Background options paper for the Criteria and Thresholds Working Groups of the joint taskforce on 'Biodiversity and Protected Areas'

October 2012 DRAFT

Recommended Citation:

TBC (2012) Background options paper for the Criteria and Thresholds Working Groups of the joint taskforce on 'Biodiversity and Protected Areas'. Unpublished report, October 2012. Cambridge, UK: The Biodiversity Consultancy Ltd.

This report has been written by The Biodiversity Consultancy Ltd., EURC, 72 Trumpington Street, Cambridge, CB2 1RR, UK.

Contents

A. Report at a Glance

This section collates summary tables from Section C to identify the key questions and issues discussed in this report, the approaches which could be used to tackle these issues, and their relative advantages and disadvantages. Optimal approaches are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question. In any case, it would be oversimplistic to use the +/- scorings as a decision-making tool. Instead, this section offers a ready summary reference point for the report.

(i) Should the criteria use absolute or percentage thresholds?

Issue: Approach:	Ability to assess global significance	Ability to deal with incomplete knowledge	Flexibility to incorporate changing information	Ease of definition and use across ecosystems/taxa	Focus on features with different spatial distribution patterns
Absolute thresholds	-	+ +	+	- -	+
Percentage thresholds	+ +	(+)	-	+	+ +
Ranking approaches	+ +	+ +	-	+ +	-

(ii) How should restricted-range definitions be established across species groups?

Issue: Approach:	Consistency	Ease of application	Minimisation of omission/commission errors
Range-based numerical	+ +	-	-
Area-based endemism	- -	+ +	-
Percentile	+ +	- -	+ +

(iii) How should vulnerability criteria be applied to groups for which the Red-listing process hasn't been applied globally?

Issue: Approach:	Taxonomic coverage	Ability to reflect global vulnerability	Ease of application
Inclusion solely of assessed globally-threatened taxa	-	+ +	+ +
Assessments of previously non-assessed taxa	+ +	+ +	- -
Inclusion of regionally-assessed taxa	+	-	-
Inclusion of threatened habitats	+	+	+

(iv) Could there be a rationale for incorporating criteria for biodiversity below the species level?

Issue: / Approach:	Ability to deal with taxonomic uncertainty	Ability to incorporate evolutionary history/ distinctiveness	Correspondence with vulnerability and irreplaceability	Ease of application	Stability	Ability to deliver an appropriate number of priorities
Incorporation of phylogenetic diversity	+ +	+ +	n/a	- -	- -	- -
Incorporation of infraspecific taxa	+	(-)	n/a	-	- -	(+)
Exclusion of biodiversity below the species level	-	+	n/a	+ +	+ +	+ +

(v) Should/How should vulnerability criteria be applied above the species level?

Issue: / Approach:	Ability to represent biodiversity process and threatened species which have not yet undergone Red List assessment	Ease of application	Consistency among vulnerability and irreplaceability criteria
Exclusion of vulnerability criteria above the species level	- -	+ +	+
Inclusion of vulnerability criteria above the species level (e.g. at the ecosystem level)	+ +	-	+ +

(vi) What should be the units for application of criteria above the species level?

Issue: / Approach:	Ability to identify the most globally significant areas within ecosystems	Appropriateness of scale	Ease of application
Use of ecosystems alone	- -	+	+ +
Use of community characteristics of ecosystems	+ +	-	-

(vii) What should be the taxonomic standards?

Issue: / Approach:	Clarity and transparency	Coherence and consistency	Ease of application
Explicit, criteria-driven taxonomies	+ +	+ +	- -
Existing global taxonomies (notably those underlying the Red List)	+	+ +	+ +

Compilation of sub-global taxonomies	- -	- -	-

(viii) At what level should thresholds be set?

Issue: / Approach:	Focus on the most significant sites	Appropriate number of sites	Logical coherence	Congruence with existing policy	Simplicity
Avoiding quantitative thresholds	n/a	-	n/a	- -	+ +
Tiered thresholds	n/a	+	n/a	+ +	-
Standardised thresholds within criteria	n/a	-	n/a	(-)	+ +
Varying thresholds within criteria	n/a	+	- -	n/a	- -
Combined vulnerability and irreplaceability thresholds	+ +	n/a	+ +	n/a	-
Separate vulnerability and irreplaceability thresholds	-	n/a	-	n/a	+

B. Executive Summary

Introduction

This background options paper supports the joint IUCN Species Survival Commission and World Commission on Protected Areas taskforce on 'Biodiversity and Protected Areas'. Specifically, it supports the taskforce's objective to forge scientific stakeholder consensus regarding global standards and criteria necessary to identify sites of biodiversity conservation significance. It does so by identifying key issues related to criteria and thresholds for identifying such sites, as a basis for discussions by working groups under the taskforce's stakeholder process. An overview is given of the importance of each issue, a brief review provided of potential approaches to each issue, and advantages and disadvantages of each approach discussed.

Throughout this paper, discussion is based around the taskforce's definition of its goals and best practice in conservation planning science. As such, consolidation and consistency of criteria/thresholds is considered an advantage, and focus is on identification of sites of global biodiversity conservation significance (or 'significant sites' for convenience) – rather than prioritisation of sites or conservation actions. Further, it focuses discussion on the ability of various approaches to assess the core conservation planning principles of vulnerability and irreplaceability at a global level. Such a focus has important implications for the utility of any resulting consolidated global standards, as these principles are also central to existing conservation efforts (e.g. the High Conservation Value Forest approach, World Heritage Areas, the Convention on Biological Diversity's Ecologically and Biologically Significant Areas, the Food and Agriculture Organization's Vulnerable Marine Ecosystems, and the International Maritime Organization's Particularly Sensitive Sea Areas), criteria used to identify potential high risk areas for development by leading multinational development banks (e.g. the International Finance Corporation and European Bank for Reconstruction and Development) and by extension the >75 banks which have signed up to the Equator Principles. Consolidated global standards for identification of globally significant sites for biodiversity conservation could thus play a central role not only in guiding selection of sites for global conservation efforts, but also in avoidance or minimisation of impacts on sites by global development efforts.

Eight key issues were identified as follows, with brief summaries of advantages and disadvantages listed below. These brief summaries are intended to provide a quick reference guide but, owing to the complexity of issues discussed, may not be entirely clear on their own without reference to the main text sections:

(i) Should the criteria use absolute or percentage thresholds?

- Percentage thresholds and ranking approaches more directly and precisely assess global significance.
- Absolute thresholds are most robust to incomplete knowledge, followed by ranking approaches. Adopting a hierarchical surrogate approach to percentage thresholds (e.g. use of % of Area of Occupancy where data on % of population are unavailable; use of % of Extent of Occurrence where data on % of Area of Occupancy are unavailable; etc.) would allow these to also effectively deal with incomplete knowledge. Such a surrogate approach would have additional advantages for groups where it may even be difficult to identify 'individuals' in a population (e.g. for some plants and fungi).
- Absolute thresholds are more stable and easy to implement when status or knowledge of a biodiversity feature is changing. Percentage thresholds and ranking approaches are more responsive to changing conservation needs.
- Percentage and ranked (e.g. 'the top 5% of sites') thresholds are likely to be easier to define and use across ecosystems and taxa.

- Percentage and absolute thresholds both have a more appropriate focus on irreplaceability than a ranking approach (which will also identify sites for widespread, low density biodiversity features).
- It might be possible to develop a single rule of thumb to enable simultaneous use of absolute and percentage thresholds. This would, however, require extensive testing and calibration and may not even be satisfactorily achievable.

(ii) How should restricted-range definitions be established across species groups?

- Global significance could be considered to be absolute across taxa (e.g. a single threshold of <10,000 km^2) or proportional within taxa (e.g. the most narrowly distributed 25% of species in each class). The former, absolute approaches to global irreplaceability fit most closely with conservation planning principles, but have not yet been advocated. If representation across taxa is instead considered important, range-based approaches could be standardised within high-level taxa within freshwater, marine and terrestrial realms in order to assess similar proportions of taxa as restricted-range.
- Range-based and percentile approaches are globally consistent, whereas area-based endemism approaches (e.g. species endemic to country X) produce different results in countries or regions of varying size.
- Area-based endemism approaches, particularly if based on national boundaries, are simpler to apply than range-based approaches – especially in data poor situations. Percentile approaches are not practically possible for many taxonomic groups.
- Percentile approaches would minimise site omission and commission errors, as, if carefully tailored to species groups, could variable absolute thresholds.

(iii) How should vulnerability criteria be applied to groups for which the Red-listing process hasn't been applied globally?

- Taxonomic coverage of globally significant sites can best be boosted by establishment of new, targeted Red List assessments, even if these are preliminary in nature, although inclusion of suitable existing sub-global assessments and threatened habitats (see Section v below) could also help.
- Sub-global Red List assessments are only directly transferable to the global level for species which are endemic to the sub-global area in question, and only when (rarely) IUCN regional guidelines are followed.
- An interim solution for species not endemic to the sub-global region in question may be to use sub-global Red List assessments which follow IUCN Categories and Criteria, as well as preliminary assessment methods (e.g. RAMAS), to identify significant 'candidate globally-significant sites' at a national or regional level.
- Incorporation of sub-global Red List assessments adds complexity, particularly in reconciling different assessments across national/regional boundaries, though not as much as initiating new assessments.

(iv) Could there be a rationale for incorporating criteria for biodiversity below the species level?

- Incorporation of all infraspecific taxa would ensure taxa were not excluded from consideration owing to taxonomic uncertainty (although undescribed taxa would still be omitted, of course).
- Biological species are likely to be the most stable units for conservation planning and are better understood by the public and policy-makers than infraspecies (e.g. subspecies) or phylogenetic diversity.
- More data exist for implementing vulnerability and irreplaceability criteria at the species level than at any sub-specific level.
- Species appear to be good surrogates for phylogenetic diversity. It is unclear whether infraspecies are better or worse surrogates, but it is clear that infraspecies – if used in identifying sites of global conservation significance – should not be considered as equivalent to species. Nonetheless, since there is

no clear congruence between phylogenetic diversity and either vulnerability or irreplaceability, infraspecific/phylogenetic diversity may best be seen as a value of biodiversity for incorporation into the prioritisation of conservation actions rather than a reason for conservation urgency *per se*.

- Basing globally significant sites on a single taxonomic level would aid simplicity, whereas incorporating additional measures of sub-specific diversity would aid comprehensiveness. Potential compromise solutions might be either to identify globally significant sites based on species plus nationally or regionally significant sites based on infraspecific taxa, and/or to incorporate factors such as evolutionary distinctiveness at the point of prioritisation among identified sites but not as *a priori* criteria for identification of globally significant sites.
- Neither species nor infraspecies approaches can deliver numbers of significant sites that are appropriate to the conservation capacity of all countries. One solution may be to identify globally significant sites based on species, with thresholds that deliver an appropriate number of significant sites globally, but – where capacity for conservation is high – to also identify nationally or regionally significant sites based on infraspecific taxa.

(v) Should/How should vulnerability criteria be applied above the species level?

- The simplest approach would be to avoid the use of vulnerability criteria for biodiversity above the species level. However, an opportunity exists to use a developing globally-consistent ecosystem threat classification alongside national/regional ecosystem classifications that either already exist or are developed for this purpose.
- Inclusion of vulnerability criteria for biodiversity above the species level, alongside that at the species level, is valuable in its own right, as well as being likely to be the most effective way to ensure representation of threatened biodiversity process and threatened species not yet assessed on the Red List.
- Inclusion of vulnerability criteria for biodiversity above the species level would more closely align vulnerability and irreplaceability criteria. Further consideration should also be given as to whether further alignment would be useful – for example, using 'ecosystem irreplaceability' alongside, or instead of, 'biome-restricted assemblages'.

(vi) What should be the units for application of criteria above the species level?

- Approaches which incorporate finer-scale characteristics of ecosystems will be better able to identify the most globally significant sites than those based on ecosystems alone. Within the former set of approaches, biome-restricted assemblage approaches with simple thresholds are likely to identify more sites and with lower average importance than ranking approaches to contextual species richness.
- Existing global (ecoregional) ecosystem classifications have been quite widely used for irreplaceability assessments but may be too broad for vulnerability assessments. Finer-scale global classifications are more likely to capture fine-grained biodiversity pattern of conservation concern, but are unlikely to emerge in the short-term. Use of national/regional classifications at mixed scales may mean fixed criteria cannot be applied under a single global threat classification system.
- An approach based on ecosystems alone, particularly one based on existing ecosystem classifications, is simpler than any approach based on characteristics of ecosystems. Of these latter approaches, one based on sites that are particularly rich in 'indicator' species within particular ecosystems is more easily applicable than a more strict 'ecosystem-restricted' approach for poorly-known taxonomic groups, and less subject to problems of areal definitions of endemism.

(vii) What should be the taxonomic standards?

- The clearest and most transparent taxonomies will be those that state their underlying criteria and document why each taxon is considered a relevant unit (e.g. species) or not. Failing this, global taxonomies used by the IUCN Red List have the highest degree of transparency.
- Use of global, broad taxonomies ensures that national or regional assessments of globally significant sites will 'fit together' and promotes equal treatment of taxa within different groups.
- Use of the global taxonomies underlying the IUCN Red List would ensure coherence with global Red List assessments.
- Application of existing global-level taxonomies, particularly those of the IUCN Red List, would be easiest and simplest where they exist.

(viii) At what level should thresholds be set?

- Use of varying thresholds within a single criterion is both confusing and impossible to justify logically or scientifically. Thresholds within criteria can be standardised, if percentage or ranking thresholds are used, and would facilitate simplification of criteria through consolidation of sub-criteria.
- Tiered thresholds could facilitate production of a number of significant sites appropriate to varying national implementation capacity yet congruent with existing international policies (notably the Ramsar Convention). Suitable thresholds would require further testing, but could be at 1% for vulnerability and 5% for irreplaceability for globally significant sites, with lower 1% thresholds for irreplaceability for nationally significant sites in countries with higher implementation capacity.
- Separation of vulnerability and irreplaceability into two separate criteria is convenient but precludes easy prioritisation among sites, an issue which can only be solved by combined vulnerability and irreplaceability thresholds. Combined thresholds also provide an opportunity to avoid identification of sites for biodiversity features that may have few spatial conservation options but may be very secure and thus not of imminent conservation priority.

Recurring themes

Within these eight issues, and consideration of potential solutions, several significant recurring themes emerged:

- Incorporation of vulnerability criteria above the species level, i.e. at the habitat/ecosystem level, would not only ensure consideration of threatened habitats but is also likely to be the most effective way to ensure representation of threatened species not yet assessed on the Red List (Sections 3, 5, 6).

- Adoption of existing standardised global classifications and datasets such as species taxonomies, the IUCN Red List or global ecoregional classifications has significant advantages in terms of simplicity, but may miss identification of some significant sites (Sections 3, 4, 6, 7). Optimal resolution, or 'how many significant sites is enough?', is country- and taxon-specific (Section 8).

- A tiered system of significant site identification could have relatively high thresholds for globally significant sites, thus producing a relatively low number of sites that are manageable for countries/taxa with more limited resources, but have lower thresholds for nationally or regionally significant sites appropriate to the resource capacity of any given nation/country. Such a tiered system would provide a potential solution for dealing with species which have only undergone sub-global Red List assessments (Section 3), for dealing with infraspecific taxa (Section 4), and facilitate production of a number of significant sites appropriate to varying national implementation capacity yet congruent with existing international policies (Section 8). A tiered system could also allow incorporation of other nationally-specific issues such as national cultural importance or sub-nationally rare species (Criteria D and E for IPAs in New Zealand[1]).

[1] http://nzpcn.org.nz/page.asp?ecosystems_important_plant_areas_identification

C. Introduction

Aim of this background paper

The primary threat to most biodiversity is habitat destruction. Thus, the primary response from conservation must be to protect the places holding these habitats. For this response to be effective, however, protected areas must be located in the right places to safeguard the earth's biodiversity. In September 2009, the chairs of the IUCN Species Survival Commission (SSC) and the World Commission on Protected Areas (WCPA) convened a joint taskforce on 'Biodiversity and Protected Areas', one of the objectives of which is to forge scientific stakeholder consensus regarding the standards and criteria necessary to identify these sites. Specifically, this objective of the taskforce is stated as:

"Consolidating the global standards for the identification of sites of biodiversity conservation significance ("key biodiversity areas"). A huge body of work and experience exists in the identification of important sites for biodiversity conservation – many of which are protected areas already, the remainder of which are targets for protecting through appropriate mechanisms. This process will undertake a broad community consultation to converge on common global standards and criteria, under the IUCN umbrella. Its objective for the life of the taskforce (i.e., by 2012) is a comprehensive set of guidelines for measuring the biodiversity conservation significance of sites."

A primary objective of this taskforce is to solicit wide stakeholder input to gain consensus around standards and criteria for the identification of areas identified using the new standard. As such, in June 2012 a framing workshop, "Consolidating the standards for identifying sites that contribute significantly to the global persistence of biodiversity", was held in Cambridge, UK. A series of technical consultation workshops will follow the framing workshop, focusing on specific topics related to consolidation of these standards. These workshops will be supported by background options papers, of which this is one. This paper should be read in conjunction with a companion paper on delineation of KBAs (De Silva *et al.* 2012). The companion paper addresses questions of whether sites even need delineation, what the relative advantages are of basing sites on ecological or political/management boundaries, how delineation of boundaries may vary in different realms (terrestrial, freshwater or marine), and whether the taxonomic group being assessed will influence how sites are delineated.

This background options paper supports this taskforce objective, specifically by identifying key issues and approaches related to criteria and thresholds for identifying globally significant sites for biodiversity conservation. An overview is given of the importance of each issue, a brief review provided of potential approaches to each issue (based on those that have been taken to date), and a discussion laid out of advantages and disadvantages of each approach. This background paper is intended to provide a basis for discussions by working groups under the taskforce's stakeholder process.

Background and assumptions

The need to identify coherent networks of the most important places to safeguard biodiversity stimulated the field of systematic conservation planning. A central tenet of systematic conservation planning has always been that the use of surrogates (e.g. habitats) for biodiversity is an unfortunate necessity owing to the near infinite complexity of biodiversity and spatial biases in species distribution data (Margules & Pressey 2000), although species data are increasingly being included directly (e.g. Lombard *et al.* 1999). Ideally, data would be incorporated into systematic conservation planning at three main scales, which can be viewed as species, sites and habitats (ignoring, for a moment, debates about taxonomic scale or habitats versus ecosystems, and the need to incorporate process as well as pattern). Habitat data are now available globally across freshwater, marine and terrestrial realms (Olson *et al.* 2001; Abell *et al.* 2008; Spalding *et al.* 2007), albeit not necessarily at an appropriate scale for conservation planning (Section 6.3.2), prioritisations of importance have been conducted (e.g. Olson & Dinerstein 1998), and a system for identification of vulnerability is being developed (Rodríguez *et al.* 2011). Data on species' vulnerability and distribution have significant taxonomic gaps but are ever-improving, in particular owing to global and national Red Lists (Rodrigues *et al.* 2006). A marked gap, however, exists at the site scale: other than already-protected areas[2], no consistent global dataset of sites of biodiversity conservation significance exists. Likewise, there is no widely adopted cross-institution/-taxon standard for identifying such sites. This effort under the joint SSC-WCPA taskforce aims to tackle this gap in standards.

The identification of sites of biodiversity conservation significance has a long history in both academic and applied conservation science. On the academic side, development of systematic conservation planning over the last two decades has built upon a conceptual framework of irreplaceability (uniqueness) and vulnerability (probability of loss) (Margules & Pressey 2000). On the applied side, the BirdLife International partnership has been using this framework of irreplaceability and vulnerability since the early 1980s to identify sites of global significance for bird conservation, known as 'Important Bird Areas' (IBAs; Osieck & Mörzer Bruyns 1981). The success of such work has stimulated identification of globally significant sites for other taxa, notably including plants ('Important Plant Areas'; e.g. Plantlife International 2004), butterflies ('Prime Butterfly Areas'; e.g. van Swaay & Warren 2006), reptiles and amphibians ('Important Herpetological Areas'; e.g. Stumpel & Corbett 2007, and 'Priority Amphibian and Reptile Conservation Areas'; Sutherland & deMaynadier 2012), fungi ('Important Fungus Areas'; e.g. Evans *et al.* 2001), and dragonflies ('Important Dragonfly Areas'; e.g. Dyatlova & Kalkman 2007). Although initiated on land, it has also stimulated identification of sites across realms, i.e. marine (e.g. Edgar *et al.* 2008b) and freshwater (e.g. Darwall & Vié 2005). The 'Alliance for Zero Extinction' (AZE) identified all sites holding the entire population of at least one globally Endangered or Critically Endangered species for several taxonomic groups (Ricketts *et al.* 2005). Langhammer *et al.* (2007) attempted the first synthesis of methods, criteria and thresholds across taxa and realms into a 'Key Biodiversity Areas' framework – an effort that included identification of key issues and further research needed. Key Biodiversity Areas-type approaches have particular value in identifying sites of certain global significance for biodiversity conservation, rather than sites of predicted significance based on surrogates. Langhammer *et al.* (2007) stimulated much further work in recent years (Foster *et al.* 2012), upon which this paper builds.

Vulnerability and irreplaceability were initially used in systematic conservation planning with very strict definitions, but their use in conservation planning has led to different, generally broader definitions. Vulnerability refers in systematic conservation planning solely to the threat status of sites, rather than the biodiversity that they hold (biodiversity vulnerability is implicitly included within irreplaceability). Within this paper, for consistency with most Key Biodiversity Area (KBA)-type approaches (Langhammer *et al.* 2007), vulnerability is used in a broad sense to refer to the threat status of biodiversity for which sites have been identified as significant. For example, a secure site with lots of globally-threatened species would be considered highly vulnerable in a broad sense, but not very vulnerable in a systematic conservation planning sense. The broad definition is preferred here, in the context of identifying sites of global significance, because use of the systematic conservation planning definition would identify priorities for conservation action (Conservation International 2006) rather than priorities for biodiversity *per se*. Irreplaceability in systematic conservation is measured against a pre-defined target: e.g., even single-site endemic species are not irreplaceable if your conservation target is to save 50% of biodiversity. Within this

[2] http://www.wdpa.org

paper, for consistency with most KBA-type approaches (Langhammer *et al.* 2007), irreplaceability is used in a broad sense to refer to relative irreplaceability within broadly assumed goals of comprehensive conservation (i.e. saving all biodiversity components).

IUCN (2012) start to discuss the degree to which criteria in KBA-type approaches cover the spectrum of biological organisation, from ecosystems to species to genes and across composition, structure and function. The following table attempts a gap analysis of these factors against the criteria and sub-criteria outlined by Langhammer *et al.* (2007), namely:

Criterion 1: Vulnerability

Criterion 2: Irreplaceability

Sub-criterion a: Restricted-range species

Sub-criterion b: Species with large but clumped distributions

Sub-criterion c: Globally significant congregations

Sub-criterion d: Globally significant source populations

Sub-criterion e: Bioregionally restricted assemblages

	Composition	**Structure**	**Function**
Ecosystems	Irreplaceability: assemblages	-	-
Species	Vulnerability	Irreplaceability: clumped distributions; congregations	Irreplaceability: congregations; source populations
Genes	-	-	-

The coverage of these criteria across composition, structure and function, and ecosystems, species and genes, would be increased by a number of potential adjustments to criteria that are discussed in this options paper. Approaches to incorporation of ecosystems are discussed in Sections 3.2.4, 5.2.2 and 6.2.2. Approaches to incorporation of infraspecific variation, such as genes, are discussed in Sections 4.2.1 and 4.2.2.

In general, issues discussed in this paper fall into two main groups. First, despite the substantial efforts to date, some particularly complex questions have not been resolved. Second, because of the diversity of efforts to date, a variety of approaches have been developed – these have yielded important advances in identifying appropriate criteria and thresholds for particular taxa or realms, but have also reduced global consistency even within taxa or realms. This second group contains the majority of issues discussed in this paper, and is a driving force behind the taskforce's goal to consolidate efforts to date into common global standards and criteria. Without greater consistency or a clear framework of relationships, priority areas for different taxa, realms or regions may present a confusing overlapping set that is difficult to understand or resolve for policymakers and other stakeholders (e.g. Melovski *et al.* 2012).

Discussion in this paper is based around the taskforce's definition of its goals and best practice in conservation planning science. The former aims for 'consolidation' of global standards for identifying 'sites of biodiversity conservation significance'; this paper thus considers consolidation and consistency of criteria/thresholds as an advantage, and is primarily focused on sites of global biodiversity conservation significance (henceforth 'significant sites' for convenience). Further, it does not consider prioritisation of significant sites or conservation actions in depth. Many factors such as site connectivity, refugium value or genetic variability (see Section 4) are important to consider during the prioritisation of conservation efforts. There have been calls to incorporate some of these into identification of KBAs as globally significant sites (e.g. Knight *et al.* 2007), but Bennun *et al.* (2007) stated that KBAs are not intended to provide a complete, packaged conservation solution, but "a focused response to a central problem in conservation." One potential compromise solution might be to incorporate these additional factors at the point of prioritisation among identified significant sites, but not as *a priori* criteria for identification of significant sites. Indeed, Holland *et al.* (2012) noted that "The identification of [significant sites] and the application of conservation planning approaches can be seen as having a synergistic relationship where the former identifies sites that are important for the conservation of species diversity and the latter prioritises amongst sites to identify a practical and effective network of protected or managed areas." The value of a global dataset of sites of biodiversity conservation significance for systematic conservation planning was stressed above.

Best practice in conservation planning science focuses, as mentioned above, on a core complement of irreplaceability and vulnerability; this paper thus focuses discussion on the ability of various approaches to assess these factors at a global level. Such a focus significantly increases the utility of any resulting consolidated global standards, as irreplaceability and vulnerability are also central to existing conservation efforts such as the UNESCO World Heritage Convention (Criterion x; Foster *et al.* 2010), the Ramsar Convention (Criteria 1, 2, 5, 6 and 9 in particular), High Conservation Value (HCV) Forest approach (Criterion 1 and 3; Jennings *et al.* 2003), the Convention on Biological Diversity's Ecologically and Biologically Significant Area (EBSA) approach for the marine realm (Criteria 1 and 3 in particular; CBD 2008; Weaver & Johnson 2012), the Food and Agriculture Organization's Vulnerable Marine Ecosystem (VME) approach (Criterion 1; FAO 2009), and the International Maritime Organization's Particularly Sensitive Sea Area (PSSA) approach (IMO 2005). Further, irreplaceability and vulnerability form the core of criteria used to identify potential high risk areas for development by leading multinational development banks such as the International Finance Corporation (Performance Standard 6) and European Bank for Reconstruction and Development (Performance Requirement 6), and by extension more than 75 private banks which have signed up to the Equator Principles. Consolidated global standards for identification of globally significant sites for biodiversity conservation could thus play a central role not only in guiding selection of sites for global conservation efforts, but also avoidance or minimisation of impacts on sites by global development efforts.

1 Should the criteria utilise absolute or percentage thresholds?

1.1 Introduction

Thresholds are at the heart of identification of significant sites since they are the cut-off points at which something higher is judged to be of 'global significance' and something lower is judged not to be of 'global significance'. Global significance is inherently based on the importance of a particular site for a given biodiversity feature (e.g. a species) in comparison to all sites known for that feature globally. Such a comparison may be based on a percentage (e.g. 'all sites holding >5% of global population') or ranking (e.g. 'top ten sites globally' or 'top 1% of sites') approach or – in the case of absolute thresholds – a 'rule of thumb' approximating to the percentage approach (e.g. 'all sites holding >20,000 individuals'). The different approaches have varying inherent limitations, for example in their ability to assess global significance, to deal with incomplete knowledge, or to deal with changing information over time. In addition, inherent biases exist. For example, percentage thresholds are focused towards conservation of biodiversity features with high irreplaceability (e.g. those with more clumped or restricted distributions) whereas the ranking approach is focused towards conservation of features which occur at many sites (i.e. those with more even or widespread distributions). After a review of existing approaches, Langhammer *et al.* (2007) defined absolute thresholds for vulnerability and percentage thresholds for irreplaceability. Such an inconsistent approach is hard to justify, since there is no inherent reason to threshold threatened and restricted-range biodiversity features differently. The varying limitations and foci of the different approaches should be evaluated and weighed against one another in order to select the single, most appropriate method for assessing global significance.

1.2 Potential approaches

1.2.1 Absolute thresholds

Heath & Evans (2000) used a variable threshold for globally Vulnerable species, which was "calculated from the size of the species' global population and also depends upon whether the species has a relatively large or small body size, and whether it has primarily dispersed or colonial nesting habits". Fishpool & Evans (2001) used a more standardised threshold of 10 pairs (or 30 individuals) for globally Vulnerable species (and of one individual for Critically Endangered or Endangered species). Current BirdLife global IBA criteria (e.g. Fishpool & Evans 2001) have moved away from such a standardised approach, stating that absolute thresholds for vulnerability are "set regionally, often on a species by species basis" – an approach which may tend even more towards setting of percentage thresholds because thresholds are tailored to population sizes of particular species (which percentage thresholds already take into account). Langhammer *et al.* (2007) proposed provisional standardised absolute thresholds for vulnerability as a "starting point for subsequent testing, including consideration of thresholds for the percentage of a species' total population".

Darwall & Vié (2005) used an absolute threshold approach to irreplaceability, identifying sites as significant if they held "non-trivial numbers of one or more species of restricted range". According to Holland *et al.* (2012) 'non-trivial' is solely used to exclude vagrants and thus the threshold is merely presence of one or more individual. In part, this is based on the difficulties involved in estimating local and global population numbers for freshwater species. Holland *et al.* (2012) tested a rather different type of absolute threshold for vulnerability to identify significant sites, based on the number of threatened species (e.g. >5 Vulnerable species occurring at a site), rather than the population of a threatened species, at a site. They concluded that such thresholds (based on the number of threatened species at a site) could "lead to serious omissions in identifying potential KBAs" (because it would miss the many sites which hold one or a few threatened species as site endemics) and that this approach should thus not be taken.

1.2.2 Percentage thresholds

Ricketts *et al.* (2005) proposed a 95% population threshold to identify sites at which Endangered or Critically Endangered species were confined as 'Alliance for Zero Extinction' (AZE) sites. Darwall & Vié (2005) proposed percentage thresholds to identify KBAs for threatened freshwater taxa. Subsequently, recommendations were given for separate thresholds for data-poor and data-rich situations and, in the latter case, for species with different life history strategies (W. Darwall pers. comm. in Langhammer *et al.* 2007). Edgar *et al.* (2008a) used a single percentage threshold for widespread Endangered and Vulnerable species in the Galapagos to avoid identifying too much of the archipelago's coastline as of global conservation significance. For 'priority threatened habitats', Plantlife International (2004) used a percentage threshold of "5% or more of the national resource (area)".

With respect to irreplaceability, Langhammer *et al.* (2007) provisionally proposed a single global percentage threshold for restricted-range species across taxa, and followed a similar approach for other irreplaceability sub-criteria. This approach was followed in the marine realm by Edgar *et al.* (2008b).

Combining vulnerability and irreplaceability considerations, Plantlife International (2004) identified as globally significant sites that contain 5% of the national population of threatened endemic or 'near endemic' species.

1.2.3 Other approaches

A mix of absolute and percentage thresholds has been used in many cases for irreplaceability (Langhammer *et al.* 2007). Global IBA criteria for irreplaceability (e.g. Fishpool & Evans 2001), for example (following on from similar mixed thresholds for waterbirds under the Ramsar Convention), use both percentage (e.g. "1% of the global population of a congregatory seabird... species") and absolute (e.g. "10,000 pairs of seabirds of one or more species") thresholds under Criterion A4, and only absolute thresholds under A2 (for restricted-range species). The only direct comparative testing of absolute and percentage thresholds to date has been conducted for marine turtles by Bass *et al.* (2011). This showed some potential for aligning absolute and percentage thresholds. There is thus possibly an opportunity that a similar 'rule of thumb' could be constructed to align absolute and percentage thresholds and so use them in parallel for any given species. This would, however, require extensive testing and calibration and might well not even be satisfactorily achievable since the level at which absolute and percentage thresholds align is likely to vary significantly among taxa.

The global IBA approach under Criterion A4 highlights another issue in that thresholds are not always set for irreplaceability of sites for individual species, but sometimes also for irreplaceability of aggregations of individuals (of one or more species). An advantage of this approach is that it might identify otherwise-missed sites important to small numbers of many different species. One disadvantage is that it would be impractical to apply such an approach across taxonomic groups (numbers of individuals would be wholly swamped by invertebrates, for example). Another consideration is that this approach shifts the unit for consideration to the level of individuals, which is unlikely to be a sensible or practical level at which to establish global conservation targets.

Another approach would be to use a ranking (rather than threshold) approach, i.e. one in which the 'top 10' or 'top 5%' of sites were considered priorities. Systematic conservation planning approaches typically take such an approach (e.g. Romo *et al.* 2007; Marignani & Blasi 2012). In defining IPAs, a mixed approach of percentage thresholds and ranking is usually used for threatened species (e.g. Plantlife International 2004;

Radford *et al.* 2011), the latter likely being a response to the frequent lack of population data for plants: either all sites holding ≥5% of the national population of a threatened species or the five 'best sites'. Similar approaches have been taken to species-rich habitats and, at least by Anderson (2002), to threatened habitats. Likewise, Sutherland & deMaynadier (2012) allowed use of percentage and/or ranking approaches for reptiles and amphibians.

Edgar *et al.* (2008a) allowed a ranking approach in some cases: identifying as KBAs sites where "individuals concentrated in high numbers relative to the global population" in situations where good estimates of total population numbers were lacking. While BirdLife global IBA criteria do not take a ranking approach, regional criteria often have elements of ranking, e.g. "The site is one of the five most important sites in the country/territory for a species with an unfavourable conservation status in the Middle East..."[3]

It should also be noted that Al-Abbasi *et al.* (2010) considered removing all thresholds and using an entirely qualitative approach to be "more flexible and pragmatic". The obvious disadvantage of such an approach is the absence of standardisation or comparability.

1.3 Key advantages and disadvantages of potential approaches

1.3.1 Ability to assess global significance

Global significance is inherently based on the importance of a particular site for a given biodiversity feature in comparison to all sites known for that feature globally. Such a comparison may be based on a percentage (e.g. 'all sites holding >5% of global population') or ranking (e.g. 'top ten sites globally' or 'top 1% of sites') approach. These both consistently identify sites of global significance across features, albeit in slightly different ways. Simplistically, the percentage approach is focused towards conservation of biodiversity features which occur at many sites whereas the ranking approach is focused towards conservation of features which occur at few sites (i.e. those with more clumped distributions).

Absolute thresholds are, however, intrinsically arbitrary in that they do not consider the relationship between a given site and the global number of sites or global population of a given species, or extent of a given ecosystem. They were developed as less precise 'rules of thumb', approximating to a percentage approach, for dealing with incomplete knowledge of all sites and global populations of species or extents of ecosystems. If absolute thresholds are set too low, sites of low global significance will be identified for some biodiversity features (e.g. Bass *et al.* 2011). Conversely, if absolute thresholds are set too high, some sites of global significance will not be identified – an even worse situation. Unless defined biodiversity feature-by-biodiversity feature, which would therefore tend towards a percentage approach, absolute thresholds will thus have difficulty in identifying sites of global significance across features. In some cases, globally significant sites will be ignored. In others, globally non-significant sites will be erroneously identified as significant.

1.3.2 Ability to deal with incomplete knowledge

Knowledge of the extent of ecosystems is relatively straightforward, depending on the scale of ecosystem classification chosen (Section 6). For many species, however, estimates of population size are neither already published nor feasible to calculate at either the global, regional or site level. As noted above, absolute thresholds were developed as less precise 'rules of thumb' for dealing with such incomplete knowledge. Ranking approaches are also able to cope with incomplete knowledge since they only require relative judgements (which sites are more important than others). Conversely, a percentage approach to populations would seem to require knowledge of global population sizes for all species. However, in a

[3] http://www.birdlife.org/datazone/info/ibacritme

different kind of global site significance assessment[4], TBC (2010) and TBC & FFI (2011) used a hierarchy of surrogates for global population size in order to deal with incomplete knowledge. In order of preference, this hierarchy was: (i) global population size itself where known (or estimated); (ii) global Area of Occupancy; and (iii) global Extent of Occurrence or number of known sites (these latter two options can only really be chosen among on a case by case basis). This surrogate approach was based on prior examples such as the ability, when assessing species against IUCN Red List Criterion A (population reduction), to infer or suspect the degree of population reduction based on a reduction in EOO, AOO, number of sites or extent of potentially suitable habitat (IUCN Standards and Petitions Working Group 2008). Such a surrogate approach would enable percentage thresholds (in either a percentage or ranking approach) to be effectively used as absolute thresholds in data-poor situations, though even refined species ranges will produce problematic omission and commission errors (Rodrigues 2011). For example, with a >1% threshold and no population data, all sites encompassing >1% of the global EOO of a species (with confirmed records of the species, to avoid commission errors) could be identified as priorities. The use of AOO as a surrogate was also trialled by Radford *et al.* (2011; Criterion A(v)), alongside 'national endemism' (Criterion A(ii)) – a similar coarse surrogate approach. Such surrogate approaches have particular advantages for groups where it may even be difficult to identify 'individuals' in a population (e.g. for some plants and fungi).

Few surrogates are perfect representations of that which they are intended to represent. The surrogates listed above assume that the global population of each species is distributed evenly across the global AOO, global EOO, and global number of sites for each species. The degree to which species, in reality, have more clumped distributions would determine the risk of such a surrogate approach to percentage thresholds in producing omission and commission errors (respectively, globally significant sites being ignored and globally non-significant sites being erroneously identified as significant). It should be noted that similar issues exist with relation to absolute thresholds (Section 1.3.1) – the magnitude of the issues for each type of threshold deserves research and field-testing.

1.3.3 Flexibility to incorporate changing information

Whether through genuine changes in status or through changing knowledge, estimates of global population sizes (or of surrogates such as AOO, EOO or number of sites) and of extent of ecosystems will vary over time. Sites identified through absolute thresholds would not require revision under such a scenario, but sites identified through percentage or ranking thresholds would require regular review. After such review, previously identified sites may be considered no longer globally significant (e.g. when a species' population increases) or sites previously considered not to be of global significance may now gain significance (e.g. when species' populations are declining). Absolute thresholds thus have the advantages of stability and ease of implementation, whereas percentage and ranking thresholds have the advantage of being more responsive to actual (changing) conservation needs.

1.3.4 Ease of definition and use across ecosystems/taxa

It is much more likely that suitable, if imperfect, single percentage or ranked thresholds could be defined across ecosystems and taxa, regardless of whether terrestrial or marine realms are being considered, and whether invertebrates, plants or vertebrates are under consideration. For example, any site with more than a certain percentage (e.g. 1% or 5%) of the global population of a species or extent of an ecosystem could be defined as globally significant (percentage threshold). Alternatively, any site in the top set (e.g. 10 or 20) globally for a species or ecosystem could be defined as globally significant (ranked threshold). Either approach would simplify the most common approaches to vulnerability, which have different absolute thresholds for different threat statuses. Further, it seems very unlikely that a single absolute threshold

[4] To assess whether sites qualify as 'Critical Habitat' under International Finance Corporation criteria within Performance Standard 6 on Biodiversity Conservation and Sustainable Natural Resource Management.

could be defined for a diversity of realms and taxa. To date, arguments have been made for defining different absolute thresholds depending on whether considered species are terrestrial or marine (e.g. Edgar *et al.* 2008b), plant (e.g. Radford *et al.* 2011), or even among different bird species (e.g. current BirdLife global IBA criteria; Fishpool & Evans 2001).

Absolute thresholds are particularly problematic for taxonomic groups in which individuals, and thus population sizes, may be difficult to isolate. For example, a number of fungi and plants form extensive genetically identical units connected by underground root or mycelial systems. For these groups, percentage thresholds, based on surrogates such as EOO (Section 1.3.2) are much easier to apply.

1.3.5 Focus on features with different spatial distribution patterns

The percentage approach is inherently more focused towards conservation of biodiversity features with more restricted or clumped distributions than the ranking approach. The ranking approach will intrinsically identify a set of 'globally significant' sites for any feature, but the percentage approach will only do so when features' distributions are either (i) restricted enough that each site holds a relatively high percentage of a feature, or (ii) clumped enough that significantly different population sizes/extents of ecosystems occur at different sites. The absolute threshold approach, as a coarse cut of the percentage approach, also tends to be more focused towards conservation of features with more restricted or clumped distributions. In general, it is expected that focus would be preferred towards features with more restricted or clumped distributions – indeed, this desire is inherent to the irreplaceability criterion – and thus that percentage thresholds (including absolute thresholds) have advantages over a ranking approach.

1.3.6 Overview of advantages and disadvantages of potential approaches

- Percentage thresholds and ranking approaches more directly and precisely assess global significance.

- Absolute thresholds are most robust to incomplete knowledge, followed by ranking approaches. Adopting a hierarchical surrogate approach to percentage thresholds (e.g. use of % of Area of Occupancy where data on % of population are unavailable; use of % of Extent of Occurrence where data on % of Area of Occupancy are unavailable; etc.) would allow these to also effectively deal with incomplete knowledge. Such a surrogate approach would have additional advantages for groups where it may even be difficult to identify 'individuals' in a population (e.g. for some plants and fungi).

- Absolute thresholds are more stable and easy to implement when status or knowledge of a biodiversity feature is changing. Percentage thresholds and ranking approaches are more responsive to changing conservation needs.

- Percentage and ranked (e.g. 'the top 5% of sites') thresholds are likely to be easier to define and use across ecosystems and taxa.

- Percentage and absolute thresholds both have a more appropriate focus on irreplaceability than a ranking approach (which will also identify sites for widespread, low density biodiversity features).

- It might be possible to develop a single rule of thumb to enable simultaneous use of absolute and percentage thresholds. This would, however, require extensive testing and calibration and may not even be satisfactorily achievable.

1.3.7 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: / Approach:	Ability to assess global significance	Ability to deal with incomplete knowledge	Flexibility to incorporate changing information	Ease of definition and use across ecosystems/taxa	Focus on features with different spatial distribution patterns
Absolute thresholds	-	+ +	+	- -	+
Percentage thresholds	+ +	(+)	-	+	+ +
Ranking approaches	+ +	+ +	-	+ +	-

2 How should restricted-range definitions be established across species groups?

2.1 Introduction

Irreplaceability criteria for identifying globally significant sites for biodiversity conservation may include both taxa and broader habitats/ecosystems/biomes/communities/assemblages (Section 6). A key consideration for understanding irreplaceability of sites for taxa will necessarily be whether percentage or absolute thresholds are used for determining how much of their population/range should be present at a site in order for it to be considered globally significant for biodiversity conservation (Section 1). However, even prior to this consideration, there is a need to define what is meant by a restricted-range taxon. A diversity of approaches have been used or suggested (Section 2.2), leading to significant inconsistency across taxa and regions such that a nationally-endemic plant in one region may be considered to be restricted-range, whereas a nationally-endemic bird in the same region may not be considered restricted-range – or vice versa in a different region. For a framework aimed at identifying globally significant sites for biodiversity conservation, a consistent approach is essential. There is thus a need to weigh advantages and disadvantages of the various approaches used to date in order to assess whether any single approach might suit all realms and taxonomic groups.

2.2 Potential approaches

In terms of irreplaceability, global significance could be considered to be absolute across taxa or proportional within taxa. For example, considering only absolute significance, taxa with generally smaller ranges (e.g. plants, invertebrates) would be considered generally more restricted. Thus, a single threshold globally (e.g. <10,000 km^2) would capture a considerably higher proportion of, e.g., plants and invertebrates than birds and mammals. Considering proportional significance assumes a desire for some degree of representation across taxonomic groups, such that a fixed percentage of each taxonomic group would be considered equally restricted. Thus, a single threshold (e.g. 25% of species in each taxonomic class) would capture a set of taxa with very different absolute ranges, e.g. those plants identified would have much smaller average range sizes than those birds identified. There are, however, also arguments that proportional significance is partly related to viability needs: larger-bodied species require larger ranges (e.g. an ungulate with a range of 40,000 km^2 could be considered restricted-range owing to a small population carrying capacity within this range, while a butterfly with the same range may have a much higher carrying capacity and thus not be considered restricted-range – the number of options for conservation of a viable population within this range are higher for the butterfly). Further, the issue of 'number of sites' confounds 'range size' when assessing spatial options for conservation or risk of extinction. Nonetheless, it appears a general truism that smaller range species – of whatever taxonomic group – have fewer spatial options for conservation and are inherently at greater extinction risk from catastrophes. Thus, in general, choice of proportional significance does express a desire for some degree of representation across taxonomic groups.

While absolute approaches to global irreplaceability fit most closely with principles underlying conservation planning (i.e. they represent a desire to prioritise based solely on the number of available options for conservation and the inherent risk of small range size), all approaches to date have been forms of proportional approaches (Langhammer *et al.* [2007] recommended an absolute approach, but only as an interim measure). This could reflect underlying societal desires for conservation representation across taxa, but is absent in vulnerability assessments (e.g. via the IUCN Red List criteria). The optimal proportional approach would be a percentile one (Section 2.2.3), but this would practically be impossible to implement for most taxonomic groups (Section 2.3.2) and so most approaches have been based on coarser proportional approaches based on thresholds. Explicitly within such proportional approaches, it is recognised that either range-based (Section 2.2.1) or area-based endemism (Section 2.2.2) thresholds should vary across taxonomic groups and realms. In general, it has been considered appropriate to use similar thresholds within realms within high-level taxonomic groups (e.g. within plants or terrestrial vertebrates).

One intermediate approach between proportional and absolute approaches might be to set different percentage thresholds for different taxonomic groups – e.g. 25% of plants may be considered restricted-range, but 15% of mammals, etc. Thus, taxa with generally smaller ranges would be considered generally more restricted but a degree of representation would take place. However, there does not appear to be any logical place at which to draw such thresholds for each taxonomic group.

2.2.1 Range-based numerical thresholds

BirdLife International's global IBA criteria (e.g. Fishpool & Evans 2001) use a definition of restricted-range for birds of "world distributions of less than 50,000 km^2", dating back to the ground-breaking work on restricted-range species by Stattersfield *et al.* (1998), in turn based on the work of Terborgh & Winter (1983). Langhammer *et al.* (2007) acknowledged issues with this threshold in relation to plants, invertebrates, and freshwater and marine systems, but provisionally recommended it be used for all taxa until better data were available to refine thresholds for other groups. They clarified 'world distribution' as 'breeding Extent of Occurrence [EOO]'. A case study from Turkey in Langhammer *et al.* (2007) considered 50,000 km^2 to be a reasonable threshold for plants and freshwater fishes, the former because "Nearly all of Turkey's 3,022 endemic plants occur in areas less than 50,000 km^2." Not all IBA inventory efforts have used the 50,000 km^2 threshold: in Canada, IBAs were identified for "species with small total breeding ranges (i.e. greater than 100,000 km^2 but less than 250,000 km^2) and important populations within North America (i.e. more than 50% of the North American distribution). At the national level, distinctive subspecies with breeding ranges of less than 50,000 km^2 are also included."[5]

A smaller threshold, of global Extent of Occurrence of <5,000 km^2, has generally been used for 'near endemic/limited range' taxa for plants (e.g. Radford *et al.* 2011), because use of a 50,000 km^2 threshold would result in too high a proportion of the area of some countries being identified as IPAs (Yahi *et al.* 2012).

Edgar *et al.* (2008b) used a larger threshold, of <100,000 km^2, for marine species based on their generally much larger distributions. Further, Edgar *et al.* adopted workshop suggestions that the area of continental shelf be used in calculations of EOO for coastal "species with linear distributions that are difficult to quantify realistically in terms of area, most notably intertidal species distributed along continental margins." Bass *et al.* (2011) followed this higher threshold for marine species.

Holland *et al.* (2012) tested percentile and range-based thresholds for freshwater taxa in Africa, concluding that the odonates, being vagile, had similar enough distributions to birds and mammals that a range-based threshold of <50,000 km^2 would be appropriate. However, they considered a range-based threshold of <20,000 km^2 more appropriate for most assessed taxa (crabs, fish and molluscs) as it captured 20-30% of species within those groups.

[5] http://www.ibacanada.ca/canadian_IBA_criteria.pdf

2.2.2 Area-based endemism thresholds

Jennings *et al.* (2003) suggested that 'endemic species' be identified at either a national or sub-national level. The Ramsar Convention includes a focus on both nationally endemic taxa and those "for which [a] country holds a significant proportion of the total global... population" (i.e. near endemic taxa). Anderson (2002) did not have a specific focus on taxon-based irreplaceability, but included nationally-endemic and 'near endemic/limited range' taxa under vulnerability criteria when they were also nationally threatened. Plantlife International (2004) and Radford *et al.* (2011) followed this approach, though replacing 'limited range' with 'restricted range' – the latter authors defining this term as having a global Extent of Occurrence of <5,000 km^2. In an Arabian assessment of globally significant sites, Al-Abbasi *et al.* (2010) included (i) nationally-endemic taxa, (ii) 'near endemic taxa', which they defined as those "endemic to a geographical unit which crosses political boundaries, for example the wet woodland of Dhofar/Hawf", (iii) regionally-endemic taxa, and (iv) 'regional range-restricted taxa', which they defined as "endemic to a certain biogeographical area, for example Afromontane endemic, which extends beyond the Arabian Peninsula." Romo *et al.* (2007) prioritised identification of sites in the Iberian Peninsula for butterflies endemic to that region. The strictest approach to area-based endemism thresholds is endemism at the site level, as contained within Ramsar Convention criterion B7: "If at least 10% of fish are endemic to a wetland... that site should be recognized as internationally important" and as used (in combination with high vulnerability) for the identification of Alliance for Zero Extinction sites (Ricketts *et al.* 2005). Sites with endemic species are also very likely to be identified as globally significant by range-based numerical and percentile approaches.

2.2.3 Percentile approach

Langhammer *et al.* (2007) outlined the potential for a percentile approach in which range restriction would be measured relative to the overall distribution of range sizes within a given taxon. For example, the lowest quartile of species' range sizes could be considered as restricted-range. However, they noted that this approach is both theoretically and practically problematic (Section 2.3.2) and did not recommend it as a way forward.

2.3 Key advantages and disadvantages of potential approaches

2.3.1 Consistency

Range-based and percentile approaches are globally consistent, whereas area-based endemism approaches produce different results in countries or regions of varying size: everything else being equal, larger areas have more endemic species with larger average ranges. Further, genuinely restricted-range species may be omitted by area-based endemism approaches when countries have borders defined by mountain ranges.

If representation across taxa is considered important, range-based approaches can be standardised within high-level taxa within realms in order to assess similar proportions of taxa as restricted-range (e.g. range-based thresholds set at the level of the most restricted 25% of terrestrial vertebrates, 25% of plants, 25% of freshwater fish, etc.) Such standardisation will require testing of various range thresholds and choice of thresholds which produce similar results in each high-level taxon in each realm. This approach is similar to a percentile approach but, because thresholds would be fixed areas, would not require re-assessment of taxa unless their known ranges changed (Section 2.3.2).

2.3.2 Ease of application

Practically, a percentile approach "requires that [ranges of] all species within a given taxon be assessed before a species can be defined as having a restricted range" (Langhammer *et al.* 2007), and would require re-categorisation of all species whenever species were discovered, split or lumped (Holland *et al.* 2012). This would hinder identification of significant sites under irreplaceability criteria in even well-known taxonomic groups. Range-based numerical approaches are easy to apply for well-known taxonomic groups, such as most terrestrial vertebrates, but are not easy to apply with precision for the majority of species for which global distributions have not been mapped or estimated. Area-based endemism approaches, particularly those based on national boundaries, are simplest as they require only imprecise data on distributions.

Langhammer *et al.* (2007) also noted that any percentile approach would have a need for clarity as to the taxonomic level at which the lowest percentile of range sizes should be assessed, because frequency distributions for range size will vary with taxonomic level (e.g. both among mammal families or genera, as well as among mammals and amphibians, or among vertebrates and invertebrates).

2.3.3 Minimisation of omission and commission errors

Flat absolute thresholds (i.e. 'one size fits all taxa' thresholds as proposed by Langhammer *et al.* 2007), and area-based endemism approaches, have the disadvantage that they either miss sites for species with larger average ranges (e.g. marine species, vertebrates) or include too many sites for species with smaller average ranges (e.g. plants and invertebrates). Percentile approaches would minimise such issues as, if carefully tailored to species groups, could variable absolute thresholds (which are emerging in practice; Section 2.2.1). A major question with variable absolute thresholds would, however, be at what taxonomic level to group taxa (e.g. at the kingdom, phylum, class or order level).

2.3.4 Overview of advantages and disadvantages of potential approaches

- Global significance could be considered to be absolute across taxa (e.g. a single threshold of <10,000 km^2) or proportional within taxa (e.g. the most narrowly distributed 25% of species in each class). Absolute approaches to global irreplaceability fit most closely with conservation planning principles, but have not yet been advocated. If representation across taxa is instead considered important, range-based approaches could be standardised within high-level taxa within freshwater, marine and terrestrial realms in order to assess similar proportions of taxa as restricted-range.

- Range-based and percentile approaches are globally consistent, whereas area-based endemism approaches (e.g. species endemic to country X) produce different results in countries or regions of varying size.

- Area-based endemism approaches, particularly if based on national boundaries, are simpler to apply than range-based approaches – especially in data poor situations. Percentile approaches are not practically possible for many taxonomic groups.

- Percentile approaches would minimise site omission and commission errors, as, if carefully tailored to species groups, could variable absolute thresholds.

2.3.5 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: Approach:	Consistency	Ease of application	Minimisation of omission/commission errors
Range-based numerical	+ +	-	-
Area-based endemism	- -	+ +	-
Percentile	+ +	- -	+ +

3 How should vulnerability criteria be applied to groups for which the Red-listing process hasn't been applied globally?

3.1 Introduction

The global IUCN Red List assesses almost 60,000 species, including over 34,000 vertebrates, 14,000 plants and 11,000 invertebrates. Coverage is comprehensive for mammals, birds, amphibians and some smaller groups such as conifers, cycads, freshwater crabs and reef-forming corals[6]. Freshwater species have been a serious gap, but recent initiatives are rapidly addressing this (e.g. Darwall *et al.* 2011b). Nonetheless, major gaps remain, particularly among marine species and plants. Since identification of globally significant sites rests upon knowledge of vulnerability and irreplaceability, the lack of global assessments of vulnerability for some groups of species is of major concern. Opportunity exists to fill some of these gaps through use of sub-global assessments of species' threat status: more than 100 countries and regions have reportedly developed sub-global Red Lists[7].

3.2 Potential approaches

3.2.1 Inclusion solely of assessed globally-threatened taxa

BirdLife International global IBA criteria (e.g. Fishpool & Evans 2001) include only globally-threatened taxa, a simple approach for BirdLife to take since all bird species have been assessed globally.

3.2.2 Assessment of previously non-assessed taxa

Edgar *et al.* (2008a) included not only assessed globally threatened taxa but also "taxa not previously assessed for the Red List, but which qualify under threatened species criteria", partly via new Red List workshops. Likewise, Holland *et al.* (2012) actively conducted participatory Red List assessments for freshwater species groups which were under-represented in global assessments. Assessment of previously non-assessed taxa could take place in formal processes or via preliminary assessment methods. For example, Red List Criterion D, related to intrinsic vulnerability owing to small population or range, is quite easily applied to species by even those with no prior Red List experience. At a more advanced level, RAMAS Red List software facilitates preliminary assessment of threat status[8]. Miller *et al.* (2012) describe and contrast two different methods for rapid assessment of plant species to identify those at risk.

3.2.3 Inclusion of regionally-threatened taxa

The Ramsar Convention includes both nationally- and globally-listed threatened taxa, as generally does guidance on identification of Ecologically and Biologically Significant Areas (EBSAs) in the marine environment (e.g. Dunstan *et al.* 2011). Likewise, Sutherland & deMaynadier (2012) included globally-, nationally- and state-threatened reptiles and amphibians, Dyatlova & Kalkman (2007) included both regionally- and nationally-threatened dragonflies, and Evans *et al.* (2001) included fungi of both regional and national conservation concern. van Swaay & Warren (2006) included regionally-threatened butterflies endemic to the region (i.e. combining a species vulnerability criterion with an area-based endemism measure of irreplaceability; see Section 2.2.2), while Romo *et al.* (2007) included only nationally-threatened butterflies. Anderson (2002) and SABONET (2004) included both regionally-listed threatened plant taxa if listed according to IUCN Categories/Criteria, and nationally-listed threatened plant taxa if not only listed according to IUCN Categories/Criteria but also endemic/near-endemic to the region in question (i.e. again, combining species vulnerability with an area-based endemism measure) or with a 'limited range', though

[6] http://www.iucnredlist.org/about/summary-statistics
[7] http://www.nationalredlist.org
[8] http://www.ramas.com/redlist.htm

only the former defined 'limited range'[9]. Plantlife International (2004) closely followed this, only changing 'limited range' to 'restricted range' (but without definition). Radford *et al.* (2011) followed Plantlife International, and defined 'restricted range' as having an extent of occurrence of <5,000 km^2 (i.e. combining species vulnerability with an absolute threshold measure of irreplaceability). Al-Abbasi *et al.* (2010) recommended inclusion of both regionally- and nationally-threatened taxa, but noted that "it is critical that [Arabian] countries publish IUCN Red Lists for the region, for both globally and regionally threatened species", since none at that time existed. Langhammer *et al.* (2007) and Edgar *et al.* (2008b) only recommended inclusion of regionally-threatened taxa endemic to an assessment region that had been evaluated according to Red List guidelines.

Regional BirdLife IBA inventories, for example in Europe[10] and the Middle East[11], have identified 'IBAs of regional importance' based on regional threat status (or national threat status, e.g. in Canada[12]). Some national/regional IPA inventories have also used a broad interpretation of 'threatened species', including – in Europe – those in Annexes of the Habitats Directive and the Bern Convention, the European Red List, and the national Red List (Anderson *et al.* 2005, Blasi *et al.* 2011). For taxa seriously lacking in data, even broader interpretations have been taken to identifying candidate threatened taxa, such as – for algae – species which are "confined to only one known site" in the country or "nationally rare and a large proportion of the world's known population" (Brodie *et al.* 2007).

3.2.4 Incorporation of threatened habitats

Where data on threat status of species does not exist, particularly for groups such as fungi and algae, information on threat status of habitats may be a possible surrogate. Application of vulnerability criteria above the species level, i.e. at the habitat or ecosystem level, is discussed further in Section 5.

3.3 Key advantages and disadvantages of potential approaches

3.3.1 Taxonomic coverage

Reliance on globally-assessed taxonomic groups alone provides the most limited taxonomic coverage. Inclusion of suitable existing sub-global Red Lists has potential to significantly boost taxonomic coverage of globally significant sites. Targeted analysis of taxonomic gaps and establishment of new Red List assessments to fill these gaps (as per Edgar *et al.* 2008a) has even greater potential to boost taxonomic coverage. Incorporation of threatened habitats does not change taxonomic coverage per se, but as a surrogate has potential to improve inclusion of non-assessed threatened taxa. However, many aspects of habitat threat (e.g. reduction in size) may not inherently cause threat in species that they contain (notably for restricted-range species, which may survive in substantially reduced habitat areas).

3.3.2 Ability to reflect global vulnerability

In identifying a set of globally significant sites, a core requirement is vulnerability assessments that are relevant and consistent at a global level. A minority of regional- and national-level threatened species assessments have used IUCN Categories and Criteria[13], let alone the IUCN guidelines (IUCN 2003) on applying Categories and Criteria at a sub-global level (Miller *et al.* 2007). Without use of these guidelines, even sub-global assessments that follow IUCN Categories and Criteria will be prone to exaggerate the number of species that are threatened in a country/region, and the degree to which they are threatened (Miller *et al.* 2007). Further, even sub-global Red List assessments which do follow the regional guidelines

[9] "...species that has more than 50% of its range within one country and occurs in no more than 2-3 countries in total, or that occurs only within one geographical unit, such as the Carpathians."
[10] http://www.birdlife.org/datazone/info/ibacriteuro
[11] http://www.birdlife.org/datazone/info/ibacritme
[12] http://www.ibacanada.ca/canadian_IBA_criteria.pdf
[13] http://www.nationalredlist.org

are only directly transferable to the global level for species which are endemic to the sub-global area in question (e.g. Langhammer *et al.* 2007). One potential interim solution, until global Red List taxonomic coverage has improved (or in case for some reason it does not improve significantly), may be to use the regional IBA approach in considering sub-global Red List assessments which follow IUCN Categories and Criteria, even for non-endemic species, as sufficient for identifying significant sites at a national or regional level (these sub-global sites essentially acting as 'candidate globally-significant sites') but not at a global level (as suggested for infraspecific taxa in Section 4.3.6). This kind of approach was favoured by Holland *et al.* (2012) and would also ensure all sites identified by the various IPA approaches are highlighted as significant (albeit not always at a global level). Preliminary Red List assessment methods could also be used in a targeted way to add to these candidate species and site lists (Section 3.2.2).

3.3.3 Ease of application

Clearly, the approach of only using existing global Red List data is simplest. Incorporation of sub-global assessments in any way adds a layer of complexity – particularly if taxa concerned are distributed across national or regional boundaries, in which case there may be a need to reconcile different threat status assessments (and even taxonomy) on a case-by-case basis. Most difficult and time-consuming would be establishment of new Red List assessments to fill specific gaps in taxonomic coverage, although preliminary Red List assessment methods may provide a swift first step – particularly for taxa which often have small ranges and populations.

3.3.4 Overview of advantages and disadvantages of potential approaches

- Taxonomic coverage of globally significant sites can best be boosted by establishment of new, targeted Red List assessments, even if these are preliminary in nature, although inclusion of suitable existing sub-global assessments and threatened habitats (see Section 5) could also help.

- Sub-global Red List assessments are only directly transferable to the global level for species which are endemic to the sub-global area in question, and only when (rarely) IUCN regional guidelines are followed.

- An interim solution for species not endemic to the sub-global region in question may be to use sub-global Red List assessments which follow IUCN Categories and Criteria, as well as preliminary assessment methods (e.g. RAMAS), to identify significant 'candidate globally-significant sites' at a national or regional level.

- Incorporation of sub-global Red List assessments adds complexity, particularly in reconciling different assessments across national/regional boundaries, though not as much as initiating new assessments.

3.3.5 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: / Approach:	Taxonomic coverage	Ability to reflect global vulnerability	Ease of application
Inclusion solely of assessed globally-threatened taxa	-	+ +	+ +
Assessments of previously non-assessed taxa	+ +	+ +	- -
Inclusion of regionally-assessed taxa	+	-	-
Inclusion of threatened habitats	+	+	+

4 Could there be a rationale for incorporating criteria for biodiversity below the species level?

4.1 Introduction

Species are the most commonly-used measure of biodiversity, but are not equal in the amounts of unique evolutionary history that they represent. For example, the two tuatara species are the only surviving members of the order Sphenodontia and thus incorporate a disproportionate amount of phylogenetic diversity. The phylogenetic diversity that exists in such evolutionarily distinct species may be crucial in facilitating future evolution and adaptation to our changing world (Vázquez & Gittleman 1998), yet phylogenetic diversity is being lost at a faster rate than expected from species loss (Purvis *et al.* 2000). As a result, a number of priority-setting exercises have incorporated measures of phylogenetic diversity or evolutionary distinctiveness (e.g. Forest *et al.* 2007). Concurrently, efforts have been made to assess the value of surrogate measures such as species richness (e.g. Rodrigues *et al.* 2011). There is a need to evaluate what, if any, added value incorporating criteria for biodiversity below the species level brings to identifying sites of global conservation significance, and how this compares to the added costs or complexity of doing so. This discussion focuses on the values of incorporating phylogenetic diversity, although it is noted that some approaches for doing so (notably those in Section 4.2.2) may have additional values such as ability to deal with taxonomic uncertainty (Section 4.3.1) – as well as additional costs, such as providing impractically large sets of priorities for many taxa/regions (Sections 4.3.6, 8.1 & 8.3.2).

4.2 Potential approaches

4.2.1 Incorporation of phylogenetic diversity

Phylogenetic diversity is the most direct measure of unique evolutionary history, yet has infrequently been incorporated into identification of site-level conservation priorities. In part, this is because comprehensive datasets of phylogenetic diversity do not yet exist globally or regionally for most taxonomic groups. Nonetheless, some assessments of conservation priorities using phylogenetic diversity have been possible regionally (e.g. Forest *et al.* 2007) or, for taxa with comprehensive phylogenetic datasets (or surrogate datasets), globally (e.g. Redding & Mooers 2006). Theoretical metrics for contributions of individual sites or populations to phylogenetic diversity have even been developed (Cadotte & Davies 2010).

For freshwater environments, Darwall & Vié (2005), followed by Holland *et al.* (2012), included both threatened species and "other species of conservation concern" within one criterion. Although this criterion was, on the face of it, a vulnerability-based criterion (complemented by a second irreplaceability-based criterion), "other species of conservation concern" was interpreted to include "Taxonomically distinct or phyletically rare species" (Darwall & Vié 2005) or "species that are evolutionary distinct" (Holland *et al.* 2012).

4.2.2 Incorporation of infraspecific taxa

In practice, infraspecific taxa – particularly subspecies – have been the way in which site-level conservation priority approaches have usually attempted to incorporate a measure of phylogenetic diversity beyond species. For identification of sites based on irreplaceability, the Ramsar Convention includes 'biogeographic populations' of both subspecies and species of waterbirds at an equal level, an approach which BirdLife International global IBA criteria (e.g. Fishpool & Evans 2001) follow. For identification of sites based on vulnerability, however, both the Ramsar Convention and BirdLife only use full species. Some regional IBA inventory efforts have included subspecies, e.g. in Canada[14].

For vulnerability assessments, Darwall & Vié (2005), followed by Holland *et al.* (2012), considered "infra-specific taxa, such as... fish stocks specific to individual river systems". Bass *et al.* (2011) suggested that, for marine turtles, 'management units' (similar to biogeographic populations) are the most appropriate level – rather than species – to consider throughout. Sutherland & deMaynadier (2012) assessed irreplaceability of species, subspecies, or phylogenetically-distinct populations of amphibians and reptiles, with 'phylogenetically-distinct' defined as "significantly distinguished by genotype or morphology from similar taxa at the same level of classification". A number of other potential approaches exist to assessing taxon uniqueness (Arponen 2012).

Anderson (2002) considered subspecies acceptable alongside species for identification of IPAs under both vulnerability and irreplaceability criteria. Others, e.g. SABONET (2004), Al-Abbassi *et al.* (2010) and Radford *et al.* (2011), appear to have considered all infraspecific taxa (i.e. subspecies and varieties) alongside species during IPA identification.

4.2.3 Exclusion of biodiversity below the species level from consideration

Plantlife International (2004) appeared to consider a species-based approach to be most appropriate for IPA identification – although this does not appear to have been the interpretation of Radford *et al.* (2011; Section 4.2.2). Likewise, the World Heritage Convention, Jennings *et al.* (2003), Langhammer *et al.* (2007) and Edgar *et al.* (2008a, b) advocated a species-based approach for all taxonomic groups.

4.3 Key advantages and disadvantages of potential approaches

4.3.1 Ability to deal with taxonomic uncertainty

Whatever species concept is used, uncertainty may exist as to whether a given taxon should be classified as a subspecies or species. Particularly, though certainly not exclusively, this is the case for less well-known taxonomic groups and regions. Under a species-based approach, taxa which should actually be considered species may be ignored if they are currently poorly-known and considered to be subspecies. Incorporation of all infraspecific taxa is one way in which to ensure all taxa are considered, whatever their current taxonomic status.

4.3.2 Ability to incorporate evolutionary history/distinctiveness

A number of authors have found genus-level measures to be weak surrogates of phylogenetic diversity (e.g. Forest *et al.* 2007; Rodrigues *et al.* 2011). Tôrres & Diniz-Filho 2004 and Rodrigues *et al.* (2005, 2011) have demonstrated, however, that datasets based simply on species richness are effective surrogates of phylogenetic diversity. Species-level analyses are thus likely to be almost as effective at incorporating evolutionary history as more direct measures of phylogenetic diversity. Nonetheless, more direct measures (or use of taxonomy as a surrogate) would be more appropriate in some areas, e.g., where ancient species are confined to species-poor areas (Rodrigues *et al.* 2005).

Inclusion of infraspecific taxa *as equivalent to* species is sometimes suggested as a way to deal with this issue, but assumes that current taxonomy has no basis. This is likely to be an incorrect assumption, and taxonomy is frequently used as a proxy for phylogeny (e.g. Brooks *et al.* 2005). Such an approach thus risks swamping significant sites identified for species (with generally higher evolutionary distinctiveness) among many more sites identified for infraspecific taxa (with generally lower evolutionary distinctiveness). One approach to incorporating diversity below the species-level, yet not mixing unequal units, may be to use

[14] http://www.ibacanada.ca/canadian_IBA_criteria.pdf

more equivalent units such as evolutionarily significant units or phylogenetic species (e.g. Peterson & Navarro-Sigüenza 1999; Fjeldså 2000), but these have other issues such as stability (Section 4.3.5).

4.3.3 Correspondence with vulnerability and irreplaceability

Greater phylogenetic diversity of some vertebrate groups has been linked to greater extinction risk (e.g. Purvis *et al.* 2000), but Davies *et al.* (2011) show the opposite to be true for plants in South Africa. Phylogenetic diversity thus seems to have no general congruence with vulnerability. The extent of congruence with irreplaceability is not known. Given no clear congruence between phylogenetic diversity and either vulnerability or irreplaceability, it may best be seen as a value of biodiversity rather than a reason for conservation urgency *per se*. The logic for the incorporation of phylogenetic diversity (or its taxonomic surrogates) into a framework to direct conservation priorities is thus weak, since it would judge as significant both restricted, threatened biodiversity and widespread, unthreatened biodiversity. One potential solution might be to incorporate factors such as evolutionary distinctiveness at the point of prioritisation among identified significant sites, but not as *a priori* criteria for identification of significant sites. This has the logic of including evolutionary distinctiveness in a step-wise manner, after species have been prioritised based on vulnerability or irreplaceability, whereas a combinatorial system would give evolutionary distinctiveness priority alongside vulnerability and irreplaceability – resulting in a risk that sites would be identified for evolutionarily distinct, but widespread and common, species (e.g. Hoatzin *Opisthocomus hoazin*) at the expense of more threatened or rare species.

4.3.4 Ease of application

Species, particularly under the biological species concept, have generally been the standard unit of biodiversity for conservation globally. As such, they have three significant practical advantages for conservation planning. First, they are better understood as a general concept by policy-makers and the public than infraspecies (e.g. subspecies) or measures of phylogenetic diversity. Second, site-based distributional data (presence/absence) for species are much more likely to exist than spatial data on phylogenetic diversity. Third, many more data exist on vulnerability (e.g. global or national threat status) and irreplaceability (e.g. population size or extent of occurrence) at the species-level than at any sub-specific level. Identification of sites of global conservation significance will thus be considerably easier in at least the short- and medium-term for species than for any sub-specific taxonomic level.

4.3.5 Stability

Species, at least under the biological species concept, have remained relatively stable units over time. In recent years, however, taxonomic inflation has occurred in some groups owing to varying application of species concepts (e.g. Isaac *et al.* 2004; Tattersall 2007). The exact threshold at which a taxon transitions from subspecies to species is controversial, particularly given multiple species concepts, but a number of recent efforts have attempted to refine quantitative, repeatable criteria for species delimitation (e.g. Tobias *et al.* 2010).

Conversely, phylogenetic species have been far from stable: developments in the sophistication of phylogenetic methods may be the main driver behind the number of phylogenetic species defined or the amount of phylogenetic diversity identified (Crandall *et al.* 2000).

4.3.6 Ability to deliver an appropriate number of priorities

Given that there are many more infraspecific taxa than species, concerns exist that 'too many' significant sites may be identified if infraspecific taxa are used instead of species. This is a question of the level at which thresholds should be set (see Section 8). It is also, however, a question of the number of significant sites identified in any given nation/region relative to the national/regional capacity that exists to address conservation of these significant sites. It seems more likely, for example, that the 294 IBAs in the UK can be successfully conserved than the 227 IBAs in Indonesia[15].

Conversely, countries with higher conservation capacity may have concerns that significant sites defined on species alone insufficiently define national priorities and abilities. Some countries, for example, have specific legislation and conservation plans for threatened subspecies (e.g. New Zealand, USA).

One solution may be to identify globally significant sites based on species (with thresholds that deliver an appropriate number of priorities globally) and, in places where capacity for conservation is high, to also identify nationally or regionally significant sites based on infraspecific taxa.

4.3.7 Overview of advantages and disadvantages of potential approaches

- Incorporation of all infraspecific taxa would ensure taxa were not excluded from consideration owing to taxonomic uncertainty (although undescribed taxa would still be omitted, of course).

- Biological species are likely to be the most stable units for conservation planning and are better understood by the public and policy-makers than infraspecies (e.g. subspecies) or phylogenetic diversity.

- More data exist for implementing vulnerability and irreplaceability criteria at the species level than at any sub-specific level.

- Species appear to be good surrogates for phylogenetic diversity. It is unclear whether infraspecies are better or worse surrogates, but it is clear that infraspecies – if used in identifying sites of global conservation significance – should not be considered as equivalent to species. Nonetheless, since there is no clear congruence between phylogenetic diversity and either vulnerability or irreplaceability, infraspecific/phylogenetic diversity may best be seen as a value of biodiversity for incorporation into the prioritisation of conservation actions rather than a reason for conservation urgency *per se*.

- Basing globally significant sites on a single taxonomic level would aid simplicity, whereas incorporating additional measures of sub-specific diversity would aid comprehensiveness. Potential compromise solutions might be either to identify globally significant sites based on species plus nationally or regionally significant sites based on infraspecific taxa, and/or to incorporate factors such as evolutionary distinctiveness at the point of prioritisation among identified sites but not as *a priori* criteria for identification of globally significant sites.

- Neither species nor infraspecies approaches can deliver numbers of significant sites that are appropriate to the conservation capacity of all countries. One solution may be to identify globally significant sites based on species, with thresholds that deliver an appropriate number of significant sites globally, but – where capacity for conservation is high – to also identify nationally or regionally significant sites based on infraspecific taxa.

[15] IBA data from http://www.birdlife.org/datazone/site/search

4.3.8 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: Approach:	Ability to deal with taxonomic uncertainty	Ability to incorporate evolutionary history/ distinctiveness	Correspondence with vulnerability and irreplaceability	Ease of application	Stability	Ability to deliver an appropriate number of priorities
Incorporation of phylogenetic diversity	+ +	+ +	n/a	- -	- -	- -
Incorporation of infraspecific taxa	+	(-)	n/a	-	- -	(+)
Exclusion of biodiversity below the species level	-	+	n/a	+ +	+ +	+ +

5 Should/How should vulnerability criteria be applied above the species level?

5.1 Introduction

While the IUCN Red List is the global standard for identification of threatened species globally (Rodrigues *et al.* 2006), it currently has a strong taxonomic bias towards more well-known – particularly terrestrial vertebrate – taxa. Identifying significant sites using vulnerability criteria that are based solely on identified threatened species thus risks excluding sites of global significance to biodiversity process and to species which are threatened but have not yet undergone Red List assessment ('unknown threatened species'). Indeed, such species may not yet even be known to science. It is possible that known threatened species are sufficient surrogates of unknown threatened species, and of threatened ecosystems (e.g. Edgar *et al.* 2008a), but this is not likely to be true for all taxonomic groups – at best, relationships are likely to be weaker across freshwater, marine and terrestrial realms (e.g. Rodrigues & Brooks 2007; Darwall *et al.* 2011a). Giam *et al.* (2011) actually found an inverse relationship between predictions of undescribed species and the human footprint index, and a positive relationship between species being listed as threatened and how recently they were described – suggesting that known threatened species may be poor surrogates for unknown threatened species. In order to ensure that threatened species which have not yet undergone Red List assessment are not ignored by approaches to significant site identification, there has been interest in including environmental surrogates such as threatened habitats/ecosystems/biomes/communities/assemblages (hereafter collectively referred to as 'threatened ecosystems'). Furthermore, prevention of elimination of ecosystems and other units of biodiversity above the species level is important in its own right. The value and feasibility of, and opportunities for, such an approach need assessment.

5.2 Potential approaches

5.2.1 Exclusion of vulnerability criteria above the species level

Most application of criteria above the species level has been not for vulnerability but for irreplaceability, such as the BirdLife IBA criterion A3 related to assemblages of biome-restricted species or consideration of "the group of species that are confined to an appropriate biogeographic unit or units" by Darwall & Vié (2005). Langhammer *et al.* (2007) noted concerns about incorporating habitats and ecosystems as environmental surrogates of biodiversity, primarily the lack of a consistent scheme or even scale for their definition and the potential that they were poor surrogates of species (particularly restricted-range species which may be most in need of conservation attention). Edgar *et al.* (2008b), partly based on data from Edgar *et al.* (2008a), did not consider it necessary to explicitly incorporate threatened habitats in marine KBA identification – stating that "the location of threatened species can provide a surrogate for threatened habitats".

5.2.2 Inclusion of vulnerability criteria above the species level

The Ramsar Convention recognised a need to identify wetlands which support 'threatened ecological communities'. Likewise, Criterion 3 for High Conservation Value Forest is "Forest areas that are in or contain rare, threatened or endangered ecosystems" (Jennings *et al.* 2003). In neither case, however, is any quantitative guidance given on how to identify such threatened ecosystems, or how much of them a site might need to contain to be considered globally significant.

Plantlife International (2004) have a criterion for 'threatened habitat or vegetation type' whereby sites are identified as IPAs if they "contain 5% or more of the national resource (area) of priority threatened habitats" or sites are selected as IPAs to hold "a total of 20-60% of the national resource", whichever is the most appropriate. Threatened habitats/vegetation are to be taken from a regionally recognised list. This approach is essentially a simplification of Anderson (2002), which was developed for a European context with existing legislation related to habitats. In North Africa and the Middle East, Radford *et al.* (2011) interpreted the Plantlife International (2004) criteria to include all nationally, as well as regionally, threatened habitats. SABONET (2004) included, with a threshold/ranking approach, all regionally and nationally threatened habitats, with the former to be defined in a peer-review process. Al-Abbassi *et al.* (2010) followed this but without specific thresholds.

An IUCN working group has been developing criteria for assessing the status of, and establishing a global Red List of, ecosystems. Recently a draft system for quantitative, threshold-based assessment of ecosystem threat was produced, based on the IUCN Red List for species (Rodríguez *et al.* 2010). Ecosystems are not as well classified globally as species, and this framework assumes existence or development of a suitable standardised ecosystem classification for the country or region in question, based on not only biotic factors such as vegetation type, structure and species composition but also abiotic factors such as climate, soils and landforms.

5.3 Key advantages and disadvantages of potential approaches

5.3.1 Ability to represent biodiversity process and threatened species which have not yet undergone Red List assessment

Species data alone are ideally suited to identification of biodiversity pattern, but may not be suitable for selection of sites for biodiversity process (Franklin 1993). Likewise, avoiding the use of vulnerability criteria for biodiversity above the species level risks ignoring threatened species which have not yet undergone Red List assessment ('unknown threatened species'), particularly those which have not yet been scientifically described. Langhammer *et al.* (2007) raised concerns about the ability of environmental surrogates such as threatened ecosystems to adequately represent species. In reality, neither known threatened species nor threatened ecosystems will be perfect surrogates for 'unknown threatened species' or threatened biodiversity process, but a combination of known threatened species and ecosystems is likely to be more effective than either one alone (Franklin 1993; see also Section 3.2.3).

5.3.2 Ease of application

Avoiding the use of vulnerability criteria for biodiversity above the species level would be the simplest solution, but does carry significant risks (as outlined in Section 5.1). Incorporation of vulnerability criteria in an ad-hoc way, by adopting or developing national/regional ecosystem classifications and ecosystem threat classifications, would be the next simplest solution. The most complex solution would be to develop a single globally-consistent ecosystem classification and ecosystem threat classification. An option for the latter is already well underway (Rodríguez *et al.* 2010), but a national/regional approach would be long and complex (see Section 6).

Concern has been raised over the ability to define discreet sites for widespread, rapidly-declining ecosystems. However, this is not likely to be a problem as similar issues have not precluded successful identification of significant sites for widespread, rapidly-declining species (e.g. tigers; Walston *et al.* 2010). Similarly, sites containing over a certain percentage of threatened ecosystems could be identified as globally significant.

5.3.3 Consistency among vulnerability and irreplaceability criteria

Inclusion of vulnerability criteria for biodiversity above the species level would more closely align vulnerability and irreplaceability criteria, since the latter consistently incorporate supra-specific criteria (e.g. for assemblages of biome-restricted species). Further consideration should also be given as to whether further alignment would be useful – for example, using 'ecosystem irreplaceability' alongside, or instead of, 'biome-restricted assemblages'. There seems to be no logical reason for using different supra-specific representations of biodiversity for irreplaceability and vulnerability.

5.3.4 Overview of advantages and disadvantages of potential approaches

- The simplest approach would be to avoid the use of vulnerability criteria for biodiversity above the species level. However, an opportunity exists to use a developing globally-consistent ecosystem threat classification alongside national/regional ecosystem classifications that either already exist or are developed for this purpose.

- Inclusion of vulnerability criteria for biodiversity above the species level, alongside that at the species level, is valuable in its own right, as well as being likely to be the most effective way to ensure representation of threatened biodiversity process and threatened species not yet assessed on the Red List.

- Inclusion of vulnerability criteria for biodiversity above the species level would more closely align vulnerability and irreplaceability criteria. Further consideration should also be given as to whether further alignment would be useful – for example, using 'ecosystem irreplaceability' alongside, or instead of, 'biome-restricted assemblages'.

5.3.5 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: / Approach:	Ability to represent biodiversity process and threatened species which have not yet undergone Red List assessment	Ease of application	Consistency among vulnerability and irreplaceability criteria
Exclusion of vulnerability criteria above the species level	- -	+ +	+
Inclusion of vulnerability criteria above the species level (e.g. at the ecosystem level)	+ +	-	+ +

6 What should be the units for application of criteria above the species level?

6.1 Introduction

Criteria above the species level (e.g. for habitats/ecosystems/biomes/communities/assemblages; hereafter collectively referred to as 'ecosystems' for simplicity), are already applied during identification of significant sites for irreplaceability, and have sometimes also been applied for vulnerability (Section 5; Section 6.2.1). At present, varying approaches to units above the species level exist – from those based solely on ecosystems themselves (e.g. 'habitats' or 'vegetation') to those focused on characteristic features of these ecosystems (e.g. 'biome-restricted assemblages' or 'characteristic species'). Approaches to vulnerability have tended to be based solely on ecosystems, whereas a variety of approaches have been used to irreplaceability. Such an inconsistent approach is hard to justify – there is no inherent reason why units above the species level should not be the same within and among assessments of both vulnerability and irreplaceability. Further, units at different scales of ecological organisation will likely produce different results and thus risk further inconsistency. The advantages and disadvantages of the different units should be evaluated and weighed against one another in order to select the single, most appropriate unit (or most appropriate combination of units) for assessing global significance.

6.2 Potential approaches

6.2.1 Use of ecosystems alone

Identification of sites under vulnerability criteria, but not under irreplaceability criteria, has sometimes used ecosystems alone. Some have no specific guidance as to what units should be (e.g. the Ramsar Convention only clarifies 'wetland types' in a 'biogeographic region' and that a continental, regional, or supranational biogeographic scheme is preferable to a national or sub-national one) and others have simply suggested a regionally recognised list be adopted (e.g. for habitats/vegetation types: Plantlife International 2004; Radford *et al.* 2011). As a result, regional assessments have tended to be more prescriptive. For example, Anderson (2002) drew from existing threatened habitat lists under the European Habitats Directive (originally based on the CORINE biotopes classification, now partially updated to the Palearctic classification) and the Bern Convention (now based on the EUNIS classification). SABONET (2004) stated that habitats could be based on a continental-scale vegetation map, a map of broad vegetation types developed from available national maps, or national maps used directly. However, for their Criterion B ('botanical diversity'), SABONET suggested that even when national habitat maps were used, only sites important in a regional, rather than just national, context should be selected.

The only suggestions that ecosystems alone be assessed for irreplaceability seems to be for sites that are in or contain 'rare ecosystems' in Criterion 3 for High Conservation Value Forest (Jennings *et al.* 2003) or wetlands that contain "rare or unique examples... of a wetland type found within the appropriate biogeographic region" under the Ramsar Convention, but in neither case is guidance given on how to identify these units.

Evans *et al.* (2001) identified ecosystems on the basis of their uniqueness: 'outstanding examples of habitat types of known mycological importance', an approach which is strictly allied neither with irreplaceability or vulnerability.

6.2.2 Use of community characteristics of ecosystems

Approaches to incorporating community characteristics of ecosystems have focused on identification of (i) species or species assemblages restricted to particular ecosystems or (ii) sites that are particularly rich in certain indicator species (e.g. characteristic, endemic, or nationally rare/scarce species) within particular ecosystems. When 'endemic species' are included in the latter approach, the former approach is a subset. Langhammer *et al.* (2007) referred to the second approach as "contextual species richness (species richness within a species assemblage that is restricted to a given bioregion)", although this is not a strictly accurate definition if one considers the inclusion of nationally rare/scarce species. Langhammer *et al.* (2007) included an irreplaceability sub-criterion of 'bioregionally restricted assemblages' but did not make any definitive recommendations about which of the above approaches to apply.

The most widely implemented example of the former approach of identifying species assemblages has been the BirdLife global IBA Criterion A3 (e.g. Fishpool & Evans 2001). This identifies significant sites for species which do not have restricted ranges but are largely or wholly restricted to single biomes. Significance in this case generally infers sites which include a number (i.e. an assemblage) of biome-restricted species but, less commonly, can also identify sites of particular importance to individual species where they would otherwise be under-represented. Biome classifications are developed from regional classifications – for example, 13 biomes were identified in mainland Africa, adapted from a continental-scale classification (Fishpool & Evans 2001). The other significant deployment of the former approach has been for freshwater ecosystems by Darwall & Vié (2005), followed by Holland *et al.* (2012), who considered "the group of species that are confined to an appropriate biogeographic unit or units" and used freshwater ecoregions (Abell *et al.* 2008) as their base units. In Turkey, Kılıç & Eken (2004) considered the bird species confined to a given terrestrial bioregion, following terrestrial ecoregions (Olson *et al.* 2001).

The latter 'contextual species richness' approach has been mostly applied for plants. It is essentially a very similar approach to the previous one, but slightly more broadly defined and with a focus on relative species richness. Anderson (2002) used the rather fine-scale level 2 EUNIS habitat classification when assessing irreplaceability in a European context, but other efforts have not used such fine-scale units. Plantlife International (2004) and Radford *et al.* (2011) suggested that 'habitat or vegetation type' under irreplaceability criteria be taken from, or based upon, a regionally accepted list. SABONET (2004) advocated use of the same ecosystem unit scale for both vulnerability and irreplaceability criteria, although ecosystems alone were sufficient for vulnerability assessment (Section 6.2.1). For irreplaceability, SABONET (2004) stated that sites should contain "a high number of species and/or species of special interest that represent all habitat types."

6.3 Key advantages and disadvantages of potential approaches

6.3.1 Ability to identify the most globally significant areas within ecosystems

Whether used alone or through their characteristics, finer-scale ecosystem units are more likely to capture fine-grained biodiversity pattern of conservation concern. Approaches based simply on 'ecosystems', 'habitats' or other land classes in isolation (Section 6.2.1) will, however, be inherently less able to identify the most globally significant areas *within* any given ecosystem (i.e. where within a specific ecosystem conservation action should be implemented; Langhammer *et al*. 2007) than those which also incorporate particular characteristics of ecosystems (Section 6.2.2). This is because, of two sites in the same land class, the most globally significant is that which is most significant for species which are restricted to that ecosystem (all other things being equal). Biome-restricted assemblage approaches have focused on a simple threshold whereby two or more biome-restricted species are present at a site. Contextual species richness approaches have used a ranking approach (Section 1.2.3) whereby the top 10% (by area) or top five (or sometimes ten) sites are identified as globally significant. Generally, a biome-restricted assemblage approach with a simple threshold is likely to identify more sites with on average lower importance, whereas a ranking approach to contextual species richness is likely to identify fewer sites (capped by the ranking threshold) but with the highest importance (if indicator species chosen accurately reflect stakeholder perceptions of importance). This is particularly so if area of sites reflects key species' populations or if the 'top set' of sites are identified on the basis of factors such as key species' population sizes at those sites.

6.3.2 Appropriateness of scale

No finer-scale global classifications of ecosystems exist than the WWF classifications for terrestrial (Olson *et al.* 2001), freshwater (Abell *et al.* 2008) and coastal marine (Spalding *et al.* 2007) realms. These are becoming increasingly well accepted and used globally (Wikramanayake *et al.* 2002). In conjunction with finer-scale characteristics (e.g. biome-restricted assemblages), these classifications have been used for some irreplaceability analyses (e.g. Kılıç & Eken 2004) – including the majority of freshwater analyses (Darwall & Vié 2005; Holland *et al.* 2012) – as have even broader-scale biome-level classifications (e.g. BirdLife global IBA criteria; Fishpool & Evans 2001). However, without incorporation of finer-scale characteristics they may be so broad-scale that they ignore fine-grained biodiversity pattern. For this reason, Rodríguez *et al. (*2010) considered ecoregions likely too broad-scale for most vulnerability assessments. Although standards for finer-scale global classifications have been developed[16], they may be time-consuming and controversial to apply, and national or regional classifications may thus have to be used or developed in the short- to medium-term.

If national/regional classifications are not at the same scale globally, any globally-developed criteria for vulnerability assessment may need to be adjusted. It is reasonable to adopt similar thresholds of vulnerability and irreplaceability for ecosystems and species if their geographic range frequency distribution is believed to be similar, i.e. if ecosystems are, in general, as widely distributed as the taxonomic units (e.g. species) that are incorporated in the framework (J. P. Rodríguez *in litt.* 2011). A national level ecosystem classification is likely to produce smaller-scale ecosystem ranges than species ranges (because it would be, in part, based on combinations of those ranges), in which case different thresholds of vulnerability would need to be used for ecosystems. If ecosystem ranges are generally smaller than species ranges, higher thresholds will be required for ecosystems because a higher proportion of ecosystems would meet absolute vulnerability criteria. It should also be noted that increasingly smaller-scale units may become irrelevant, as they tend towards the scale of individual species ranges which are already covered by other criteria.

Issues with scale also exist with regard to taxonomic groups being assessed as restricted to ecosystems Peterson & Watson (1998). Langhammer *et al.* (2007) suggested that ecosystem classifications could be scaled in a nested way such that broader-scale units would be used for widespread species (e.g. many vertebrates) and a finer subset of units used for more species with generally smaller distributions (e.g. many plants), but also noted that this would cause logical problems regarding the lack of equivalence within and across different taxonomic levels.

One solution to issues of varying national/regional classification scales may be the adoption of existing broad-scale (e.g. ecoregional) ecosystem classifications for definition of globally significant sites, and development of (consistently) finer-scale sub-classifications for nationally/regionally significant sites. This is, however, in essence piecemeal development of a global fine-scale ecosystem classification, with all the difficulties that would entail. Rather than scaling ecosystems, it would theoretically be possible to also scale thresholds (e.g. those for EOO and AOO in the system proposed by Rodríguez *et al.* 2010) to deal with

[16] http://www.natureserve.org/explorer/classeco.htm

varying taxonomic group average distribution size or national/regional classification scale. This could reduce issues of scale, but would likely be complex and confusing.

6.3.3 Ease of application

An approach based on ecosystems alone is inherently simpler than any (similarly-scaled) approach based on characteristics of these ecosystems. Use of existing ecosystem classifications will always be easier than development of new ones, with the associated stakeholder processes that would entail. In this respect, use of the global ecoregional classification, the finest-scale classification globally available, becomes attractive.

Of approaches based on ecosystem characteristics, one based on sites that are particularly rich in certain species (e.g. characteristic, endemic, or nationally rare/scarce species) within particular ecosystems would be more easily applicable than a more strict 'ecosystem-restricted' approach for taxonomic groups in which individual distributions (and thus ecosystem restrictions) are not well-known. It is also less subject to problems of areal definitions of endemism inherent in 'ecosystem-restricted' approaches.

6.3.4 Overview of advantages and disadvantages of potential approaches

- Approaches which incorporate finer-scale characteristics of ecosystems will be better able to identify the most globally significant sites than those based on ecosystems alone. Within the former set of approaches, biome-restricted assemblage approaches with simple thresholds are likely to identify more sites and with lower average importance than ranking approaches to contextual species richness.

- Existing global (ecoregional) ecosystem classifications have been quite widely used for irreplaceability assessments but may be too broad for vulnerability assessments. Finer-scale global classifications are more likely to capture fine-grained biodiversity pattern of conservation concern, but are unlikely to emerge in the short-term. Use of national/regional classifications at mixed scales may mean fixed criteria cannot be applied under a single global threat classification system.

- An approach based on ecosystems alone, particularly one based on existing ecosystem classifications, is simpler than any approach based on characteristics of ecosystems. Of these latter approaches, one based on sites that are particularly rich in 'indicator' species within particular ecosystems is more easily applicable than a more strict 'ecosystem-restricted' approach for poorly-known taxonomic groups, and less subject to problems of areal definitions of endemism.

6.3.5 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: / Approach:	Ability to identify the most globally significant areas within ecosystems	Appropriateness of scale	Ease of application
Use of ecosystems alone	- -	+	+ +
Use of community characteristics of ecosystems	+ +	-	-

7 What should be the taxonomic standards?

7.1 Introduction

Species are the basic unit of most conservation planning. Section 4 considers whether criteria should be incorporated for biodiversity below the species level, for example by planning for conservation at the subspecies level. Whatever the units ultimately used, they will fundamentally remain a "man-made system of pigeonholes" devised for the purpose of subdividing biological variation into practical units (Dobzhansky 1937). As artificial constructs, the exact boundaries of these units are subject to considerable debate. Thus, any conservation exercise has to either develop its own taxonomy of these units (e.g. by following a set of criteria such as those suggested by Tobias *et al.* 2010) or choose between existing local, national, regional or global taxonomies. Choice of taxonomy can influence the results of exercises to identify sites of global conservation significance – for example, taxa may be considered as units in one taxonomy (and sites identified for their conservation) but as sub-units in another (and thus ignored). There is no single perfect taxonomy, but conservation applications – such as identification of the most significant sites for biodiversity conservation – require taxonomy that is stable, clear and transparent (Tobias *et al.* 2010), as well as practical.

7.2 Potential approaches

Langhammer *et al.* (2007) recommended that "For higher taxa that have been comprehensively assessed for the IUCN Red List, the standard species-level taxonomies used as the basis for these assessments should be followed when applying the KBA criteria. For higher taxa that have yet to be comprehensively assessed, the taxonomy used by the IUCN Red List should also be followed for application of the vulnerability criterion, and the most appropriate consensus taxonomy for these species should be followed when applying the irreplaceability criterion." BirdLife International global IBA criteria (e.g. Fishpool & Evans 2001) deal only with birds and use the (BirdLife-produced) taxonomy that underlies the IUCN Red List for birds. In Europe, Anderson *et al.* (2002) stated that the IPA Secretariat, in collaboration with partners, would produce a taxonomic list for vulnerability assessment, but did not give guidance on taxonomic standards for irreplaceability assessment. Radford *et al.* (2011) acknowledged the lack of a unified taxonomy for species in North Africa and the Mediterranean, and could only construct an *ad hoc* taxonomic list in the time available for their assessment. In acknowledgement of the serious gap in unified plant taxonomies, Target 1 of the 2011-2020 Global Strategy for Plant Conservation was "An online flora of all known plants"[17]. This was accomplished for land plants with the publication of a working version of 'The Plant List'[18].

7.3 Key advantages and disadvantages of potential approaches

7.3.1 Clarity and transparency

The clearest and most transparent taxonomies will be those that state their underlying criteria (e.g. Tobias *et al.* 2010) and explain why each taxon is considered a relevant unit (e.g. species) or not. Global taxonomies used by the IUCN Red List have a reasonable degree of transparency in that varying sources for considering a particular taxon as a species or subspecies are publicly documented. This is often not the case for other global-level, and particularly not for regional- or national-level, taxonomies.

[17] http://www.cbd.int/gspc
[18] http://www.theplantlist.org

7.3.2 Coherence and consistency

Use of global IUCN Red List taxonomies would ensure coherence with global IUCN Red List assessments – an important factor to consider given the importance of such assessments in identifying sites of global conservation significance. Use of these, or other, global taxonomies would ensure that regional assessments of globally significant sites 'fit together' in a coherent fashion. Use of regional- or national-level taxonomies is likely to result in situations where, for example, a taxon is considered to be a species in one area but a subspecies in another. Such a situation would be wholly inappropriate for a global-level approach and would have to be remedied by preferential use of one of the taxonomies over the other for this taxon.

Likewise, taxonomies that cover as broad a range of taxa as possible (e.g. a taxonomy for all mammals in preference to one for carnivores plus one for ungulates, etc.) are most likely to ensure use of similar species concepts and units throughout. Use of varying species concepts can lead to situations in which some taxonomic groups are 'over split' relative to others and thus receive disproportionate levels of conservation attention (Isaac *et al.* 2004).

7.3.3 Ease of application

Construction of new taxonomies from underlying criteria is very time-consuming. Use of existing regional- or national-level taxonomies would be much simpler and quicker, but would still require some time-consuming decisions in order to ensure coherence globally (Section 7.3.2). Use of existing global-level taxonomies would be the easiest and simplest solution, particularly when IUCN Red List taxonomies (which will need to be incorporated owing to their importance in identifying globally significant sites based on vulnerability) are adopted.

7.3.4 Overview of advantages and disadvantages of potential approaches

⅄ The clearest and most transparent taxonomies will be those that state their underlying criteria and document why each taxon is considered a relevant unit (e.g. species) or not. Failing this, global taxonomies used by the IUCN Red List have the highest degree of transparency.

⅄ Use of global, broad taxonomies ensures that national or regional assessments of globally significant sites will 'fit together' and promotes equal treatment of taxa within different groups.

⅄ Use of the global taxonomies underlying the IUCN Red List would ensure coherence with global Red List assessments.

⅄ Application of existing global-level taxonomies, particularly those of the IUCN Red List, would be easiest and simplest where they exist.

7.3.5 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: Approach:	Clarity and transparency	Coherence and consistency	Ease of application
Explicit, criteria-driven taxonomies	+ +	+ +	- -
Existing global taxonomies (notably those underlying the Red List)	+	+ +	+ +
Compilation of sub-global taxonomies	- -	- -	-

8 At what level should thresholds be set?

8.1 Introduction

Thresholds are at the heart of identification of significant sites since they are the cut-off points at which something higher is judged to be 'of significance' and something lower is judged to be 'not of significance'. Global significance is inherently based on the importance of a particular site for a given species in comparison to all sites known for that species globally. While this paper does not discuss issues of prioritisation among sites, identification of significant sites can be considered a 'binary prioritisation' (based on vulnerability and irreplaceability). Thresholds used within criteria are those at which vulnerability and/or irreplaceability are considered high enough for a site to be 'significant' for global biodiversity conservation.

How high should these thresholds be set? Theoretically, it would be possible to identify as many 'significant sites' as habitat exists globally, as long as it was possible to prioritise among them and resources existed to identify, prioritise and conserve these sites. While significant advances in systematic conservation planning have provided many tools for prioritisation, there are resource limitations to identification, prioritisation and conservation of globally significant sites for biodiversity conservation. Such limitations have extensive geographic and taxonomic variation. For example, resources for bird conservation in Europe are vastly higher than those for marine invertebrate conservation in Africa: thresholds that identified an appropriate number of sites for the former would likely produce a set of sites for the latter that swamped the ability of conservationists to prioritise and conserve; conversely thresholds that identified a manageable number of sites for the latter would likely produce a set of sites for the former much lower than those already considered priorities by stakeholders and already subject to national and regional conservation legislation and implementation.

One way around this issue would be to set relatively high thresholds for globally significant sites, thus producing a relatively low number of sites that are manageable for countries/taxa with more limited resources, but to have lower thresholds for nationally or regionally significant sites appropriate to the resource capacity of any given nation/country[19]. Such a tiered system has been identified earlier in this paper as a potential solution for dealing with species which have only undergone sub-global Red List assessments (Section 3.3.2) and for dealing with infraspecific taxa (Section 4.3.6). Such a system would resolve the core issue of global consistency, but still leaves some key questions:

(i) Can thresholds within each set of criteria (i.e. those for vulnerability or those for irreplaceability) be standardised (and, if so, at what level)?

(ii) If thresholds can be standardised within each set of criteria, can sub-criteria be consolidated/simplified?

(iii) Should thresholds for vulnerability and irreplaceability even be separate or should they be combined?

[19] Where those countries have geographically inflexible funding that cannot be spent on higher conservation priorities overseas.

8.2 Potential approaches

8.2.1 Avoiding quantitative thresholds

Al-Abbasi *et al.* (2010) considered removing all thresholds and using an entirely qualitative approach to be "a more flexible and pragmatic approach". Such pragmatism was also considered to be necessary for identification of KBAs for threatened species in the Philippines owing to lack of data on Vulnerable species' populations at sites (Ambal *et al.* 2012).

8.2.2 Tiered thresholds

A number of efforts to identify IBAs have used more liberal criteria than the BirdLife International global IBA criteria. For example, European[20] and Middle Eastern[21] IBA inventories have identified 'IBAs of regional importance' based on population thresholds relevant to the region and/or regional threat status. This approach is being taken even further in the United States with identification of state-level IBAs, nested within continental-level IBAs, themselves nested within global-level IBAs[22]. IUCN (2012) supported a tiered approach, stating that "thresholds could be "relaxed" at sub-global levels, provided these always performed better than the global thresholds (i.e., were more inclusive)."

8.2.3 Standardised thresholds within criteria

Within consideration of irreplaceability, percentage thresholds under the Ramsar Convention are equal across taxa (Criteria B6 and B9; "1% or more of a biogeographical population").

Within consideration of vulnerability, although with some exceptions, Anderson (2002) used essentially the same thresholds for species and habitats (all sites containing 5% or more of the national resource [area] or the five 'best' sites). Subsequent approaches for plants have basically followed this combination (e.g. Plantlife International 2004; Radford *et al.* 2011). Bass *et al.* (2011) experimented with various absolute and percentage thresholds for marine turtles in Melanesia, concluding that a standardised threshold within vulnerability may be most appropriate (1% of management unit population).

Although using varying thresholds within their irreplaceability criterion (Section 8.2.4), Langhammer *et al.* (2007) acknowledged that consistent thresholds would be preferable and encouraged the testing of 1% and 5% thresholds across irreplaceability sub-criteria in order to ascertain if one or the other was appropriate.

IUCN (2012) noted that "a site's contribution towards the persistence of biodiversity can be measured using techniques from systematic conservation planning", and thus that "these methods should be used to inform the establishment of (likely high) thresholds of significance." Building from this, a process is underway to explore further the potential lower level at which KBA-type irreplaceability thresholds still facilitate complementarity approaches without a need to explicitly incorporate them.

8.2.4 Varying thresholds within criteria

Langhammer *et al.* (2007) suggested different vulnerability thresholds for considering sites significant if they hold globally Critically Endangered or Endangered species (simple presence was sufficient) or Vulnerable species ("30 individuals or 10 pairs"). Within their irreplaceability criterion, while acknowledging it was less than ideal (Section 8.2.3), Langhammer *et al.* also used different thresholds for considering sites significant for restricted-range species and those with large but clumped distributions (5% of global population) to those for globally significant congregations or source populations (1% of global population). Edgar *et al.* (2008a, b) followed this guidance in the marine realm. Eken *et al.* (2007) found mere presence of globally Endangered species to produce too many significant sites owing to the widespread nature of

[20] http://www.birdlife.org/datazone/info/ibacriteuro
[21] http://www.birdlife.org/datazone/info/ibacritme
[22] http://iba.audubon.org/iba/viewCountry.do

some Endangered species, and suggested progressively higher thresholds from Vulnerable to Critically Endangered.

BirdLife global IBA criteria (e.g. Fishpool & Evans 2001) show perhaps the greatest variance in thresholds within criteria. These have different vulnerability thresholds for considering sites significant if they hold globally Critically Endangered or Endangered species (simple presence is sufficient) or Vulnerable species (threshold numbers are required and "set regionally, often on a species by species basis"). BirdLife irreplaceability criteria also differ, even within sub-criteria: for example, a site is considered significant if it holds 1% of the biogeographic population of a congregatory waterbird species, but only if it holds 1% of the global population of a congregatory seabird, and thresholds for migratory species at bottleneck sites are set regionally or inter-regionally. Such variance appears to be tied more to historical legacy (particularly the Ramsar Convention) than any evidence that thresholds should differ, for example that sites for waterbirds have higher irreplaceability than those for seabirds. Regional IBA efforts introduce even more variability – for example, 'global IBAs' are identified in Canada if they "hold 1% or more of the global or North American population of a species."

For both vulnerability and irreplaceability criteria in the freshwater realm, Darwall & Vié (2005) suggest that 'significant' and 'non-trivial' thresholds are defined on a taxon-specific basis.

8.2.5 Combined vulnerability and irreplaceability thresholds

Anderson (2002) combined measures of vulnerability and irreplaceability to some extent for species in their Criterion A, with any sites considered significant if they contained globally or regionally threatened species, but sites holding nationally threatened species only considered significant if those species were also nationally-endemic or 'near endemic/limited range'. Subsequent approaches for plants have mainly followed this combination (e.g. Plantlife International 2004; Radford *et al.* 2011), although SABONET (2004) partially separated vulnerability and irreplaceability (in Criteria A1-3 and A4, respectively). Ricketts *et al.* (2005) identified Alliance for Zero Extinction sites based on a combination of irreplaceability (near-endemism) and vulnerability (Endangered or Critically Endangered species).

Another approach to combining vulnerability and irreplaceability has been to combine thresholds in a matrix, such that – for example – presence at a site of a widespread Endangered species may be considered equivalent to presence of a restricted-range Vulnerable species or to a Near Threatened site endemic species (e.g. BirdLife International *et al.* 2007).

8.2.6 Separate vulnerability and irreplaceability thresholds

Common practice outside of plants (and the Alliance for Zero Extinction) has been to have largely separate vulnerability and irreplaceability criteria (although range size is an inherent consideration in some IUCN Red List criteria, confounding complete separation). For example, this is the case for BirdLife International global IBA criteria (Criterion A1 dealing with vulnerability, Critieria A2-4 with irreplaceability; e.g. Fishpool & Evans 2001), freshwater criteria (Criterion 1 for vulnerability, Criterion 2 for irreplaceability; Darwall & Vié 2005, Holland *et al.* 2012), marine criteria (Criterion 1 for vulnerability, Criterion 2a-d for irreplaceability; e.g. Edgar *et al.* 2008b), the Ramsar Convention (Criterion A2 for vulnerability, Criteria B5, 6 and 9 for irreplaceability), and cross-taxon guidance by Langhammer *et al.* (2007; Criterion 1 for vulnerability, Criterion 2 for irreplaceability).

8.3 Key advantages and disadvantages of potential approaches

8.3.1 Focus on the most significant sites

Knight *et al.* (2007) pointed out that "the IUCN Red List shows that there are a number of range-restricted, biome-restricted and congregating species in assessed taxa that are not thought to be at risk of extinction. For example, 44.8% of the mammal species that have had their ranges mapped and would be defined as being range-restricted are not threatened." Combined vulnerability and irreplaceability thresholds provide an opportunity to focus on the species most urgently needing conservation attention at the most significant sites, by avoiding identification of sites for biodiversity features that may have few spatial conservation options but may be very secure and thus not of imminent conservation priority.

8.3.2 Appropriate number of sites

The question of how much conservation is enough has been frequently discussed within the conservation and policy arenas, with widely varying conclusions (e.g. Svancara *et al.* 2005). The issue of how many significant sites are appropriate to a particular country or taxon is not merely academic, but highly relevant to conservation implementation. Goerck & Wege (2005) note that in the Atlantic Forest of Brazil there are "too many sites for any one conservation organization to address." In Europe, IBAs identified by Heath & Evans (2000) have been used as a framework for designation of protected areas under the Birds Directive in Europe, with the European Court of Justice serving judgements on a number of countries for failing to designate protection for sufficient IBAs (even though these may cover >25% of a country's land area)[23].

Differences among developed and developing country capacity to implement conservation may conflate consideration of this issue. For example, it has been stated that the 1% threshold "has been found by long experience and evaluation to give an appropriate degree of protection to waterbird populations and to assist in the definition of ecologically "sensible" sites" (Pritchard 2007). However, outside of the most developed countries this threshold may be unrealistically low for implementation – for example, BirdLife International (2005) found only 11% of sites identified as fulfilling Ramsar criteria (for birds alone) had been designated as Ramsar sites, and the majority of these were insufficiently protected.

Differences in ability or willingness to implement conservation for different taxa may also conflate consideration of this issue. In large part, this is an issue of irreplaceability – with many more invertebrates and plants, for example, having small ranges than vertebrates. Varied thresholds for considering different taxa restricted-range may thus be thought appropriate (Section 2).

Bass *et al.* (2011) looked at significant sites for marine turtles in Melanesia, concluding that "the inclusion of all records for CR and EN species resulted in an excessively high number of [significant sites] for Melanesia." They proposed basing thresholds on regional populations in order to ensure an appropriate number of sites. Ranking approaches to regional IBA identification and to IPA identification (Section 1.2.3) deliver very specific limitations on the number of sites identified (e.g. "the five 'best sites'", "up to 10% of the national resource (area)"), which can usefully be tailored to national or regional circumstances and may be simpler and more defensible than actually varying thresholds for global criteria on a regional basis (Section 8.2.4).

8.3.3 Logical coherence

Use of varying thresholds within a single criterion is both confusing and impossible to logically or scientifically justify. For example, when considering the irreplaceability criterion, Edgar *et al.* (2008b) noted that "An anomaly within the methodology developed for terrestrial KBA identification [i.e. Langhammer *et al.* 2007], and inherited by the provisional thresholds outlined here, is that a much smaller proportion of

[23] e.g. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:62004J0418:EN:HTML

the total population is sufficient to trigger a KBA for species that aggregate seasonally (1%) compared to spatially (5%)."

Separation of vulnerability and irreplaceability into two separate criteria is convenient but precludes easy prioritisation among sites – for example, answering questions such as that posed by Edgar *et al.* (2008b): "Is an MPA [Marine Protected Area] with 90% of the population of two EN [Endangered] species a higher conservation priority than an MPA with 50% of the population of a CR [Critically Endangered] species?" Combined vulnerability and irreplaceability thresholds (Section 8.2.5) are the only simple solution to this issue.

8.3.4 Congruence with existing policy

The 1% thresholds used for aspects of irreplaceability by the Ramsar Convention are a particular historical feature that has induced variance in irreplaceability thresholds (e.g. Section 8.2.4). The importance of aligning identification of significant sites with widely-supported global conventions should not be understated if a key goal is to obtain protection for such sites. However, these 1% thresholds may be unrealistically low for implementation in most countries (Section 8.3.2). One potential solution would be that tiered thresholds could be tailored to varying national implementation capacity. Suitable thresholds would require further testing, but – based on existing thresholds being implemented – these could be 5% thresholds for globally significant sites and lower 1% thresholds for nationally significant sites in countries with higher implementation capacity. For ease of application, a 1% or 5% threshold (likely the former, based on experience to date) could also be applied to vulnerability thresholds.

8.3.5 Simplicity

Standardisation of thresholds within vulnerability or irreplaceability criteria would facilitate simplification of criteria by consolidation of sub-criteria. For example, if a 5% threshold was adopted for globally significant sites for all aspects of irreplaceability (Section 8.3.4), the five different facets/sub-criteria of irreplaceability identified by Langhammer *et al.* (2007) could be consolidated into one, such as 'Species, species assemblages or habitats that are geographically restricted, whether permanently or temporally'. Adopting percentage, rather than absolute, thresholds for a vulnerability criterion would enable one simple threshold within this criterion (Section 1.3.4).

8.3.6 Overview of advantages and disadvantages of potential approaches

- Use of varying thresholds within a single criterion is both confusing and impossible to logically or scientifically justify. Thresholds within criteria can be standardised, if percentage or ranking thresholds are used, and would facilitate simplification of criteria through consolidation of sub-criteria.

- Tiered thresholds could facilitate production of a number of significant sites appropriate to varying national implementation capacity yet congruent with existing international policies (notably the Ramsar Convention). Suitable thresholds would require further testing, but could be at 1% for vulnerability and 5% for irreplaceability for globally significant sites, with lower 1% thresholds for irreplaceability for nationally significant sites in countries with higher implementation capacity.

- Separation of vulnerability and irreplaceability into two separate criteria is convenient but precludes easy prioritisation among sites, an issue which can only be solved by combined vulnerability and irreplaceability thresholds. Combined thresholds also provide an opportunity to avoid identification of sites for biodiversity features that may have few spatial conservation options but may be very secure and thus not of imminent conservation priority.

8.3.7 Summary table

Optimal approaches in the table below are likely to be those which can deal effectively with all issues for a given question (i.e. have least - - and - scores), rather than those that have the most + scores for a given question – although considering these scores alone would be an oversimplistic way to identify optimal approaches.

Issue: / Approach:	Focus on the most significant sites	Appropriate number of sites	Logical coherence	Congruence with existing policy	Simplicity
Avoiding quantitative thresholds	n/a	-	n/a	- -	+ +
Tiered thresholds	n/a	+	n/a	+ +	-
Standardised thresholds within criteria	n/a	-	n/a	(-)	+ +
Varying thresholds within criteria	n/a	+	- -	n/a	- -
Combined vulnerability and irreplaceability thresholds	+ +	n/a	+ +	n/a	-
Separate vulnerability and irreplaceability thresholds	-	n/a	-	n/a	+

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