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Floras and Faunas, and descriptive taxonomy serving biodiversity: current uses and future perspectives for conservation biology

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Abstract

Informative conservation science is reliant on accurate, high quality and robust data. Floras and Faunas can often provide the baseline information which feeds into a wide variety of conservation decisions made at a national, regional and global level, particularly for species based conservation. Conservation priority-setting algorithms make increasing use of species distribution ranges and the ecological and life history information provided by such works. Taxonomy underpins conservation, and both conservation and taxonomy face severe funding limitations. Incomplete taxonomic coverage continues to hamper conservation, however, even within known organisms taxonomic fluctuation and taxonomic inflation have the propensity to adversely impact conservation priority-setting tools by altering the basic unit, the species. Conservation planning depends on species lists reflecting richness, diversity, endemism, threat and many other attributes that can be compared across locations and taxa. To aid conservation planning, conservation biology requires a taxonomic solution that both standardises the species units included on species lists, and that recognises that the units chosen for conservation reflect dynamic natural systems, and may differ from the units in the species listing process. In a time when human impact on natural systems continues to accelerate, we must seek novel solutions to reverse negative trends in biodiversity. Resolving these issues can only be achieved using comprehensive data and with intricate knowledge on the conservation and sustainable use of biodiversity. Electronic data availability is revolutionising our ability to provide accurate information on the status and trends of biodiversity, and make robust conservation management decisions. New types of collaboration are required between conservation biology and systematics to enhance the availability and utility of such data, to enable robust and accurate measures of biodiversity. This

framework will allow us to better predict anthropogenic impacts and devise effective ways to mitigate them.

Introduction

Conservation science is a discipline which has been born in response to the simple fact that biodiversity is declining at never before seen rates (Millennium Ecosystem Assessment, 2005). Background extinction rates are being dramatically exceeded, and models of future scenarios predict that this rate will only increase (Figure 1), perhaps by an order of magnitude, unless preventative action is taken (Regan *et al.*, 2001). The reasons for this decline are at least well known, if not well understood. Land clearance reduces available habitat; exploitation removes healthy animals from the population; introduced predators and diseases impact ‘naïve’ species, and ultimately extinction breaks down ecological networks - Diamond’s evil quartet (Diamond, 1989). Increasingly, climate change is enhancing the negative impacts of this list of threats (IPCC, 2002, Thomas *et al.*, 2004). The problem and its effects are so pressing that it has been framed under international legislation, and more than 190 countries have signed up to a target set to achieve a significant reduction in biodiversity loss by 2010 (UNEP, 2002). Effective action to achieve such a target requires detailed information, and Floras and Faunas often provide much of the data that underpin priority setting decisions derived from biodiversity data. While the key taxonomic issue to be faced by biodiversity conservation remains the under-description of species (Wilson 2003, May 1988), a growing issue that threatens to complicate and perhaps undermine conservation planning is taxonomic inflation (Isaac, Mallet & Mace, 2004, Mace, 2004).

Throughout this chapter I primarily refer to species conservation, as species are often considered the natural taxonomic rank to form the basis for both conservation assessments and management. There are of course habitat based conservation alternatives that are also possible. Informative conservation science relies on accurate, high quality data that feeds into conservation decisions at all levels, particularly in species conservation. Species are of great importance to conservation in many different ways. Species form both a means of measurement to gauge human impact on biodiversity, and a target for action – the way in which we manage biodiversity. Species have a resonance with the public, and policy makers; it is arguable that the majority of conservation funding is derived from species level or species focused conservation projects. They are the subject of national legislation; species are used at the national level in law, for example US Endangered Species

Act, or UK Biodiversity Action Plans. Species are also subject to international legislation, for example, multilateral environmental agreements such as the Convention on International Trade in Endangered Species (CITES) and Convention in Migratory Species (CMS) are species focused.

In this chapter I undertake a review of the role that descriptive taxonomy plays in conservation biology. I address the impact of taxonomic change on conservation biology, and the role that Floras and Faunas have to play in providing baseline data for conservation priority setting and planning. Resolving the current elevated rate of biodiversity decline can only be achieved using comprehensive and representative data and with intricate knowledge on the conservation and sustainable use of biodiversity. The increasingly wide availability of electronic data are revolutionising our ability to provide ever larger volumes of accurate and up to date information on the status and trends of biodiversity, and from which to make robust conservation management decisions. New types of collaboration are required between conservation biology and systematics to enhance the availability and utility of such data, to enable robust and accurate measures of biodiversity. This framework will allow better prediction of anthropogenic impacts and devise effective ways to mitigate them.

Current uses of floras and faunas

With a critical shortage of biodiversity information with which to address challenges to conservation, Floras and Faunas are often one of the first providers of data. The production of Floras and Faunas is clearly still a popular endeavour. A survey of the *Zoological Record* on BIOSIS from 1989 to 2007 showed that using the search term "Fauna of*", in excess of 1000 volumes were published during the period. A brief search through the Zoological Society of London library catalogue, founded in 1826, one of the world's most comprehensive zoological libraries, contains records of 131 Faunas of India alone. Clearly this does not represent the Floras published in this period as well.

Identifying concentrations of species richness, diversity, or endemism is a central theme of many conservation studies (Gomez de Silva & Medellin, 2001). Floras and Faunas might be used in conservation biology in the first instance, for generating species lists for a given area or location. These species lists may then form the basis of many conservation actions, including protected area location, priority area selection algorithms (Pressey & Cowling, 2001), and perhaps even monitoring data

(Roberts, Donald & Green, 2007). There are however several sources of uncertainty or instability in species list generation which, left unchecked or unaccounted for, may adversely impact conservation. Taxonomic coverage and the effect of cryptic species are particularly problematic, however, change in the use of species concepts (Isaac et al., 2004), the effect of which I will return to later, is of growing concern in certain vertebrate groups in particular. Gomez de Silva & Medellin (2001) point out, for example, that limits to the use of existing species lists for conservation are primarily due to their compilation by an array of field observers, with varying level of skill, and different goals. The resulting heterogeneous data across a given area means that missing species from species lists are likely to be a non-random subset of the total assemblage in many cases, particularly when original goals are highly varied, and when single studies focus on a particular issue. Incompleteness of lists and heterogeneous data can lead to misleading results (e.g. see Kodric-Brown & Brown, 1993). Also further information may still be required, even when comparing two areas based on species lists alone. For example, abundance may matter if the underlying incomplete lists do not accurately reflect the ecological character of a given area (Balmer, 2002).

Even within some of the most species rich countries, certain groups have been recently seen to almost double over a very short period of time (e.g. Sri Lanka: Meegaskumbura *et al.*, 2002). In another example, alpha diversity has increased by up to six times in Bolivian amphibians during a 15 year period (Padial & De la Riva, 2006). For conservation biology this is unfortunate, since mastering species numbers may be crucial to discerning the changing patterns of global diversity. Further, instability in species lists is likely to be more prevalent in local and national level lists, due to localised population extinction processes, or expansion in range through colonisation or re-introduction. A distinction must be made though, between fluctuations in numbers of species caused by extinction (and colonization), and those caused because taxonomy is not complete. The two issues will require very different solutions.

Conservation biology often requires more fundamental data than simple species lists, some of which might be provided by Flora and Fauna publications. The next logical step is to use basic information from Floras and Faunas to inform conservation assessments, such as the IUCN Red List of Threatened Species (herein ‘Red List’; IUCN, 2009), as these give far greater information to conservation biologists (Mace & Lande, 1991). However, they require more detailed knowledge of species’ ecology, life history and geographical information from Floras and Faunas, combined with population trend information and data on threatening processes, to build a comprehensive dataset to give robust conservation assessments.

In a broader context, a key aspect for conservation biology is the trade off between simple lists of species, and something that may be more informative to conservation, such as the relationships described in Figure 2a-c. Green *et al.*, (2005) use the same model as another application of a similar principle. For the purposes of this chapter, let us consider the following hypothetical example. You are trying to decide on the status of species within an area. You may ask several questions about how you might go about this, but the decision should account for two main factors: fitness for purpose of the techniques you are intending to use, and the resources available. In this example, we will consider two options: firstly to generate a species list or inventory for the area, and secondly to generate some sort of conservation assessment for those species.

Step 1 in Figure 2a shows that however much work is put into a species inventory it will never be as useful to conservation biology as the conservation assessment; however the assessment will take longer to complete, though both techniques become more accurate as they progress. Figure 2b evaluates completeness against effort needed to complete each of the techniques. The advantage of the species inventory is that it can be completed with less effort. Figure 2c combine steps 1 and 2 and addresses what you would do if had ‘a’ units of effort to expend, against what would you do if you had ‘b’ units? The model formalises decisions to use informative datasets that can be most readily gathered – the ‘low hanging fruit’ (*sensu* Raven & Wilson, 1992). It is important because temptation may often be to gather the easiest to obtain data, regardless of limited use (failure to consider Figure 2a), or the efficiency of adding to any existing data (failure to consider Figure 2b). Working together in this manner and considering this framework, Floras and Faunas can compliment the more stringent data demands of biodiversity data for conservation biology. Knowing the shapes of these curves would ultimately benefit decision making in conservation biology.

Taxonomy underpinning biodiversity

In all areas of species based conservation, taxonomy underpins our appreciation of biodiversity, and plays a fundamental role (Geeta *et al.*, 2004). However, the incomplete and non-random coverage of species description continues to be an issue in biodiversity conservation. In 1992, Raven & Wilson set out a fifty-year plan for biodiversity surveys to catalogue the Linnean shortfall (Raven & Wilson, 1992). So 15 years on, how are we doing? Raven & Wilson estimated that there were 1.4 million species known in 1992; approximately 15% of the actual total. Two major taxonomic federations, Species 2000 and ITIS catalogue of life, released a check list in 2009 of 1,160,711 species (Bisby *et al*. 2009), which they estimate to be around half of the world's known species. They aim to have catalogued 1.75 million by 2011. So progress remains slow, even for the known species.

While we cannot necessarily expect to conserve organisms that we cannot identify, several attempts at conservation shortcuts have been made to prioritise action amongst the species we do know. All recognise that the available resources for conservation are insufficient to prevent the loss of much of the world's threatened biodiversity. Conservation planners have been forced to prioritise which species and areas should receive the most protection, in the context of great uncertainty – this has become known as 'the agony of choice'. Several tools have been developed to aid them in prioritising conservation actions. One of the most highly cited is that which weights areas of high species richness and high rate of degradation most strongly - Biodiversity Hotspots (Myers *et al.*, 2000). However, there are many others (see Brooks *et al.* (2006) for a review).

Of particular relevance to systematics and conservation is the concept of incorporating measures of phylogenetic diversity into conservation selection algorithms (Faith, 1992, May, 1990, Vane-Wright, Humphries & Williams, 1991). Species do not represent equal components of evolutionary history; rather they differ in the amount of phylogenetic diversity they represent, reflecting the tempo and mode of divergence across the phylogenetic tree. It is therefore implicit that the extinction of an old, monotypic or species poor clade would result in the loss of a greater proportion of biodiversity, than that of a comparatively young species, or one with many close relatives (Mace, Gittleman & Purvis, 2003, May, 1990). Figure 3 demonstrates how using evolutionary branch length as a measure of independent evolution, the extinction of species A, would result in the loss of a far greater amount of evolutionary history than if species B or C were lost, the inference being that the loss would be felt more keenly. Given that extinction risk appears to be clustered (Purvis *et al.*, 2000), this might matter. Combining branch length data from a recent publication on the relationships of all mammals (Bininda Emonds *et al.*, 2007) with threat evaluations from the IUCN Red List (IUCN, 2007), has resulted in a technique, intricately tying two key areas in which Floras and Faunas, descriptive taxonomy and systematics can contribute to conservation biology (Isaac *et al.*, 2007).

Measuring species level trends in biodiversity

As signatories to the CBD 2010 target, almost all nations are compelled to assess progress towards reducing biodiversity loss. Seven focal areas have been outlined by the CBD in order to direct the development of headline indicators of biodiversity change under the CBD framework (see Table 1; UNEP, 2006). Information from Floras and Faunas are most likely to feed into baseline data for the focal areas 'Trends in abundance and distribution of selected species' and 'Change in status of threatened species', which include indicators such as the Living Planet Index (Collen *et al.*, 2008, Loh *et al.*, 2005) and Common Bird Index (Gregory *et al.*, 2005, Pan-European Common Bird Monitoring, 2006) and the IUCN Red List Index (Butchart *et al.*, 2007, Butchart *et al.*, 2004). The CBD framework and existence of the target has motivated further development in some indicators (Mace & Baillie, 2007: e.g. see Butchart *et al*., 2007, Butchart *et al*., 2004, Loh *et al*., 2005). Nevertheless, taxonomic coverage is still limited.

Geographic range distributions can provide improved resolution for conservation strategies allowing better spatial mapping of key areas for conservation. All bird, mammal and amphibian distributions are mapped (Cardillo *et al.*, 2005, Orme *et al.*, 2005, Stuart *et al.*, 2004), and are revealing a great deal about the patterns of species' geographic range; not least that while overall distribution between vertebrate taxa might be similar, congruence between groups might be low, in particular amongst rare taxa (Grenyer *et al.*, 2006). We still do not know though, how representative these groups are of broader biodiversity, which may yet prove to be a problem for conservation strategies and biodiversity targets. In all these processes, the user groups require robust, accurate and high quality data in order to make the best decisions. Certain approaches such as a sampled approach to Red Listing are set to broaden coverage (Baillie *et al.*, 2008; Collen *et al.*, 2009), however, Floras and Faunas can play an increasingly important role on collating and disseminating key biodiversity data for taxa not yet included.

Taxonomic inflation

By impacting the very unit that many conservation actions are determined by, taxonomic inflation threatens to undermine conservation (Isaac *et al*., 2004, Mace, 2004). Two conflicting explanations of this phenomenon have been put forward. The first is that the problem is geopolitical (Harris & Froufe, 2004), owing to a strong geographical bias in the early work on DNA sequence data. DNA variation between the species assessed was very low because of the relatively low genetic diversity in northern species in comparison to their tropical relatives. The second is that increased use of the phylogenetic species concept (PSC), rather than the biological species concept (BSC) is responsible, at least amongst larger charismatic species groups (Isaac *et al*., 2004: see Figure 4). However, in the more species rich groups such as insects or fungi, drivers of change are likely to be different (Knapp, Nic Lughadha & Paton, 2004), and with the particular species concept applied rarely being adequately documented, the effect of species concept on description rates is difficult to assess. In seed plants in particular, new descriptions on the whole are thought to represent new species discovery, rather than circumscription (Knapp *et al*., 2004).

Nonetheless, the magnitude of the effect is likely to be large for vertebrates at least. Agapow *et al*. (2004) estimate that adoption of the PSC over the BSC would give rise to an increase of 48% in species richness, with an associated reduction in average population size, and geographic range. In combination with threatening processes, such changes are likely to lead to an increased number of threatened species under threat classification schemes such as the IUCN Red List, with 11% moving from the Vulnerable category, to the higher risk Endangered category (Agapow *et al*., 2004). What is less clear on a global scale is where that species richness would show up geographically. The implications are not insignificant. Conservation might experience a negative impact by spreading already restricted funding ever more thinly due to species which are classified as threatened due to having small ranges and being in threatened habitats requiring a greater share of the available resources. Under widespread taxonomic change, it is not clear whether the areas selected by some priority setting algorithms, such as hotspots based on species richness, might change. Accumulating lines of evidence suggest amongst certain groups at least, changes could be dramatic (Peterson & Navarro-Sigüenza, 1999).

Areas of new species discovery

It is estimated that just 1.5 - 1.8 million of the approximately 14 million extant species (Wilson, 2003) have been described, and there is still considerable uncertainty how many species exist (Godfray, 2002). If description of species is inherently non-random, with species in some taxa more likely to be described than those in others, then views of diversity are correspondingly distorted, and so are our conservation actions that we base on them. This matters if, for instance, conservation policies are based on skewed reflections of true diversity patterns. Across higher taxa, studies consistently show that probability of description is not equal for all species within a taxon (Collen, Purvis & Gittleman, 2004, Allsop, 1997, Cabrero-Sanudo & Lobo, 2003, Gaston, 1991). Broad scale comparisons among lower taxa have suggested that certain groups may receive a greater degree of taxonomic scrutiny (May, 1988), perhaps because they appeal to us more (Purvis *et al.*, 2003), and that some taxa have a higher chance of observation due to larger size (Gaston, 1991). Even within taxa, accumulating evidence suggests that some species are more likely to be described than others, though explanations are more subtle and vary among groups (Collen *et al*., 2004, Reed & Boback, 2002).

Figure 5 shows that if the traits that predispose carnivores and primates to being described more recently are examined, the overwhelmingly most significant predictive trait is geographic range size. But this is the trait which is prized so highly in many area selection algorithms; so the species which are most likely to receive conservation attention (restricted range) are least likely to have been described. While global level studies might point to general patterns, more targeted regional scale analyses might provide target areas for renewed research efforts. For example, in a study of the taxonomic description of anurans in the Brazilian Cerrado, Diniz-Filho *et al.* (2005) are able to note the likely effect on reserve system design, as well as aligning them with areas most likely to contain new species.

Biodiversity data coverage

A further issue that limits the usefulness of current outputs is the extent of species coverage. Biodiversity data are biased towards the large and charismatic species, and the process of conservation assessment has in the past been opportunistic and sporadic. With rare exception, we can surmise that biodiversity data are lacking for many plants, the majority of insects and all microorganisms (Balmford & Bond, 2005). This creates many problems, as when trying to address human impact on biodiversity, we are attempting to talk broadly; in reality the data are still very restrictive. The biodiversity crisis is undeniably in large part an insect crisis (Dunn, 2005). Taking IUCN Red List coverage as an indication of available biodiversity data, and data that are extremely useful for many different conservation actions (Lamoreux *et al.*, 2003), an examination of the 2007 IUCN Red List of Threatened Species shows coverage is incomplete for many groups (Figure 6; though see Baillie *et al*., 2008).

Descriptive taxonomy might be able to further influence conservation by aiding in the issue of reclassifying Data Deficient species on the IUCN Red List of Threatened species. The Data Deficient (DD) category is applied to a species when the available information is not sufficient for a full assessment of conservation status to be made. In reality, there are 3 reasons why a species might be classified as DD:

1. Unknown provenance, e.g. a species only from one specimen with extremely uncertain locality information
2. Insufficient information, e.g. lack of relevant data on population, trend or geographic range to apply criteria
3. Uncertain taxonomic status, i.e. we are unable to understand the unit to be assessed.

For this final reason, there is a clear role for descriptive taxonomy in clarifying these species dilemmas. With 5,590 species classified on the Red List as DD (IUCN 2009), the problem is not insubstantial.

In contrast, well over half of the 1000+ publications of Floras and Faunas identified by the survey were on invertebrates. However, the biogeographic coverage is dramatically skewed towards the Palearctic (Figure 7). Combining the two endeavours is critical for biodiversity conservation. Initiatives such as a sampled approach to Red Listing (the IUCN Red List Index sampled approach: Baillie *et al*., 2008; Collen *et al*., 2009), provide a step in the right direction, though results take time, and can be costly. Developing inexpensive methods which are simple to implement might improve the coverage of some groups. For example, Roberts et al. (2007) use independent data sets to demonstrate that simple species lists might be used to monitor bird populations. It is imperative with such techniques that repeat sampling occurs though, something which is being aided in many cases by web based initiatives.

Biodiversity on the web

Many examples of best practice come from new web-based initiatives. There are several notable projects, the first is from the New South Wales Parks and Wildlife service (2007). This web-based database of floral and faunal records from the region draws together more than one million recorded sightings, using data from historical reports, department of Environment & Conservation staff, survey data from major projects, consultants and the general public. The user can also generate distributions for the species, as well as a number of other features.

These types of data may then have a number of positive influences on conservation. Recording threatened species occurrences encourages additional data to be gathered, and therefore better conservation decisions to be made on enhanced data sets. They provide many avenues for research, including a test case for parameterising new advances such as the IUCN Red List 'Possibly Extinct' category (Butchart, Stattersfield & Brooks, 2006), the potential for niche modeling, and base information for planning.

A second example is provided by the Atlas of Australian Birds. The stated aims are:

- To collect and analyse data on the distribution and relative abundance of Australia's bird species.
- To compare the distribution and abundance of bird species to the previous Atlas.
- To collect information on rare and threatened bird species.
- To involve the community in the conservation and monitoring of Birds.

Much like the US Christmas bird counts (see http://www.audubon.org/bird/cbc/) the general public are used to produce the data. Practical conservation is aided by providing opportunity and the tools for large numbers of people to monitor, providing a more extensive monitoring network which raises awareness, and provides data that feed back into conservation research (e.g. interpreting trends) and could feed back into refining taxonomy (e.g. if decisions based in sympatry/allopatry with little distributional data).

From all projects, the over-riding message is that quality is paramount, as exemplified by the American Museum of Natural History SPIDA project (http://research.amnh.org/invertzoo/spida/common/index.htm). By providing the facility for expert identification online, it takes away observer bias, and recognises that we are probably not all going to become spider taxonomists. The lack of trained systematists is particularly problematic in relatively small and inconspicuous organisms, which compromise the majority of biodiversity.

One warning sign though is that all of these examples of best practice are in developed countries. Initiatives such as the Global Biodiversity Information Facility (GBIF, 2007) and the Encyclopaedia of Life project (EOL, 2007) both aim to put biodiversity data on the web, this making it more accessible to developing nations. Both projects, however, require that primary biodiversity data are collected, the majority of which reside in the tropics, in countries least able to provide the data. Repatriating data that originated in Less Developed countries, but which is currently held in Developed country institutions should be a key aim of any such project.

Conclusions

Conservation biologists must weigh up the obligation to keep pace with developing taxonomic knowledge, and the necessity to accurately measure biodiversity depletion. In order to be successful in tackling the biodiversity crisis, predictive conservation science must move beyond just recognising lists of species, to monitoring, modelling, predicting, and managing biodiversity based on those outcomes. In the future, conservation science requires three things from descriptive taxonomy:

1. that a solution is found to the problems posed by taxonomic inflation or change, and that this solution might be different for the generation of species lists, and the units used for conservation management. Taxonomic and nomenclatural changes (be they rank, circumscription or new species) must be presented in such a way as to allow users to manage biodiversity effectively;
2. that Floras and Faunas feed into monitoring programmes, and might in the future be incorporated into forecasting tools; and
3. that the baseline coverage for biodiversity data is broadened, to include the species and groups that represent the majority of biodiversity.

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Figure legends

Figure 1. Variation in rate of extinction over time, redrawn from the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005). Distant past = average extinction rates estimated from fossil record. Recent past = calculated from known extinctions (lower estimate) or known plus 'possibly extinct' species (upper bound). Future = model derived estimates including species-area, rates of shift between threat categories, probability associated with IUCN threat categories, impact of projected habitat loss and correlation of species loss with energy consumption.

Figure 2. Hypothetical relationships between utility, effort and completeness for species inventory (grey curves) and conservation assessment (black curves). Figures adapted with permission from Green et al. (2005).

Figure 3. Hypothetical phylogenetic tree (www.edgeofexistence.org; Isaac *et al.*, 2007).

Figure 4. Change in primate species numbers between 1965 and 2005 (reproduced with permission from Isaac *et al.* (2004).

Figure 5. Relationship between contrasts of date of description and geographic range, after Collen *et al*. (2004). Solid circles denote carnivores (solid line is regression line); open circles denote primates (dotted line is regression). An ANCOVA (not reported) showed a significant effect of order.

Figure 6. Species groups remaining to be assessed for the IUCN Red List (Data from IUCN Red List 2007). Values in brackets are the percentage of species within each group which have not yet been assessed by IUCN. Note all birds have been evaluated.

Figure 7. Proportion of Faunas published between 1989 and 2007 and their associated biogeographic realm. Data from Zoological Record search of term "fauna of*".

Figures and tables

Table 1. Focal areas identified in the Convention on Biological Diversity framework (http://www.cbd.int/2010-target/framework/indicators.shtml).

Focal area	Indicator
Status and trends of the components of biological diversity	• Trends in extent of selected biomes, ecosystems, and habitats • Trends in abundance and distribution of selected species • Coverage of protected areas • Change in status of threatened species • Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socioeconomic importance
Sustainable use	• Area of forest, agricultural and aquaculture ecosystems under sustainable management • Proportion of products derived from sustainable sources • Ecological footprint and related concepts
Threats to biodiversity	• Nitrogen deposition • Trends in invasive alien species
Ecosystem integrity and ecosystem goods and services	• Marine Trophic Index • Water quality of freshwater ecosystems • Trophic integrity of other ecosystems • Connectivity / fragmentation of ecosystems • Incidence of human-induced ecosystem failure • Health and well-being of communities who depend directly on local ecosystem goods and services • Biodiversity for food and medicine
Status of traditional knowledge, innovations and Practices	• Status and trends of linguistic diversity and numbers of speakers of indigenous languages • Other indicator of the status of indigenous and traditional knowledge
Status of access and benefit-sharing	• Indicator of access and benefit-sharing
Status of resource transfers	• Official development assistance provided in support of the Convention • Indicator of technology transfer

Figure 1.

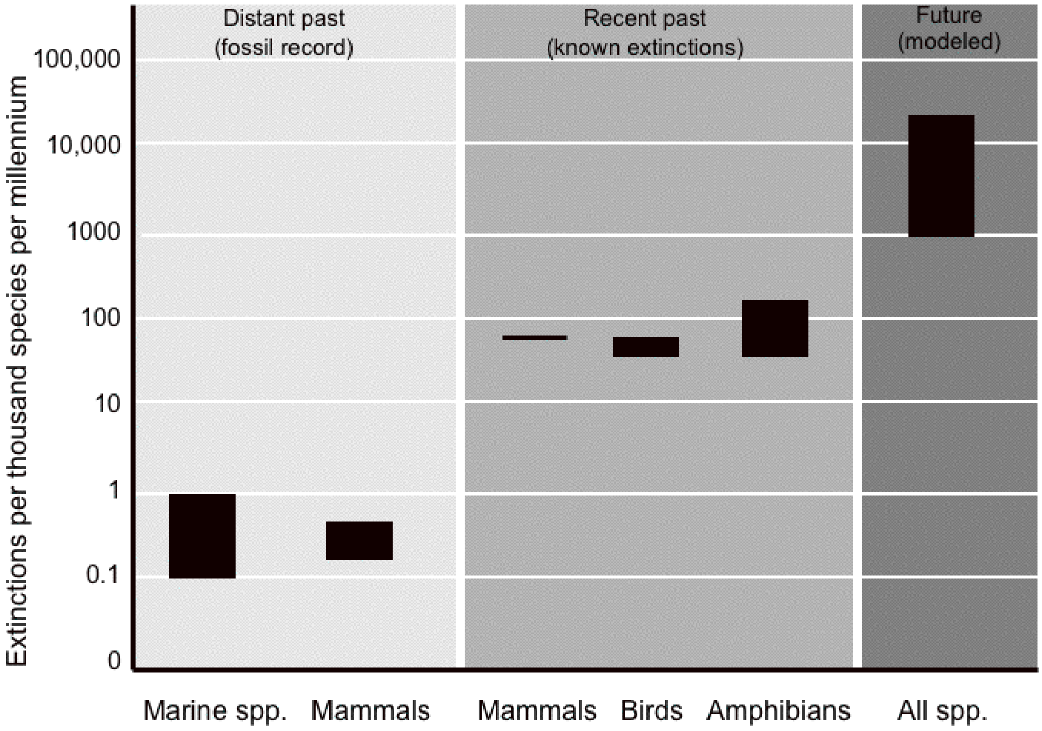

Distant past
(fossil record)
Recent past
(known extinctions)
Future
(modeled)
Extinctions per thousand species per millennium
100,000
10,000
1000
100
10
1
0.1
0
Marine spp.
Mammals
Mammals
Birds
Amphibians
All spp.

Figure 2.

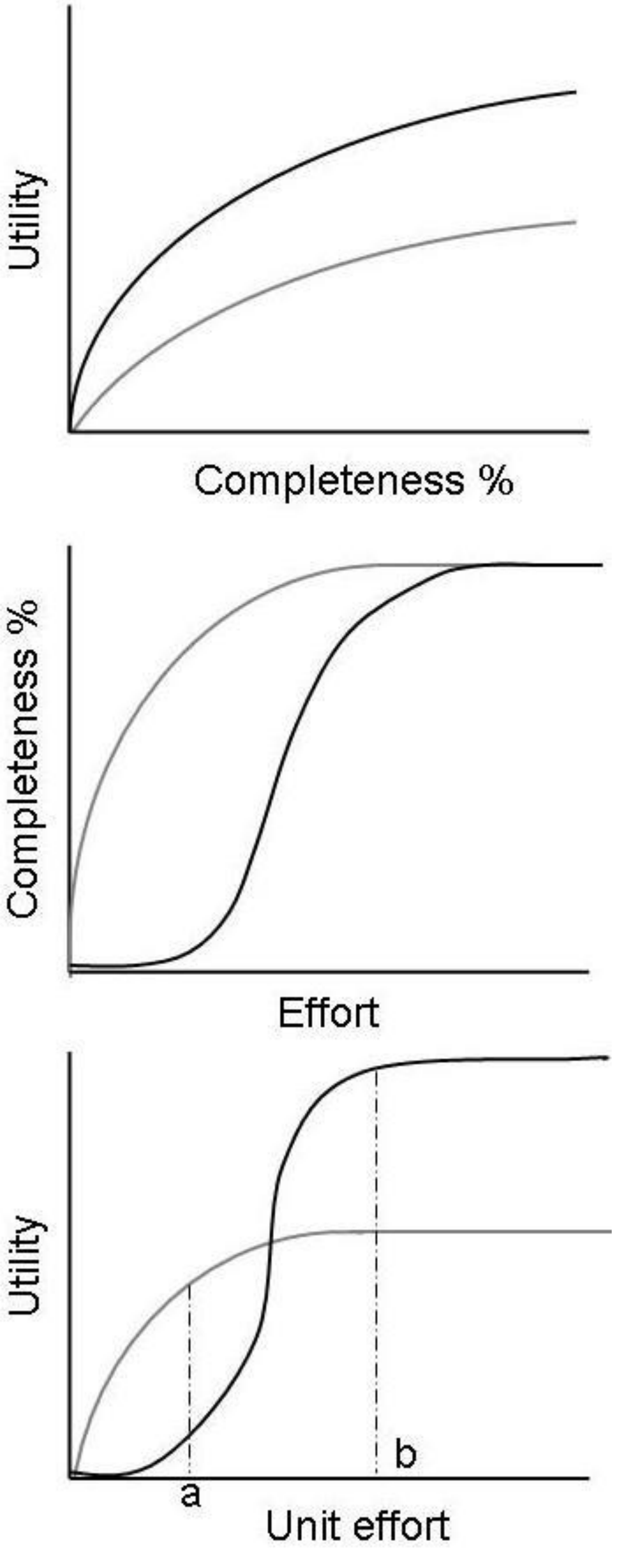

Utility
Completeness %
Completeness %
Effort
Utility
b
a
Unit effort

Figure 3.

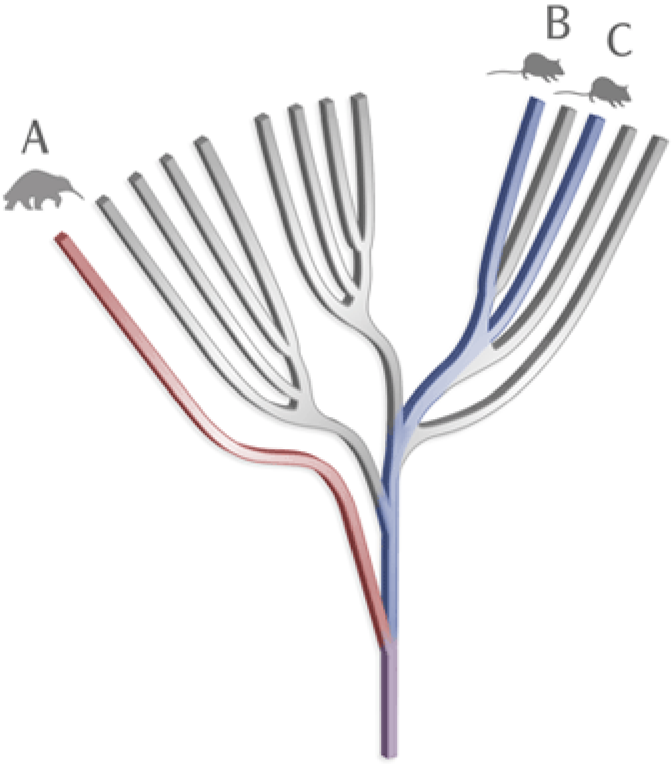


Figure 4.

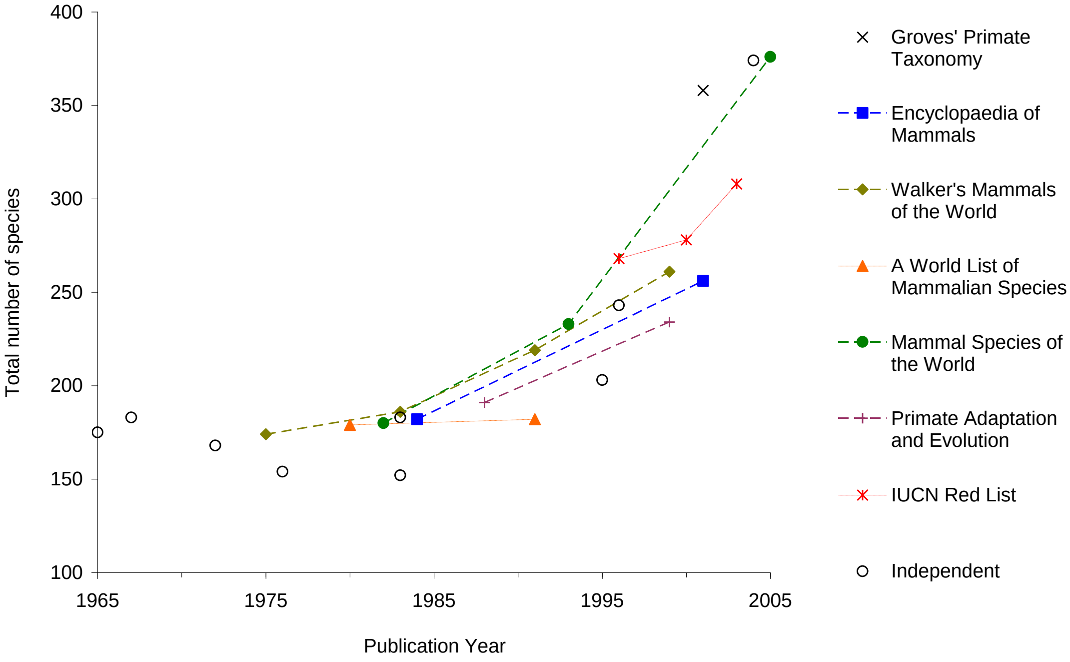


Figure 5.

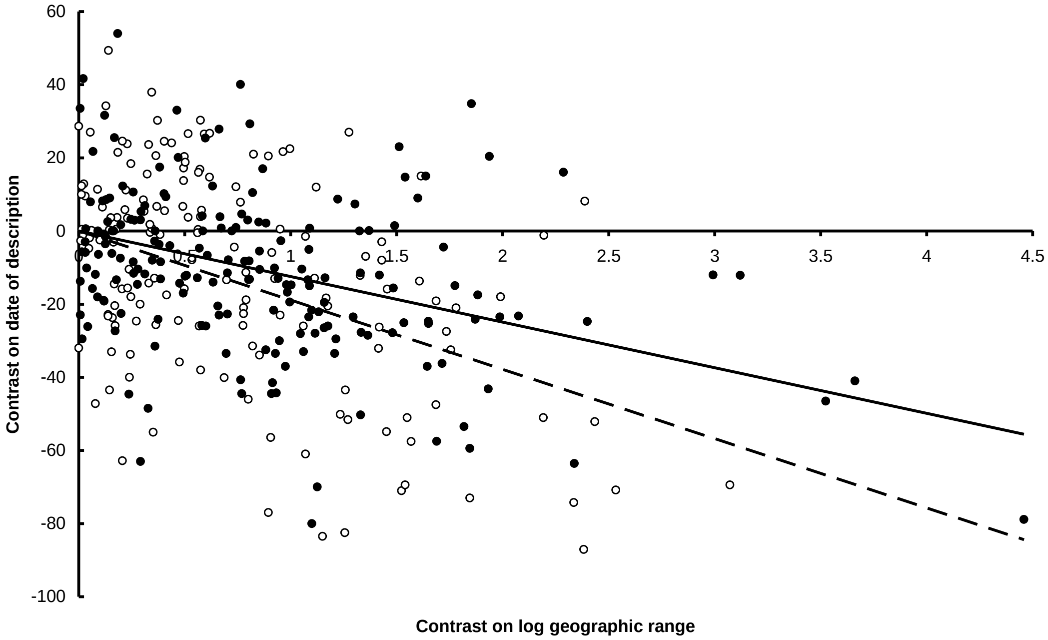


Figure 6.

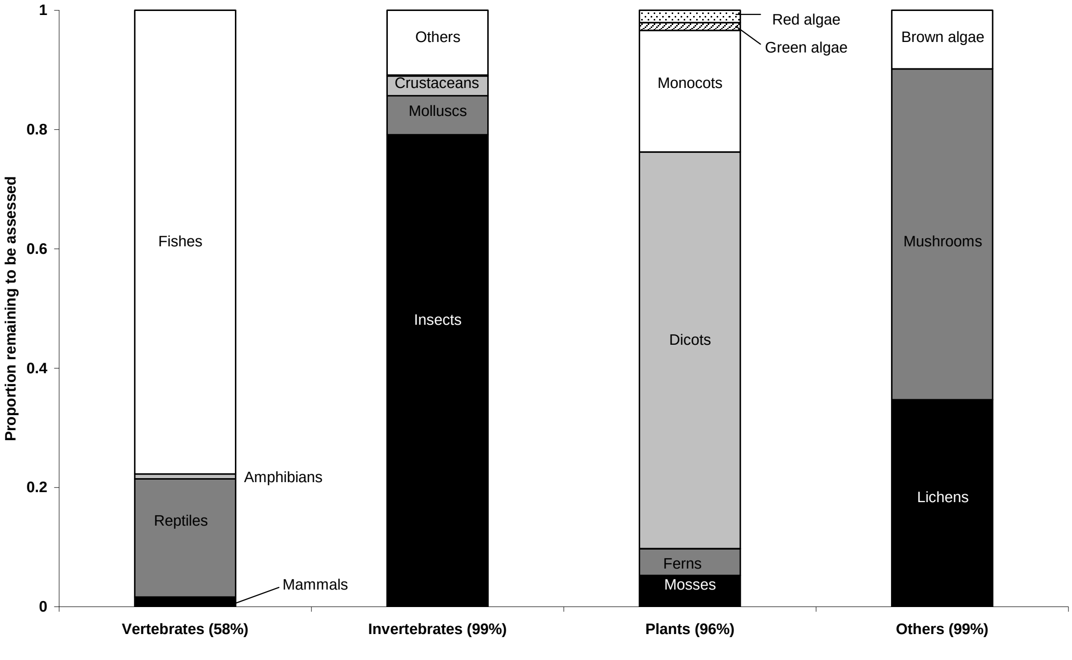
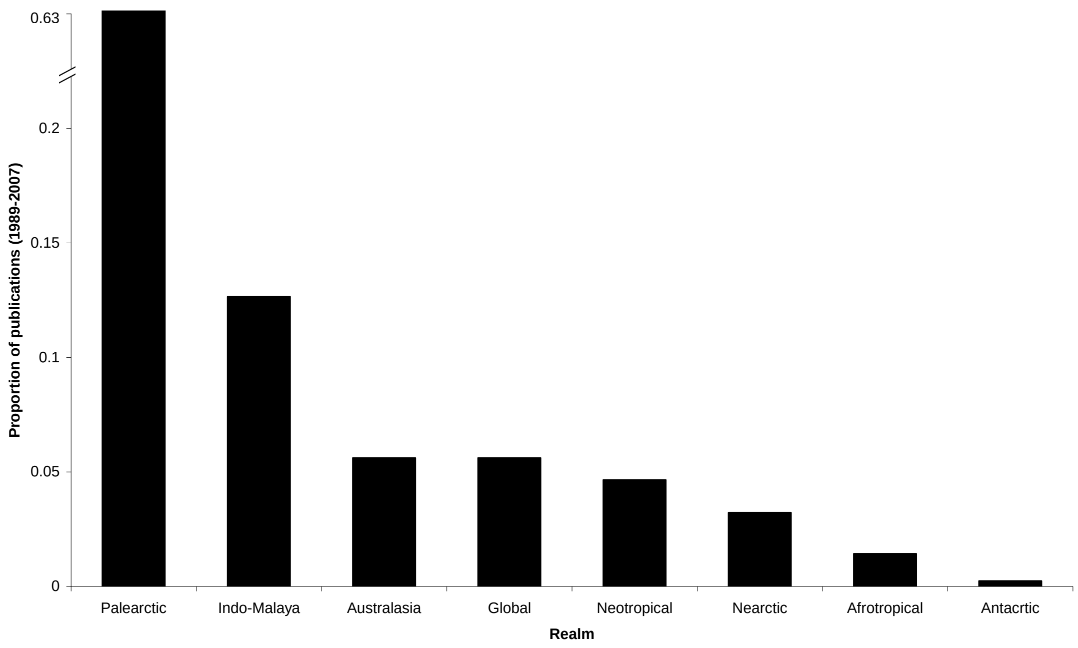


Figure 7.


0.63
0.2
0.15
0.1
0.05
0
Proportion of publications (1989-2007)
Palearctic
Indo-Malaya
Australasia
Global
Neotropical
Nearctic
Afrotropical
Antacrtic
Realm