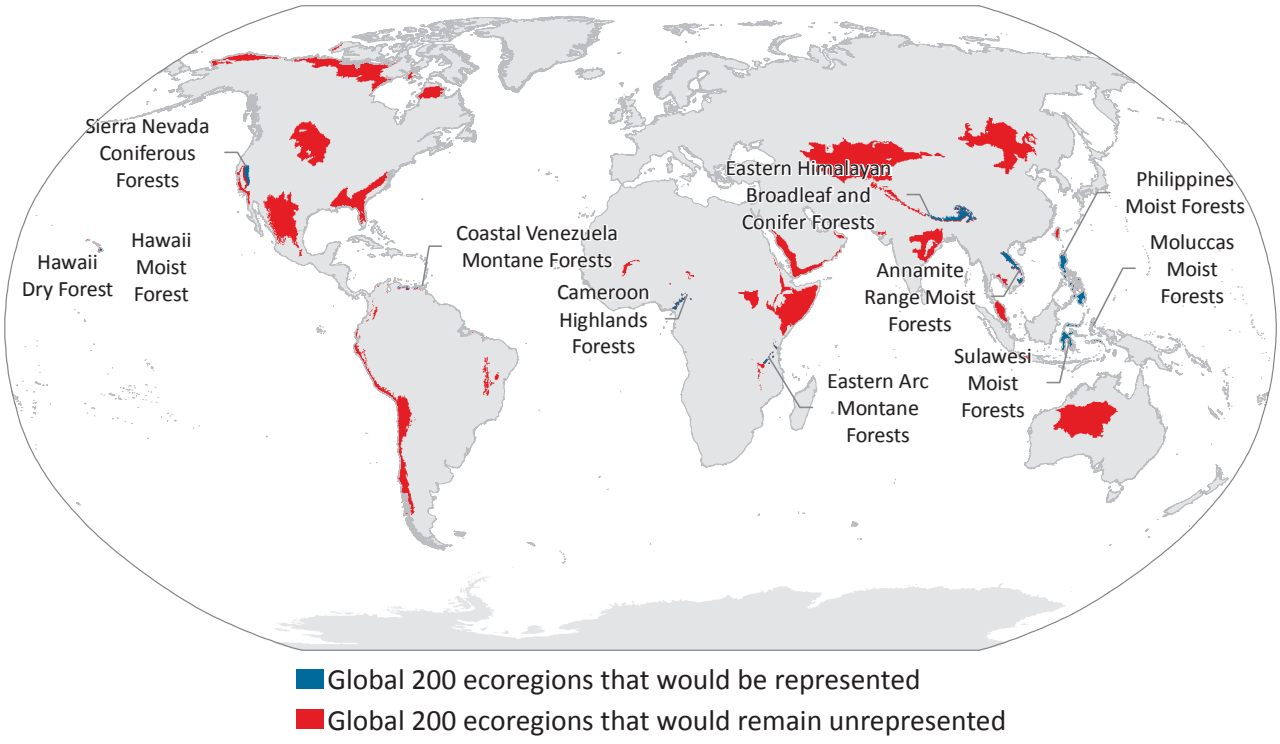


Figure 4.3 Map showing the 46 Global 200 terrestrial priority ecoregions without biodiversity World Heritage sites (see Figure 3.8 for all Global 200 terrestrial priority ecoregions). Inscription of the candidate sites or clusters identified in this study under biodiversity criteria would ensure representation of 11 of the 46 Global 200 ecoregions on the World Heritage List (blue, labelled). However, the remaining Global 200 ecoregions without biodiversity sites (red) do not overlap with any of the candidate sites identified in this study.

which is likely only feasible at the regional level, to consider possibilities for the recognition of multiple globally-important sites on the WH List, preferably via listing as serial sites (see also Section 2.4.3). Such work should also consider the potential to extend and reconfigure existing WH sites to better represent outstanding biodiversity values, and to better protect them in relation to threats, including that from climate change. This includes, where appropriate, formal recognition by the WH Committee of extensions and reconfigurations that may have occurred at national level after the inscription of a protected area on the WH List. Moreover, a focus on transboundary / transnational WH sites should also be a priority, considering the need for international cooperation in the protection of many priority areas for biodiversity that stretch across political boundaries.

This study provides a useful basis for a second phase of regional initiatives, ideally in the form of workshops, led by regional biodiversity conservation experts, and involving States Parties and other relevant stakeholders. To overcome the inherent limitations of this global study, complementary regional WH studies and programmes of support are needed to refine and follow up the findings of this study, and to provide more detailed guidance for specific regions. Translation of this global study into relevant languages should be considered to facilitate this process.

The assessment of possible biodiversity priorities for the WH List in Africa (Bertzky and Kenney 2011) provides a recent example of such a regional study and programme of support in the form of an effective partnership to support States Parties in preparing nominations, organized in partnership and led by the African World Heritage Fund. Future regional studies should also make use of regional datasets on species, ecosystems and ecological and/or biological processes, and consider possible extensions, serial and transboundary / transnational sites.

Based on the results of this global study, a priority region for follow up would be Latin America, which has over half of the potential candidate sites identified in this study. However, regional initiatives are needed across many regions, and should integrate consideration of terrestrial, freshwater and marine sites. The Pacific and Arctic are examples of regions that support important terrestrial and marine biodiversity values that do not yet appear to be adequately recognized on the WH List. A global study for freshwater biodiversity may also be needed to complement the terrestrial and marine studies, and provide guidance for regional initiatives.

The next chapter outlines the process for inscribing sites on the WH List and provides basic information and guidance for anybody considering nominations.

5. Process for inscribing sites on the World Heritage List

5.1 Nomination process

Only States Parties to the WH Convention can submit nominations for properties on their territory to be considered for inclusion on the WH List. However, other stakeholders such as NGOs and researchers often play a key role in initiating and supporting the nomination process, and their support can be critical for the success of nominations.

Before a property can be nominated, it must be included on the State Party's Tentative List, an inventory of important properties that the country might consider for nomination in the near future. Once a State Party wishes to nominate a property from its Tentative List, it must prepare a nomination file following the standard format available on the webpage of the WH Centre. The process of preparing a nomination file can take several years and should involve all relevant stakeholders, including local communities within and surrounding the site. Once completed, the nomination file is submitted to the WH Centre, from where it is sent to the appropriate Advisory Bodies for their evaluation.

A detailed timetable of the process is included in the Operational Guidelines (§168). In short, nominations may be submitted to the WH Centre at any time during the year, but only 'complete' nominations that are received by February 1st are sent to the Advisory Bodies and considered by the WH Committee during the following year.

However, before States Parties begin to prepare a full nomination file, the Operational Guidelines (§122) recommend carrying out some preparatory work to establish that a property has the potential to justify Outstanding Universal Value, including the integrity, protection and management requirements:

> "Such preparatory work might include collection of available information on the property, thematic studies, scoping studies of the potential for demonstrating Outstanding Universal Value, including integrity or authenticity, or an initial comparative study of the property in its wider global or regional context, including an analysis in the context of the Gap Studies produced by the Advisory Bodies. Such work will help to establish the feasibility of a possible nomination at an early stage and avoid use of resources on nominations that may be unlikely to succeed. States Parties are invited to contact the Advisory Bodies and the World Heritage Centre at the earliest opportunity in considering nominations to seek information and guidance."

There is increasing support available, including a range of publications, to ensure early advice and planning for possible WH nominations (see Box 5.1 and Section 5.4). Eligible States Parties can request financial support for the preparation of

Box 5.1 World Heritage Resource Manual: "Preparing World Heritage Nominations"

This manual, published by the UNESCO World Heritage Centre in collaboration with the Advisory Bodies IUCN and ICOMOS, provides guidance on preparing nominations to the World Heritage List for natural, cultural and mixed properties. It complements the text of the Operational Guidelines to the Convention and will be regularly updated to reflect revisions of the Operational Guidelines.

The manual illustrates and interprets key World Heritage concepts, includes a detailed overview of the nomination and evaluation process, and provides detailed guidance on the different steps involved in the preparation of nominations. It covers a wide range of topics such as setting up an expert team, compiling relevant information, participation of local people and other stakeholders, defining the potential Outstanding Universal Value and boundaries of a property, and writing the nomination file.

Together with the Operational Guidelines, the manual thus represents a key resource for the preparation of successful nominations. The latest edition is available on the webpage of the UNESCO World Heritage Centre:
http://whc.unesco.org/en/resourcemanuals

Tentative Lists and nominations from the World Heritage Fund ("International Assistance") and a range of other donors. Technical support for the preparation of nominations, including the comparative analysis required (see Section 5.2), is available from WH experts in the IUCN World Commission on Protected Areas (WCPA) for example. IUCN's World Heritage Programme and UNESCO's World Heritage Centre are able to provide sources of advice for those considering nominations.

5.2 Comparative analysis

One of the key requirements in the preparation of a nomination is a so-called 'comparative analysis'. The purpose of this analysis is to demonstrate the importance of a property in its national and international context and, in the case of serial properties, the justification for the selection of its component parts (§132 and Annex 5 of the Operational Guidelines).

The analysis should compare the property under all relevant WH criteria to similar properties, whether on the WH List or not, both at national and international levels. It should outline the similarities the property shares with other comparable properties and the reasons that make the property stand out globally. The analysis should also make reference to relevant thematic studies and gap analyses produced by the Advisory Bodies. It is important to understand that even properties identified as potential priorities in any thematic studies or gap analyses still require a detailed comparative analysis as part of the nomination process.

As noted in the Operational Guidelines (§122), it is advisable to carry out an initial comparative analysis in advance of preparing a full nomination file, which can help to establish the feasibility of a possible nomination at an early stage. IUCN's World Heritage Programme, in cooperation with UNEP-WCMC, can provide advice on and input to such an analysis if requested.

Key resources for the preparation of comparative analyses for natural properties include (see also the references in the World Heritage Resource Manual featured in Box 5.1):

1. Thematic studies and gap analyses prepared by IUCN and UNEP-WCMC (available from the IUCN and UNEP-WCMC webpages; see also Annex 3).
2. Comparative analyses included in nominations and evaluations of other relevant properties (available from the UNESCO World Heritage webpage).
3. The IUCN / UNEP-WCMC World Database on Protected Areas, available at www.protectedplanet.net, which can be used to identify comparable properties.
4. The IUCN Red List of Threatened Species, available at www.iucnredlist.org. This can be used to assess the importance of properties for the conservation of globally threatened species.
5. The IUCN Red List of Threatened Ecosystems, currently under development (see www.iucnredlistofecosystems.org). This can in the future be used to assess the importance of properties for the conservation of globally threatened ecosystems.
6. Global biogeographic classification schemes and biodiversity prioritization schemes such as those used in the present analysis (see Sections 3.1 and 3.2).
7. Other scientific assessments, especially peer reviewed publications, which can assist in defining how unique, or not, a property is at the global level.

5.3 Evaluation process

The Advisory Bodies evaluate whether or not nominated properties have Outstanding Universal Value, meet the conditions of integrity and/or authenticity, and meet the requirements of protection and management (§143 and Annex 6 of the Operational Guidelines).

Each 'complete' nomination is independently evaluated by the Advisory Bodies – IUCN for natural properties and ICOMOS for cultural properties. IUCN and ICOMOS work together for the evaluation of mixed (natural and cultural) properties. The evaluation process is carried out over the period of one year, from the receipt of nominations in March to the submission of the evaluations to the WH Centre in May of the following year. The evaluations are then reviewed by the WH Committee at its annual meeting in June or July. The Committee decides which properties to inscribe on the WH List. It can also defer or refer a nomination back to the State Party for further work or reject a nomination.

The main elements of the IUCN evaluation process are illustrated in Figure 5.1. The rigorous process is managed by IUCN's World Heritage Programme and involves a field mission and external reviews for each nomination. In addition, for nominations under biodiversity criteria, IUCN usually works with UNEP-WCMC to confirm the global comparative analysis provided by the State Party.

The IUCN World Heritage Panel reviews the nomination files, mission reports, external reviews, comparative analyses and other relevant reference material at its meetings in December and March and submits its technical recommendation on each nomination to IUCN. The members of the Panel comprise IUCN staff with responsibility for IUCN's World Heritage work, other relevant IUCN staff, members of IUCN's expert commissions, and external experts selected for their high level of experience with the WH Convention.

Following the Panel meetings, IUCN's World Heritage Programme prepares the final evaluation report and recommendations for submission to the WH Centre, which makes the evaluations available to the WH Committee and publishes them on its webpage. More details about the process can be found in the annual IUCN evaluation reports.

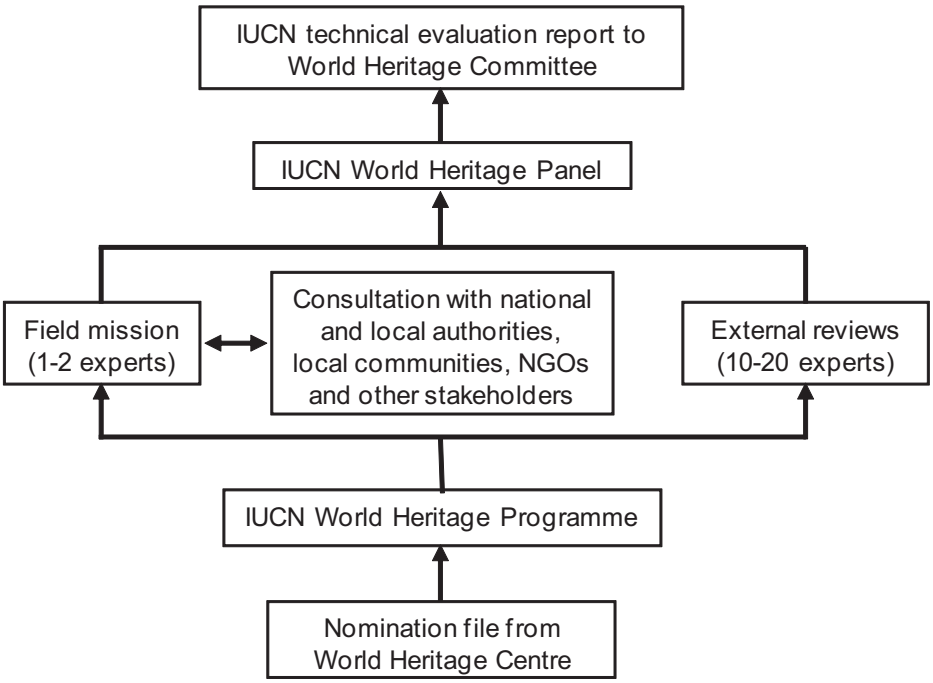


Figure 5.1 The IUCN evaluation process.

5.4 Useful resources

Up-to-date information on the nomination and evaluation process is available from a wide range of resources developed by UNESCO and IUCN. Key resources include the latest versions of the Operational Guidelines (which include the nomination format) and the World Heritage Resource Manual (Box 5.1), the annual IUCN evaluation reports, the IUCN compendium on Outstanding Universal Value published in 2008, and the thematic studies and gap analyses produced by IUCN and UNEP-WCMC (see also Annex 3). A list of webpages where these resources can be accessed is provided in Box 5.2.

Box 5.2 Relevant online resources and webpages.

UNESCO
World Heritage List: http://whc.unesco.org/en/list
World Heritage criteria: http://whc.unesco.org/en/criteria
World Heritage Tentative Lists: http://whc.unesco.org/en/tentativelists
World Heritage nomination format: http://whc.unesco.org/en/nominations
World Heritage nomination manual: http://whc.unesco.org/en/resourcemanuals
World Heritage Operational Guidelines: http://whc.unesco.org/en/guidelines
World Heritage Fund: http://whc.unesco.org/en/funding

IUCN
World Heritage Programme: http://www.iucn.org/worldheritage

UNEP-WCMC
World Heritage work: http://www.unep-wcmc.org/world-heritage-sites_189.html

References

Alliance for Zero Extinction (2012) 2010 AZE Update. Online: www.zeroextinction.org (latest version of spatial dataset obtained on 16 March 2012).

Badman, T. *et al.* (2008) Outstanding Universal Value: Standards for Natural World Heritage. IUCN, Gland, Switzerland.

Bertzky, B. and S. Kenney (2011) African Natural Heritage: Possible Priorities for the World Heritage List. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

Bertzky, B. *et al.* (2012) Protected Planet Report 2012: Tracking progress towards global targets for protected areas. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

BirdLife International (2012) Important Bird Areas (IBAs). Online: www.birdlife.org/action/science/sites/

BirdLife International, Conservation International and partners (2012) Global Key Biodiversity Areas. BirdLife International, Cambridge, UK and Conservation International, Arlington, USA. (latest version of spatial dataset obtained on 7 March 2012).

Brooks, T.M. *et al.* (2006) Global biodiversity conservation priorities. Science 313: 58–61.

Brooks, T.M. *et al.* (2010) Global biodiversity conservation priorities: An expanded review. In: J.C. Lovett and D.G. Ockwell (eds) A Handbook of Environmental Management. Edward Elgar Publishing, Cheltenham, UK and Northampton, USA: 8–29.

Buchanan, G.M. *et al.* (2011) Identifying priority areas for conservation: A global assessment for forest-dependent birds. PLoS ONE 6(12): e29080. doi:10.1371/journal.pone.0029080

Butchart, S.H.M. *et al.* (2012) Protecting important sites for biodiversity contributes to meeting global conservation targets. PLoS ONE 7(3): e32529. doi:10.1371/journal.pone.0032529

Davis, S.D. *et al.* (1994, 1995, 1997) Centres of Plant Diversity: A Guide and Strategy for their Conservation. Volumes 1–3. WWF, Gland, Switzerland and IUCN, Cambridge, UK.

Dingwall, P. *et al.* (2005) Geological World Heritage: A Global Framework. IUCN, Gland, Switzerland.

Dudley, N. (ed.) (2008) Guidelines for Applying Protected Area Management Categories. IUCN, Gland, Switzerland.

Eken, G. *et al.* (2004) Key biodiversity areas as site conservation targets. BioScience 54 (12): 1110–1118.

Engels, B. and S. Winkler (2008) World Heritage and the 2010 Biodiversity Target. World Heritage 49: 4–17.

Engels, B. *et al.* (eds) (2009) Nominations and Management of Serial Natural World Heritage Properties: Present Situation, Challenges and Opportunities. BfN-Skripten 248, Federal Agency for Nature Conservation (BfN), Bonn, Germany.

Foster, M.N. *et al.* (2010) Synergies between World Heritage sites and Key Biodiversity Areas. World Heritage 56: 4–17.

Foster, M.N. *et al.* (2012) The identification of sites of biodiversity conservation significance: progress with the application of a global standard. Journal of Threatened Taxa 4(8): 2733–2744.

IUCN CNPPA (1982) The World's Greatest Natural Areas: An Indicative Inventory of Natural Sites of World Heritage Quality. IUCN Commission on National Parks and Protected Areas (CNPPA), Gland, Switzerland.

IUCN (2006a) The World Heritage List: Guidance and Future Priorities for Identifying Natural Heritage of Potential Outstanding Universal Value. IUCN, Gland, Switzerland.

IUCN (2006b) Enhancing the IUCN Evaluation Process of World Heritage Nominations: A Contribution to Achieving a Credible and Balanced World Heritage List. BfN-Skripten 181, Federal Agency for Nature Conservation (BfN), Bonn, Germany.

IUCN (2012) IUCN Red List of Threatened Species. Version 2012.2. Online: www.iucnredlist.org

IUCN and UNEP-WCMC (2012) The World Database on Protected Areas (WDPA): October 2012. UNEP-WCMC, Cambridge, UK. Online: www.protectedplanet.net

Jenkins, C.N. and L. Joppa (2009) Expansion of the global terrestrial protected area system. Biological Conservation 142: 2166–2174.

Langhammer, P.F. *et al.* (2007) Identification and Gap Analysis of Key Biodiversity Areas: Targets for Comprehensive Protected Area Systems. IUCN, Gland, Switzerland.

Le Saout, S. (2010) The Role of Protected Areas in Global Species Conservation. Unpublished Master's Thesis, Centre d'Ecologie Fonctionnelle et Evolutive, CNRS UMR 5175, Montpellier, France. Contact: Ana.Rodrigues@cefe.cnrs.fr

Le Saout, S. *et al.* (in prep.) Saving the crown jewels: strategic priorities for consolidating the global protected area network. Contact: Ana.Rodrigues@cefe.cnrs.fr

Magin, C. and S. Chape (2004) Review of the World Heritage Network: Biogeography, Habitats and Biodiversity. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

Margules, C.R. and R.L. Pressey (2000) Systematic conservation planning. Nature 405: 243–253.

Mittermeier, R.A. *et al.* (1997) Megadiversity: Earth's Biologically Wealthiest Nations. CEMEX, Mexico City, Mexico.

Mittermeier, R.A. *et al.* (2002) Wilderness: Earth's Last Wild Places. CEMEX, Mexico City, Mexico.

Mittermeier, R.A. *et al.* (2003) Wilderness and biodiversity conservation. Proceedings of the National Academy of Sciences 100 (18): 10309–10313.

Mittermeier, R.A. *et al.* (2004) Hotspots Revisited: Earth's Biologically Richest and Most Endangered Ecoregions. CEMEX, Mexico City, Mexico.

Myers, N. *et al.* (2000) Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

Olson, D.M. and E. Dinerstein (1998) The Global 200: A representation approach to conserving the earth's most biologically valuable ecoregions. Conservation Biology 12: 502–515.

Olson, D.M. and E. Dinerstein (2002) The Global 200: Priority ecoregions for global conservation. Annals of the Missouri Botanical Garden 89: 199–224.

Olson, D.M. *et al.* (2000) The Global 200: A Representation Approach to Conserving the Earth's Distinctive Ecoregions. Conservation Science Program, WWF-US, Washington DC, USA.

Olson, D.M. *et al.* (2001) Terrestrial ecoregions of the world: A new map of life on earth. BioScience 51: 933–938.

Ricketts, T.H. *et al.* (2005) Pinpointing and preventing imminent extinctions. Proceedings of the National Academy of Sciences 102 (51): 18497–18501.

Rodrigues, A.S.L. (2011) Improving coarse species distribution data for conservation planning in biodiversity-rich, data-poor, regions: no easy shortcuts. Animal Conservation 14: 108–110.

Schmitt, C.B. (2011) A tough choice: Approaches towards the setting of global conservation priorities. In: F.E. Zachos and J.C. Habel (eds) Biodiversity Hotspots: Distribution and Protection of Conservation Priority Areas. Springer-Verlag, Berlin, Germany: 23–42.

Stattersfield, A.J. *et al.* (1998) Endemic Bird Areas of the World: Priorities for Biodiversity Conservation. BirdLife International, Cambridge, UK.

Thorsell, J. and T. Sigaty (1997a) Human Use of World Heritage Natural Sites: A Global Overview. IUCN, Gland, Switzerland.

Thorsell, J. and T. Sigaty (1997b) A Global Overview of Forest Protected Areas on the World Heritage List. IUCN, Gland, Switzerland.

Thorsell, J. and L. Hamilton (2002) A Global Overview of Mountain Protected Areas on the World Heritage List. IUCN, Gland, Switzerland.

Udvardy, M.D.F. (1975) A Classification of the Biogeographical Provinces of the World. IUCN, Morges, Switzerland.

Wells, R.T. (1996) Earth's Geological History: A Contextual Framework for Assessment of World Heritage Fossil Site Nominations. IUCN, Gland, Switzerland.

Williams, K.J. *et al.* (2011) Forests of East Australia: The 35th Biodiversity Hotspot. In: F.E. Zachos and J.C. Habel (eds) Biodiversity Hotspots: Distribution and Protection of Conservation Priority Areas. Springer, Berlin, Germany: 295–310.

Annex 1. List of the 156 'biodiversity World Heritage sites'

The following table shows the 156 natural and mixed World Heritage sites that are inscribed under biodiversity criteria (ix) and/or (x). Only these sites are formally recognized by the Convention for their outstanding biodiversity values. Sites are sorted alphabetically by State Party and site name. The size of each site was calculated based on the site boundaries recorded in the World Database on Protected Areas (WDPA; IUCN and UNEP-WCMC 2012).

The table includes the irreplaceability score and rank of each site for a) all species analysed and b) all globally threatened species analysed. The irreplaceability scores are based on 21,296 vertebrate species recorded in the 2012.2 version of the IUCN Red List of Threatened Species (IUCN 2012): 6,240 amphibian species (of which 1,922 were classified as globally threatened), 9,916 bird species (1,311) and 5,263 mammal species (1,096). For guidance, an irreplaceability score of 1 is equivalent to one of the assessed species being entirely confined to the corresponding WH site, but can also be obtained if multiple species have smaller percentages of their ranges in the site. The irreplaceability rank indicates the relative importance of a site (based on its irreplaceability score) among the 173,461 existing protected areas for which a site boundary was recorded in the October 2012 version of the WDPA (IUCN and UNEP-WCMC 2012).

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Argentina	Iguazu National Park	(vii)(x)	589.7	0.07	0.03	2,045	1,196
Argentina	Península Valdés	(x)	3,848.3	0.09	0.05	1,723	976
Australia	Australian Fossil Mammal Sites (Riversleigh / Naracoorte)	(viii)(ix)	103.7	<0.01	<0.01	11,537	17,174
Australia	Fraser Island	(vii)(viii)(ix)	1,820.8	1.21	1.12	513	271
Australia	Gondwana Rainforests of Australia	(viii)(ix)(x)	3,697.4	1.11	0.81	559	425
Australia	Great Barrier Reef	(vii)(viii)(ix)(x)	350,426.1	0.20	0.03	1,229	1,161
Australia	Heard and McDonald Islands	(viii)(ix)	6,576.5	0.01	<0.01	5,001	8,677
Australia	Kakadu National Park	(i)(vi)(vii)(ix)(x)	19,230.7	6.76	2.92	63	100
Australia	Lord Howe Island Group	(vii)(x)	1,465.2	1.00	1.00	648	340
Australia	Ningaloo Coast	(vii)(x)	6,077.5	0.02	<0.01	3,830	5,031
Australia	Shark Bay, Western Australia	(vii)(viii)(ix)(x)	22,100.2	5.08	3.97	92	59
Australia	Tasmanian Wilderness	(iii)(iv)(vi)(vii)(viii)(ix)(x)	14,095.7	3.60	0.14	163	726
Australia	The Greater Blue Mountains Area	(ix)(x)	10,364.9	1.00	0.33	656	568
Australia	Wet Tropics of Queensland	(vii)(viii)(ix)(x)	8,987.9	32.49	10.51	6	8
Bangladesh	The Sundarbans	(ix)(x)	1,669.5	0.01	<0.01	5,267	5,035
Belize	Belize Barrier Reef Reserve System	(vii)(ix)(x)	1,164.6	<0.01	<0.01	12,167	29,891
Bolivia	Noel Kempff Mercado National Park	(ix)(x)	16,213.8	4.51	0.02	108	1,537
Brazil	Atlantic Forest Southeast Reserves	(vii)(ix)(x)	4,432.0	6.33	1.41	72	223
Brazil	Brazilian Atlantic Islands: Fernando de Noronha and Atol das Rocas Reserves	(vii)(ix)(x)	141.4	0.85	0.85	738	415
Brazil	Central Amazon Conservation Complex	(ix)(x)	51,313.1	1.46	0.03	433	1,220
Brazil	Cerrado Protected Areas: Chapada dos Veadeiros and Emas National Parks	(ix)(x)	3,834.8	2.51	1.61	247	203
Brazil	Discovery Coast Atlantic Forest Reserves	(ix)(x)	1,357.6	2.47	1.08	251	279

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Brazil	Iguaçu National Park	(vii)(x)	1,704.2	0.08	0.01	1,940	1,871
Brazil	Pantanal Conservation Complex	(vii)(ix)(x)	1,991.1	0.05	<0.01	2,509	3,193
Bulgaria	Pirin National Park	(vii)(viii)(ix)	392.7	<0.01	<0.01	10,353	11,580
Bulgaria	Srebarna Nature Reserve	(x)	6.4	<0.01	<0.01	36,166	29,481
Cameroon	Dja Faunal Reserve	(ix)(x)	5,847.3	1.15	0.04	537	1,131
Canada	Wood Buffalo National Park	(vii)(ix)(x)	44,705.4	0.46	0.22	922	637
Canada; United States	Waterton Glacier International Peace Park	(vii)(ix)	4,575.7	0.04	0.00	2,796	107,834
Central African Republic	Manovo-Gounda St Floris National Park	(ix)(x)	18,870.7	0.22	<0.01	1,171	2,394
Central African Republic; Republic of the Congo; Cameroon	Sangha Trinational	(ix)(x)	7,599.9	0.69	<0.01	805	3,168
China	Mount Emei Scenic Area, including Leshan Giant Buddha Scenic Area	(iv)(vi)(x)	256.9	1.16	1.04	532	292
China	Mount Huangshan	(ii)(vii)(x)	164.1	<0.01	<0.01	8,814	6,635
China	Mount Wuyi	(iii)(vi)(vii)(x)	963.9	0.03	<0.01	2,890	2,094
China	Sichuan Giant Panda Sanctuaries – Wolong, Mt Siguniang and Jiajin Mountains	(x)	9,860.9	4.99	0.44	94	528
China	Three Parallel Rivers of Yunnan Protected Areas	(vii)(viii)(ix)(x)	21,134.0	9.48	2.39	42	121
Colombia	Los Katíos National Park	(ix)(x)	743.4	0.94	0.01	700	1,774
Colombia	Malpelo Fauna and Flora Sanctuary	(vii)(ix)	9,642.2	<0.01	<0.01	10,148	14,803
Congo, Democratic Republic of the	Garamba National Park	(vii)(x)	5,162.5	1.18	<0.01	524	5,296
Congo, Democratic Republic of the	Kahuzi-Biega National Park	(x)	6,611.4	3.31	1.81	180	184
Congo, Democratic Republic of the	Okapi Wildlife Reserve	(x)	14,034.2	1.21	0.08	515	857
Congo, Democratic Republic of the	Salonga National Park	(vii)(ix)	35,322.0	1.33	0.03	464	1,158
Congo, Democratic Republic of the	Virunga National Park	(vii)(viii)(x)	7,822.6	4.32	1.32	118	233
Costa Rica	Area de Conservación Guanacaste	(ix)(x)	1,514.3	2.03	1.04	311	293
Costa Rica	Cocos Island National Park	(ix)(x)	1,734.7	2.00	2.00	323	161
Côte d'Ivoire	Comoé National Park	(ix)(x)	11,575.1	0.28	0.01	1,063	1,819
Côte d'Ivoire	Taï National Park	(vii)(x)	3,482.5	4.72	2.44	99	120
Côte d'Ivoire; Guinea	Mount Nimba Strict Nature Reserve	(ix)(x)	193.8	3.88	2.26	147	127
Croatia	Plitvice Lakes National Park	(vii)(viii)(ix)	296.3	<0.01	<0.01	8,285	3,908
Cuba	Alejandro de Humboldt National Park	(ix)(x)	694.5	3.92	3.85	143	62
Dominica	Morne Trois Pitons National Park	(viii)(x)	67.4	0.27	0.22	1,085	632

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Ecuador	Galápagos Islands	(vii)(viii)(ix)(x)	146,678.6	24.39	11.02	15	5
Ecuador	Sangay National Park	(vii)(viii)(ix)(x)	2,526.8	1.89	0.47	354	517
Ethiopia	Simien National Park	(vii)(x)	132.6	0.07	0.06	2,059	923
France	Gulf of Porto: Calanche of Piana, Gulf of Girolata, Scandola Reserve	(vii)(viii)(x)	119.5	<0.01	<0.01	8,915	21,661
France	Lagoons of New Caledonia: Reef Diversity and Associated Ecosystems	(vii)(ix)(x)	15,752.3	<0.01	<0.01	12,823	8,194
France	Pitons, cirques and remparts of Reunion Island	(vii)(x)	1,065.3	2.61	0.77	236	437
Gabon	Ecosystem and Relict Cultural Landscape of Lopé-Okanda	(iii)(iv)(ix)(x)	4,945.4	2.38	0.04	258	1,061
Germany; Netherlands	The Wadden Sea	(viii)(ix)(x)	9,801.1	<0.01	<0.01	11,859	10,098
Guatemala	Tikal National Park	(i)(iii)(iv)(ix)(x)	578.6	0.04	<0.01	2,850	3,151
Honduras	Río Plátano Biosphere Reserve	(vii)(viii)(ix)(x)	5,089.5	2.46	2.07	253	148
Iceland	Surtsey	(ix)	33.7	<0.01	<0.01	77,966	46,574
India	Kaziranga National Park	(ix)(x)	433.9	0.06	0.05	2,236	1,039
India	Keoladeo National Park	(x)	29.5	<0.01	<0.01	22,207	19,068
India	Manas Wildlife Sanctuary	(vii)(ix)(x)	450.7	0.85	0.84	735	417
India	Nanda Devi and Valley of Flowers National Parks	(vii)(x)	738.9	0.02	<0.01	3,509	3,127
India	Sundarbans National Park	(ix)(x)	1,043.4	0.02	<0.01	4,084	3,248
India	Western Ghats	(ix)(x)	8,165.4	24.03	14.58	17	2
Indonesia	Komodo National Park	(vii)(x)	1,745.8	0.16	0.12	1,361	763
Indonesia	Lorentz National Park	(viii)(ix)(x)	23,707.6	24.56	3.56	13	68
Indonesia	Tropical Rainforest Heritage of Sumatra	(vii)(ix)(x)	25,977.4	18.03	4.54	23	44
Indonesia	Ujung Kulon National Park	(vii)(x)	1,268.5	1.08	1.03	575	294
Japan	Ogasawara Islands	(ix)	79.7	1.34	1.34	460	228
Japan	Shirakami-Sanchi	(ix)	160.9	0.01	<0.01	5,057	3,872
Japan	Shiretoko	(ix)(x)	715.0	<0.01	<0.01	6,570	7,632
Japan	Yakushima	(vii)(ix)	107.6	<0.01	<0.01	5,732	10,227
Kazakhstan	Saryarka – Steppe and Lakes of Northern Kazakhstan	(ix)(x)	4,482.4	<0.01	<0.01	5,648	7,221
Kenya	Kenya Lake System in the Great Rift Valley	(vii)(ix)(x)	333.4	0.02	<0.01	3,524	11,512
Kenya	Lake Turkana National Parks	(viii)(x)	1,545.5	0.03	<0.01	2,889	3,211
Kenya	Mount Kenya National Park/Natural Forest	(vii)(ix)	1,779.9	2.46	2.08	254	144
Kiribati	Phoenix Islands Protected Area	(vii)(ix)	408,258.1	0.03	<0.01	3,307	2,183
Madagascar	Rainforests of the Atsinanana	(ix)(x)	4,810.9	20.18	10.58	20	7
Madagascar	Tsingy de Bemaraha Strict Nature Reserve	(vii)(x)	1,574.7	4.41	3.64	111	67
Malawi	Lake Malawi National Park	(vii)(ix)(x)	73.6	<0.01	<0.01	11,668	19,771
Malaysia	Gunung Mulu National Park	(vii)(viii)(ix)(x)	527.4	3.82	3.26	148	81
Malaysia	Kinabalu Park	(ix)(x)	770.4	10.18	4.95	36	38
Mauritania	Banc d'Arguin National Park	(ix)(x)	11,916.4	0.03	<0.01	3,036	10,663
Mexico	Islands and Protected Areas of the Gulf of California	(vii)(ix)(x)	22,834.4	13.17	12.04	28	4

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Mexico	Sian Ka'an	(vii)(x)	5,311.3	0.51	0.01	887	1,900
Mexico	Whale Sanctuary of El Vizcaino	(x)	2,834.5	0.07	0.03	2,030	1,257
Mongolia; Russia	Uvs Nuur Basin	(ix)(x)	12,535.3	0.05	<0.01	2,318	3,446
Montenegro	Durmitor National Park	(vii)(viii)(x)	360.2	<0.01	<0.01	9,096	5,768
Nepal	Chitwan National Park	(vii)(ix)(x)	1,184.3	0.39	0.08	959	863
New Zealand	New Zealand Sub-Antarctic Islands	(ix)(x)	14,721.9	6.10	5.10	77	35
New Zealand	Te Wahipounamu – South West New Zealand	(vii)(viii)(ix)(x)	25,139.4	4.37	3.55	116	69
Niger	Air and Ténéré Natural Reserves	(vii)(ix)(x)	78,680.9	0.17	0.05	1,328	985
Niger	W National Park of Niger	(ix)(x)	2,225.2	0.02	<0.01	3,562	5,643
Palau	Rock Islands Southern Lagoon	(iii)(v)(vii)(ix)(x)	1,011.1	0.17	<0.01	1,302	3,138
Panama	Coiba National Park and its Special Zone of Marine Protection	(ix)(x)	4,330.6	1.25	1.24	496	246
Panama	Darien National Park	(vii)(ix)(x)	5,502.4	23.54	6.30	18	28
Panama; Costa Rica	Talamanca Range-La Amistad Reserves / La Amistad National Park	(vii)(viii)(ix)(x)	4,073.2	29.21	8.93	7	14
Peru	Historic Sanctuary of Machu Picchu	(i)(iii)(vii)(ix)	374.9	0.09	0.02	1,740	1,596
Peru	Manú National Park	(ix)(x)	17,051.5	6.11	0.47	75	520
Peru	Río Abiseo National Park	(iii)(vii)(ix)(x)	2,739.9	2.64	2.14	233	137
Philippines	Puerto-Princesa Subterranean River National Park	(vii)(x)	60.2	0.02	<0.01	3,725	2,766
Philippines	Tubbataha Reefs Natural Park	(vii)(ix)(x)	970.7	<0.01	0.00	43,723	107,834
Portugal	Laurisilva of Madeira	(ix)(x)	150.9	0.12	<0.01	1,543	2,447
Romania	Danube Delta	(vii)(x)	3,151.3	0.02	<0.01	4,286	4,634
Russian Federation	Central Sikhote-Alin	(x)	3,999.0	0.02	<0.01	3,414	3,821
Russian Federation	Golden Mountains of Altai	(x)	17,264.9	0.10	<0.01	1,693	3,462
Russian Federation	Lake Baikal	(vii)(viii)(ix)(x)	85,508.4	1.20	<0.01	518	2,398
Russian Federation	Natural System of Wrangel Island Reserve	(ix)(x)	20,092.7	1.91	<0.01	346	5,759
Russian Federation	Putorana Plateau	(vii)(ix)	19,801.0	0.04	<0.01	2,812	4,941
Russian Federation	Virgin Komi Forests	(vii)(ix)	28,702.8	0.03	<0.01	3,223	4,711
Russian Federation	Volcanoes of Kamchatka	(vii)(viii)(ix)(x)	39,826.9	0.09	<0.01	1,729	2,145
Russian Federation	Western Caucasus	(ix)(x)	2,877.9	0.64	0.55	826	491
Senegal	Djoudj National Bird Sanctuary	(vii)(x)	210.2	<0.01	<0.01	12,859	15,900
Senegal	Niokolo-Koba National Park	(x)	8,283.4	0.13	<0.01	1,484	2,511
Seychelles	Aldabra Atoll	(vii)(ix)(x)	353.8	0.96	0.94	685	386
Seychelles	Vallée de Mai Nature Reserve	(vii)(viii)(ix)(x)	0.1	<0.01	<0.01	18,750	11,860
Slovakia; Ukraine; Germany	Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany	(ix)	289.2	<0.01	<0.01	8,990	12,551

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Solomon Islands	East Rennell	(ix)	828.3	2.35	0.29	263	587
South Africa	Cape Floral Region Protected Areas	(ix)(x)	5,600.5	4.67	2.14	100	138
South Africa	iSimangaliso Wetland Park	(vii)(ix)(x)	2,530.4	0.11	0.01	1,605	1,719
South Africa	uKhahlamba / Drakensberg Park	(i)(iii)(vii)(x)	2,381.3	0.26	0.06	1,096	929
Spain	Doñana National Park	(vii)(ix)(x)	536.9	0.08	0.07	1,893	874
Spain	Garajonay National Park	(vii)(ix)	37.4	0.01	<0.01	4,617	3,245
Spain	Ibiza, Biodiversity and Culture	(ii)(iii)(iv)(ix)(x)	89.1	<0.01	<0.01	42,775	27,559
Sri Lanka	Central Highlands of Sri Lanka	(ix)(x)	537.4	10.02	9.86	40	12
Sri Lanka	Sinharaja Forest Reserve	(ix)(x)	96.4	1.37	1.27	445	242
Suriname	Central Suriname Nature Reserve	(ix)(x)	16,272.1	2.04	0.01	309	1,748
Sweden	Laponian Area	(iii)(v)(vii)(viii)(ix)	9,287.3	<0.01	<0.01	6,187	7,558
Switzerland	Swiss Alps Jungfrau-Aletsch	(vii)(viii)(ix)	825.7	0.01	<0.01	5,293	28,980
Tanzania	Ngorongoro Conservation Area	(iv)(vii)(viii)(ix)(x)	8,326.9	0.93	0.47	703	516
Tanzania	Selous Game Reserve	(ix)(x)	47,518.1	2.74	0.06	224	958
Tanzania	Serengeti National Park	(vii)(x)	13,123.0	1.88	0.05	355	1,026
Thailand	Dong Phayayen-Khao Yai Forest Complex	(x)	6,218.6	3.26	0.03	184	1,159
Thailand	Thungyai - Huai Kha Khaeng Wildlife Sanctuaries	(vii)(ix)(x)	7,206.5	0.86	0.32	734	578
Tunisia	Ichkeul National Park	(x)	124.4	<0.01	<0.01	13,013	21,430
Uganda	Bwindi Impenetrable National Park	(vii)(x)	329.4	0.25	0.18	1,107	674
Uganda	Rwenzori Mountains National Park	(vii)(x)	1,001.2	2.52	2.17	242	133
United Kingdom	Gough and Inaccessible Islands	(vii)(x)	3,917.8	3.51	3.47	170	73
United Kingdom	Henderson Island	(vii)(x)	41.3	4.00	4.00	135	56
United Kingdom	St Kilda	(iii)(v)(vii)(ix)(x)	253.2	<0.01	0.00	54,941	107,834
United States	Everglades National Park	(viii)(ix)(x)	5,853.5	0.06	<0.01	2,132	2,542
United States	Grand Canyon National Park	(vii)(viii)(ix)(x)	4,897.2	0.07	<0.01	1,949	2,299
United States	Great Smoky Mountains National Park	(vii)(viii)(ix)(x)	2,048.7	1.46	0.17	431	682
United States	Mammoth Cave National Park	(vii)(viii)(x)	208.2	<0.01	<0.01	11,110	18,976
United States	Olympic National Park	(vii)(ix)	3,685.1	1.26	0.14	492	734
United States	Papahanaumokuakea	(iii)(vi)(viii)(ix)(x)	364,792.7	4.03	4.01	130	54
United States	Redwood National and State Parks	(vii)(ix)	573.5	0.04	<0.01	2,825	40,481
United States	Yellowstone National Park	(vii)(viii)(ix)(x)	8,904.5	0.08	0.00	1,848	107,834
United States; Canada	Kluane / Wrangell-St Elias / Glacier Bay / Tatshenshini-Alsek	(vii)(viii)(ix)(x)	97,401.3	1.32	<0.01	465	5,623
Venezuela	Canaima National Park	(vii)(viii)(ix)(x)	29,019.0	41.16	8.33	3	16
Yemen	Socotra Archipelago	(x)	4,108.2	4.85	2.98	96	98
Zimbabwe	Mana Pools National Park, Sapi and Chewore Safari Areas	(vii)(ix)(x)	6,753.9	0.13	<0.01	1,476	2,912

Annex 2. List of the 61 'non-biodiversity World Heritage sites'

The following table shows the 61 natural and mixed World Heritage sites that are not inscribed under biodiversity criteria (ix) and/or (x). Sites are sorted alphabetically by State Party and site name. The size of each site was calculated based on the site boundaries recorded in the World Database on Protected Areas (WDPA; IUCN and UNEP-WCMC 2012).

The table includes the irreplaceability score and rank of each site for a) all species analysed and b) all globally threatened species analysed. The irreplaceability scores are based on 21,296 vertebrate species recorded in the 2012.2 version of the IUCN Red List of Threatened Species (IUCN 2012): 6,240 amphibian species (of which 1,922 were classified as globally threatened), 9,916 bird species (1,311) and 5,263 mammal species (1,096). For guidance, an irreplaceability score of 1 is equivalent to one of the assessed species being entirely confined to the corresponding WH site, but can also be obtained if multiple species have smaller percentages of their ranges in the site. The irreplaceability rank indicates the relative importance of a site (based on its irreplaceability score) among the 173,461 existing protected areas for which a site boundary was recorded in the October 2012 version of the WDPA (IUCN and UNEP-WCMC 2012).

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Algeria	Tassili n'Ajjer	(i)(iii)(vii)(viii)	75,712.7	0.20	0.02	1,226	1,514
Argentina	Ischigualasto / Talampaya Natural Parks	(viii)	2,704.8	0.04	<0.01	2,574	5,887
Argentina	Los Glaciares National Park	(vii)(viii)	7,186.4	0.15	0.02	1,363	1,393
Australia	Macquarie Island	(vii)(viii)	5,559.4	<0.01	<0.01	6,510	2,678
Australia	Purnululu National Park	(vii)(viii)	2,452.4	0.03	<0.01	2,977	7,717
Australia	Uluru – Kata Tjuta National Park	(v)(vi)(vii)(viii)	1,346.2	<0.01	0.00	5,790	107,834
Australia	Willandra Lakes Region	(iii)(viii)	2,398.1	0.03	<0.01	3,353	3,841
Belarus; Poland	Belovezhskaya Pushcha / Białowie a Forest	(vii)	926.2	0.07	0.07	2,027	896
Canada	Canadian Rocky Mountain Parks	(vii)(viii)	23,581.5	0.12	0.00	1,544	107,834
Canada	Dinosaur Provincial Park	(vii)(viii)	83.8	<0.01	<0.01	21,908	29,467
Canada	Gros Morne National Park	(vii)(viii)	1,807.3	<0.01	<0.01	11,827	21,684
Canada	Joggins Fossil Cliffs	(viii)	5.8	<0.01	0.00	57,931	107,834
Canada	Miguasha National Park	(viii)	0.7	<0.01	0.00	77,138	107,834
Canada	Nahanni National Park	(vii)(viii)	4,835.3	0.01	0.00	4,806	107,834
Chad	Lakes of Ounianga	(vii)	632.3	<0.01	<0.01	17,644	11,999
China	Chengjiang Fossil Site	(viii)	4.9	<0.01	<0.01	27,565	24,938
China	China Danxia	(vii)(viii)	838.3	0.02	<0.01	3,667	3,708
China	Huanglong Scenic and Historic Interest Area	(vii)	449.9	0.04	0.01	2,651	1,780
China	Jiuzhaigou Valley Scenic and Historic Interest Area	(vii)	706.8	0.05	<0.01	2,488	1,984
China	Mount Sanqingshan National Park	(vii)	233.2	<0.01	<0.01	8,295	6,707
China	Mount Taishan	(i)(ii)(iii)(iv)(v)(vi)(vii)	270.2	<0.01	<0.01	12,687	13,563
China	South China Karst	(vii)(viii)	363.0	<0.01	<0.01	5,533	5,735

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
China	Wulingyuan Scenic and Historic Interest Area	(vii)	433.7	<0.01	<0.01	5,955	4,694
Cuba	Desembarco del Granma National Park	(vii)(viii)	326.5	0.28	0.25	1,072	607
Denmark	Ilulissat Icefjord	(vii)(viii)	4,006.9	<0.01	<0.01	16,844	13,892
Egypt	Wadi Al-Hitan (Whale Valley)	(viii)	192.7	<0.01	<0.01	13,543	23,400
Finland; Sweden	High Coast / Kvarken Archipelago	(viii)	3,541.2	<0.01	<0.01	15,527	23,257
France; Spain	Pyrénées – Mont Perdu	(iii)(iv)(v)(vii)(viii)	250.5	0.02	0.01	3,748	1,642
Germany	Messel Pit Fossil Site	(viii)	0.4	<0.01	0.00	91,758	107,834
Greece	Meteora	(i)(ii)(iv)(v)(vii)	2.7	<0.01	<0.01	41,725	44,901
Greece	Mount Athos	(i)(ii)(iv)(v)(vi)(vii)	348.1	<0.01	<0.01	11,535	12,281
Hungary; Slovakia	Caves of Aggtelek Karst and Slovak Karst	(viii)	595.2	<0.01	<0.01	9,824	9,174
Italy	Isole Eolie (Aeolian Islands)	(viii)	74.6	<0.01	<0.01	38,815	31,797
Italy	The Dolomites	(vii)(viii)	1,417.5	0.02	<0.01	3,956	11,446
Italy; Switzerland	Monte San Giorgio	(viii)	11.2	<0.01	<0.01	27,353	14,584
Jordan	Wadi Rum Protected Area	(iii)(v)(vii)	731.3	<0.01	<0.01	7,916	7,348
Korea, Republic of	Jeju Volcanic Island and Lava Tubes	(vii)(viii)	92.7	<0.01	<0.01	11,402	11,314
Macedonia, FYR	Natural and Cultural Heritage of the Ohrid region	(i)(iii)(iv)(vii)	829.6	0.01	<0.01	4,575	4,034
Mali	Cliff of Bandiagara (Land of the Dogons)	(v)(vii)	3,334.1	0.03	<0.01	2,948	6,317
Mexico	Monarch Butterfly Biosphere Reserve	(vii)	137.4	0.01	<0.01	4,370	3,401
Nepal	Sagarmatha National Park	(vii)	1,144.3	0.03	<0.01	2,865	3,426
New Zealand	Tongariro National Park	(vi)(vii)(viii)	793.9	0.03	0.02	3,228	1,461
Norway	West Norwegian Fjords – Geirangerfjord and Nærøyfjord	(vii)(viii)	1,226.4	<0.01	0.00	14,601	107,834
Peru	Huascarán National Park	(vii)(viii)	3,418.4	1.34	0.67	458	459
Russian Federation	Lena Pillars Nature Park	(viii)	12,178.1	0.02	<0.01	4,010	9,972
Saint Lucia	Pitons Management Area	(vii)(viii)	19.4	0.02	<0.01	3,876	3,716
Slovenia	Škocjan Caves	(vii)(viii)	4.0	<0.01	<0.01	38,714	19,475
South Africa	Vredefort Dome	(viii)	315.7	<0.01	<0.01	6,214	4,802
Spain	Teide National Park	(vii)(viii)	191.9	0.04	0.02	2,542	1,405
Switzerland	Swiss Tectonic Arena Sardona	(viii)	331.0	<0.01	<0.01	8,243	29,604
Tanzania	Kilimanjaro National Park	(vii)	754.9	3.06	1.01	197	314
Turkey	Göreme National Park and the Rock Sites of Cappadocia	(i)(iii)(v)(vii)	92.0	<0.01	<0.01	15,369	24,856
Turkey	Hierapolis-Pamukkale	(iii)(iv)(vii)	13.7	<0.01	<0.01	34,968	32,568
United Kingdom	Dorset and East Devon Coast	(viii)	26.0	<0.01	<0.01	46,559	49,962
United Kingdom	Giant's Causeway and Causeway Coast	(vii)(viii)	2.1	<0.01	<0.01	101,347	82,731
United States	Carlsbad Caverns National Park	(vii)(viii)	192.6	<0.01	<0.01	8,504	5,662
United States	Hawaii Volcanoes National Park	(viii)	847.7	0.34	0.32	993	579
United States	Yosemite National Park	(vii)(viii)	3,029.8	0.68	0.38	808	549

State Party	World Heritage site	World Heritage criteria	WDPA area (km²)	Irreplaceability score		Irreplaceability rank amongst all protected areas	
				All species	Threatened species	All species	Threatened species
Vietnam	Ha Long Bay	(vii)(viii)	471.2	<0.01	<0.01	26,076	16,531
Vietnam	Phong Nha-Ke Bang National Park	(viii)	903.9	1.27	0.03	487	1,245
Zimbabwe; Zambia	Mosi-oa-Tunya / Victoria Falls	(vii)(viii)	77.6	<0.01	<0.01	10,294	12,331

Annex 3. Selected global and regional theme studies

The following studies, prepared by IUCN and/or UNEP-WCMC, have a particular relevance for the consideration of terrestrial biodiversity values under the World Heritage Convention.

Badman, T. *et al.* (2008) Outstanding Universal Value: Standards for Natural World Heritage. IUCN, Gland, Switzerland.

Bertzky, B. and S. Kenney (2011) African Natural Heritage: Possible Priorities for the World Heritage List. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

Garstecki, T. *et al.* (2011) Tabe'a. Nature and World Heritage in the Arab States: Towards Future IUCN Priorities. IUCN, Gland, Switzerland.

Goudie, A. and M. Seely (2011) World Heritage Desert Landscapes: Potential Priorities for the Recognition of Desert Landscapes and Geomorphological Sites on the World Heritage List. IUCN, Gland, Switzerland.

IUCN CNPPA (1982) The World's Greatest Natural Areas: An Indicative Inventory of Natural Sites of World Heritage Quality. IUCN Commission on National Parks and Protected Areas (CNPPA), Gland, Switzerland.

IUCN (2004) The World Heritage List: Future Priorities for a Credible and Complete List of Natural and Mixed Sites. IUCN, Gland, Switzerland.

IUCN (2006) The World Heritage List: Guidance and Future Priorities for Identifying Natural Heritage of Potential Outstanding Universal Value. IUCN, Gland, Switzerland.

Magin, C. (2005) World Heritage Thematic Study for Central Asia: A Regional Overview. IUCN, Gland, Switzerland.

Magin, C. and S. Chape (2004) Review of the World Heritage Network: Biogeography, Habitats and Biodiversity. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

Smith, G. and J. Jakubowska (2000) A Global Overview of Protected Areas on the World Heritage List of Particular Importance for Biodiversity. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

Thorsell, J., R. Ferster Levy and T. Sigaty (1997) A Global Overview of Wetland and Marine Protected Areas on the World Heritage List. IUCN, Gland, Switzerland.

Thorsell, J. and T. Sigaty (1997) A Global Overview of Forest Protected Areas on the World Heritage List. IUCN, Gland, Switzerland.

Thorsell, J. and L. Hamilton (2002) A Global Overview of Mountain Protected Areas on the World Heritage List. IUCN, Gland, Switzerland.

Williams, P. (2008) World Heritage Caves and Karst. A Global Review of Karst World Heritage Properties: Present Situation, Future Prospects and Management Requirements. IUCN, Gland, Switzerland.

Wood, C. (2009) World Heritage Volcanoes. A Global Review of Volcanic World Heritage Properties: Present Situation, Future Prospects and Management Requirements. IUCN, Gland, Switzerland.

INTERNATIONAL UNION
FOR CONSERVATION OF NATURE

WORLD HEADQUARTERS
Rue Mauverney 28
1196 Gland, Switzerland
Tel: +41 22 999 0000
Fax: +41 22 999 0002
www.iucn.org