Plant conservation in the Anthropocene - challenges and future prospects

Plant Diversity 39 (2017) 314–330

Contents lists available at ScienceDirect

Plant Diversity

journal homepage: http://www.keaipublishing.com/en/journals/plant-diversity/ http://journal.kib.ac.cn

Plant conservation in the Anthropocene – Challenges and future prospects

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A R T I C L E I N F O

Article history:
Received 9 May 2017
Accepted 24 October 2017
Available online 11 November 2017

(Editor: Yonghong Hu)

Keywords:
Plant conservation
Anthropocene
Aichi targets
Biodiversity governance
Protected areas

A B S T R A C T

Despite the massive efforts that have been made to conserve plant diversity across the world during the past few decades, it is becoming increasingly evident that our current strategies are not sufficiently effective to prevent the continuing decline in biodiversity. As a recent report by the CBD indicates, current progress and commitments are insufficient to achieve the Aichi Biodiversity Targets by 2020. Threatened species lists continue to grow while the world's governments fail to meet biodiversity conservation goals. Clearly, we are failing in our attempts to conserve biodiversity on a sufficient scale. The reasons for this situation are complex, including scientific, technical, sociological, economic and political factors. The conservation community is divided about how to respond. Some believe that saving all existing biodiversity is still an achievable goal. On the other hand, there are those who believe that we need to accept that biodiversity will inevitably continue to be lost, despite all our conservation actions and that we must focus on what to save, why and where. It has also been suggested that we need a new approach to conservation in the face of the challenges posed by the Anthropocene biosphere which we now inhabit. Whatever view one holds on the above issues, it is clear that we need to review the effectiveness of our current conservation strategies, identify the limiting factors that are preventing the Aichi goals being met and at the same time take whatever steps are necessary to make our conservation protocols more explicit, operational and efficient so as to achieve the maximum conservation effect. This paper addresses the key issues that underlie our failure to meet agreed targets and discusses the necessary changes to our conservation approaches. While we can justifiably be proud of our many achievements and successes in plant conservation in the past 30 years, which have helped slow the rate of loss, unless we devise a more coherent, consistent and integrated global strategy in which both the effectiveness and limitations of our current policies, action plans and procedures are recognized, and reflect this in national strategies, and then embark on a much bolder and ambitious set of actions, progress will be limited and plant diversity will continue to decline.

1. Introduction

> '*The transformed world of 2050 will demand new strategies and new approaches in conservation*'
>
> Redford et al. (2013)

Despite the massive investments and efforts that have been made to conserve plant diversity across the world during the past few decades, it is becoming increasingly evident that our current strategies and actions are not sufficiently effective to prevent the continuing decline in biodiversity, as recent assessments such as the CBD's *Updated Analysis of the Contribution of Targets Established by Parties and Progress Towards the Aichi Biodiversity Targets* clearly indicate (CBD, 2016). Habitats continue to be lost or degraded, threatened species' lists continue to grow, while the world's governments fail to meet their commitment to achieve biodiversity conservation goals such as the Aichi Targets and those of the Global Strategy for Plant Conservation. Clearly, we are failing in our attempts to conserve biodiversity on a sufficient scale.

Our collective failure to stem the loss of biodiversity globally, regionally, and nationally is a problem that has several dimensions –

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Peer review under responsibility of Editorial Office of Plant Diversity.

https://doi.org/10.1016/j.pld.2017.10.004

technical, scientific, social, economic, organizational, political and communicational. It is a matter of urgency that we address this issue because unless we can identify the root causes of our inability to take the necessary effective action, biodiversity will continue to disappear or degrade. This paper looks at the major achievements that have been made in conserving plant diversity in particular since the 1980's, and places them in context and then reviews the underlying causes of the continuing loss of plant diversity today in the context of the dramatic changes that are taking place in today's world, in a period that is now frequently been termed the Anthropocene,[1] sometimes referred to as the 'age of man', referring to the predominant human influence on our planet which some regard as threatening the planetary conditions required for human societies to flourish (Steffen et al., 2016).

Various explanations for the current state of biodiversity have been offered. We still debate what biodiversity is and how it should be assessed and with what metrics. Our current understanding of biodiversity has been described by Lean and Maclaurin (2016) as a mess – 'a fortunate, productive, and useful mess but a mess none the less', a situation which they trace to 'the lack of a guiding set of standards from which to assess the value of proposed biodiversity measures. Although measures are tested, the testing has often been piecemeal across conservation biology and related disciplines leading to conflicts over whether a metric has been proved'. They propose that best justified general measure of biodiversity will be some form of phylogenetic diversity (PD) which is now widely advocated as playing a key role in conservation decision-making although this has been questioned by Mazel et al. (2017) in a paper entitled 'Conserving phylogenetic diversity can be a poor strategy for conserving functional diversity' in which they assert that if our goal is to maintain trait diversity, then conserving taxa based on phylogenetic diversity will not reliably conserve at least as much functional diversity as choosing randomly.

Some commentators would argue that our conservation actions have failed to halt the loss of biodiversity because it lacks, in the words David Orr (2005), 'a deep explanation of what ails us and a larger cosmology that resonates with the public'. Others query the emphasis on sustainable development or even suggest that in the way in which it is currently interpreted as attempting to satisfy the needs of the present with those of the future, will inevitably fail because the former will always prevail. In his book *The Sustainability Mirage* Foster argues that unless we start focussing on the urgency of taking action now, rather than planning for the future, sustainable development will always be the pursuit of a mirage, the politics of never getting there. To break free of the illusion, claims Foster, we must break through to a new way of understanding sustainability (Foster, 2008). Conservationists are divided about how to respond and various alternative models for conservation have been suggested, although mostly theoretical and with little indication of how they may be implemented or success measured. Some believe that saving all existing biodiversity is still an achievable goal. The European Union Biodiversity Strategy to 2020,[2] for example, has as its headline target 'Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020'.[3] On the other hand, there are those who believe that we need to accept that biodiversity loss will inevitably continue to be lost, despite all our conservation actions and that we must focus on what to save, why and where. Others, such as Bridgewater (2016), go further and suggest that we need a new approach to conservation in the face of the challenges posed by the Anthropocene biosphere which we now inhabit. Bridgewater queries whether Red Listing processes for threatened species and expanding protected areas should continue to be the key foci in the science, policy and practice of nature conservation in the Anthropocene biosphere and cautions against letting ecosystem services and their valuation becoming an over-dominant paradigm.

Other responses to the continuing loss of biodiversity include:

- A growing importance attached to ecological restoration
- A shift towards achieving a better understanding of the societal benefits of ecosystem services and aiming for a new compact between biodiversity science and decision makers, as evidenced by the creation of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).
- A growing realization that the present system of state-run systems of protected area is not sufficient and that other actors such as private landowners, nongovernmental bodies and trusts should play a larger role in area-based conservation
- A recognition that of the need to increase the scale of conservation action and adopt a landscape-scale approach to management and restoration
- A recognition that despite its limitations, ex situ conservation has a major role to play as part of an integrated approach in many conservation procedures, such as species recovery and reintroduction and ecological restoration

The notion that instead of pursuing the protection of biodiversity for biodiversity's sake, an approach known as 'The new conservation' has been proposed that seeks to enhance those natural systems that benefit the widest number of people, especially the poor. Proponents of the 'New Conservation, Kareiva, Marvier and Lalasz, in a celebrated article 'Conservation in the Anthropocene' (2012) wrote:

> 'Conservation's binaries – growth or nature, prosperity or biodiversity – have marginalized it in a world that will soon add at least two billion more people. In the developing world, efforts to constrain growth and protect forests from agriculture are unfair, if not unethical, when directed at the 2.5 billion people who live on less than two dollars a day and the one billion who are chronically hungry. By pitting people against nature, conservationists actually create an atmosphere in which people see nature as the enemy.'

Known as the 'parks vs. people' debate, this perspective has generated an important, and at times heated, discussion and exchange of views that continues to divide the conservation and development communities (see for example Minter and Miller, 2011 and subsequent articles in the special issue of Biodiversity Conservation; Soulé, 2013), although as Holmes et al. (2017) point out, the debate 'has been dominated by a few high-profile individuals, and so far there has been no empirical exploration of existing perspectives on these issues among a wider community of conservationists'. A more optimistic vision is offered by Bennett et al. (2016) who write that 'Although both relatively utopian and dystopian … scenarios of the future exist, discussions tend to be dominated by dystopian visions of irreversible environmental degradation and societal collapse that ultimately diminish human quality of life. Whether or not one agrees with these characterizations, extrapolations of current, maladaptive trends into a bleak future run the risk of becoming self-fulfilling, because people base their actions on what they believe about society and their future…'

[1] There is, however, much debate over the application of the term (Davies, 2016).

[2] http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm.

[3] The mid-term review (Report from the Commission to The European Parliament and the Council The Mid-Term Review of the Eu Biodiversity Strategy to 2020 Com/2015/0478 Final) a noted that 'much more needs to be done on the ground to translate the EU's policies into action'.

They suggest that such scenarios may be improved and diversified by incorporating current examples of good practice, innovations, and experiments which they term ‘seeds of a good Anthropocene’ aspects of which can be used either alone, or in combination with one another to build a better, more sustainable future.

The need for optimism is also emphasized by Balmford (2017) who writes that it is vital ‘to inspire people rendered hopeless by what can seem like an unending torrent of bad news, and motivate them to purposeful action; to learn more about what works – and hence be able to sharpen our efforts; and so that we can reinforce rather than let drift the many gains that the conservation movement is making’. While agreeing with Balmford – and indeed the next section of this paper is devoted to outlining our major successes and achievements – I would suggest part of the cause of our failures is that conservation is indeed still seen by many as a ‘movement’ and not yet fully mainstreamed and integrated into our policy structure, despite the almost universal adherence to the CBD and other biodiversity-related treaties, as discussed below.[4]

Whatever view one holds on the above issues, it is clear that we need to review the effectiveness of our current conservation strategies, identify the limiting factors and take whatever steps are necessary to make our conservation protocols more explicit, operational and efficient so as to achieve the maximum conservation effect.

2. Plant conservation today – what have we achieved?

> ‘*We argue that no country is currently getting plant conservation right; plants are becoming increasingly rare around the world. Plants are often not fully protected by policy, their conservation is underfunded, and their importance is underappreciated*’
>
> Havens et al. (2014)

If we compare the situation of plant conservation today with the situation some 30 or so years ago, it is clear that we have made enormous progress. In the 1980s, plants tended to be neglected by conservation organizations as compared with animals, and this led IUCN and WWF to launch a Plants Conservation Programme (Synge, 1984; Hamann, 1985) with six main aims:

(1) To build public awareness to help stimulate action by pressure on governments and industries, by citizen action and by encouraging donations
(2) To build the capacity to conserve.
(3) To promote the conservation of plant genetic resources, both *in situ* and *ex situ.*
(4) To promote the conservation of wild plants of actual or potential economic importance, in particular medicinal plants.
(5) To enhance the conservation work of the 600 or so botanic gardens around the world.
(6) To support plant conservation in selected countries.

The programme, under the guidance of a joint IUCN/WWF advisory group chaired by Peter Raven, established the basis for a series of effective conservation initiatives and notable achievements included the Chiang Mai International Consultation and Declaration on medicinal plants (with WHO) and the *Guidelines on the Conservation of Medicinal Plants* (WHO, IUCN, WWF, 1993), the establishment of the IUCN Botanic Gardens Conservation Secretariat (later Botanic Gardens Conservation International), the Botanic Gardens Conservation Congress and the Declaration of Gran Canaria 1995 (Bramwell et al., 1987), the Centres of Plant Diversity project (Davis et al., 1994, 1995, 1997), the commissioning and publication of David Given's *Principles and Practice of Plant Conservation* (1994), *Conserving the Wild Relatives of Crops* (with IBPGR) (Hoyt, 1988). It also laid the groundwork for a series of conservation programmes and initiatives, some of which are still ongoing.

The subsequent decades, partly stimulated by the almost universal acceptance by governments of the Convention on Biological Diversity (as discussed below), and in particular by its adoption of the Global Strategy for Plant Conservation (GSPC),[5] have seen major achievements in plant conservation including the following:

- Every country now has a Protected Area system: just under 15% of the world's terrestrial and inland waters, just over 10% of the coastal and marine areas within national jurisdiction, and approximately 4% of the global ocean are covered by PAs.
- Most countries have developed a programme of threatened species assessment (Red Listing) and the IUCN Red List currently manages some 87,967 species, including some 23,074 plant species (out of a total of c.400,000) (see 3.2.2 below).
- Some countries have well developed endangered species legislation and a conservation recovery implementation system.
- The development of botanic gardens as a major player in plant conservation: the number of botanic gardens has increased from c. 1400 in 1990 to some 3000 today and many of them are engaged in conservation activities. In China, the number of gardens has grown dramatically, from 9 in 1950 to c.200 today.
- Substantial growth in the number of genebanks and other *ex situ* facilities and in the representation of wild species as seed samples or other plant propagules stored in them.
- Numerous assessments, strategies, action plans and targets and, global, regional and national electronic databases have been prepared, and meetings, seminars, workshops and reviews take place on almost a daily basis.
- A proliferation of both biodiversity databases such as GBIF, Biodiversity Observation Network (GEO–BON), SDG Knowledge Hub, The Digital Observatory for Protected Areas (DOPA), and plant diversity databases and information systems and the production of e-Floras as consequence of dramatic improvements in computing capacity and software.
- A recognition of the importance of agricultural biodiversity and in particular the role of crop wild relatives.
- The production of a vast literature on plant conservation and conservation biology.
- A growing recognition of the need to control the risks to plant diversity caused by biological invasions and the role played by some plant species in such invasions.
- A recognition of the linkages between plant diversity, nutrition and health.
- The transformation of ethnobotany and ethnopharmacology from largely descriptive to evidence-based approaches.
- A recognition of the importance of plant diversity in urban and peri-urban habitats.
- The development of new, more inclusive models of protected area management, including community-based approaches to plant conservation and a growing recognition that community participation is essential for the attainment of the economic, political, social and environmental objectives that underpin conservation.

[4] The United Nations Biodiversity Conference, Cancun, Mexico, 2016, had as its theme “mainstreaming biodiversity for well-being”.

[5] Initially published in 2002 and reformulated in 2010 (Sharrock, 2012).

– The growing recognition of the importance of ecosystem goods and services provided by plant diversity.
– The growth of the science, technology and politics of translocation and restoration biology and in particular the role of plants.
– The development of new approaches to plants conservation that bridge the gap between *ex situ* and *in situ* (Volis, 2016a,b)
– The development of an ethical regime to regulate the exploitation of plant diversity, in particular the adoption by the CBD of the Nagoya Protocol.

It would be wrong, however to interpret this array of achievements and developments as an indication that we are making adequate progress in addressing the loss of plant diversity. We are in fact failing to meet the targets set by the CBD, as reported in the detailed analysis of Progress towards the Aichi Biodiversity Targets for the period 2011–2020 (Leadley et al., 2014), the mid-term analysis of progress on the Aichi targets (Tittensor et al., 2014), and the CBD's *Updated Analysis of the Contribution of Targets Established by Parties and Progress Towards the Aichi Biodiversity Targets* (CBD, 2016). The latter analysis states that while the Parties have made efforts to adopt national targets in line with the Convention's Aichi Biodiversity Targets and have taken national action in support of the Targets, current progress and commitments are insufficient to achieve the Targets by 2020. A review of National Biodiversity Action Plans (NBSAPs) submitted by countries to assess whether national targets are in line with the Aichi targets; and information contained in Parties' fifth National Reports to assess progress towards achieving the Aichi Targets, finds that:

– 101 Parties (out of 196) have submitted their initial or revised NBSAPs;
– on average, less than 20% of national targets are commensurate with or more ambitious than the respective Aichi Targets;
– the majority of targets were less ambitious or did not address all aspects of the respective Aichi Targets;
– and many Parties have set targets that are more general than the Aichi Targets, often addressing several Aichi Targets with a single national target.

Analysis of National Reports reveals that:

– the majority of Parties have made progress towards the Aichi Targets, but progress is insufficient to meet the Targets by the 2020 deadline; and
– between 63% and 87% of Parties are not on track to meet a given Aichi Target.

Specifically for plants, an analysis of progress in meeting the goals of the revised Global Strategy for Plant Conservation (Sharrock et al., 2014) makes equally sobering reading.

Hardly a week passes without the publication of some new reports, detailing some particular aspect of the loss plant of diversity or habitat; and the messages they convey is little different from what was being said some 30–40 years ago, except that the cumulative amount of plant diversity loss continues to grow and the trajectory has scarcely altered.[6] Evidently, the conservation of plants still does not generate the sense of urgency as that of animals (Corlett, 2016) but the apparent neglect or lack of support (Balding and Williams, 2016) is more complex as is discussed below (see also the analysis of current plant conservation by Havens et al. (2014)).

3. Key issues that need to be addressed

A diagnosis of both the proximate and underlying factors that have limited our progress in addressing plant conservation and our failure to meet the targets that have been agreed under the CBD or other treaties or mechanisms reveals a variety of issues. Some of these have to do with the global socio-economic context, some with the context of global change, some with the perception of the importance of plant life, and some are technical, scientific conservation issues. These are discussed below after a scrutiny of the role of the Convention on Biological Diversity.

3.1. The convention on biological diversity – hard law with a soft centre?

Since its implementation some 33 years ago, the Convention on Biological Diversity has established itself as the pivotal international instrument covering the conservation and sustainable development of the diversity of plants and animals and has been ratified by most countries in the world (196 are parties to the Convention as at March 2017). It marked a turning point in political awareness of the issues of biodiversity conservation and sustainable use in that the Parties entered into a binding commitment to undertake the provisions of the Convention and subsequent decisions agreed by the Conference of the Parties. The Convention recognized for the first time in international law that the conservation of biological diversity is 'a common concern of humankind' but decisively rejected the notion that biological diversity was a 'common heritage of humankind' and it is enshrined in the treaty that countries retain sovereignty over their own biodiversity and control access to their genetic resources. It follows therefore that countries are responsible for the inventory, monitoring and conservation of and access to their native biodiversity but as the text of the Convention makes clear for each of the relevant Articles requiring conservation or sustainable use actions, only 'as far as possible and as appropriate' (Hagerman and Pelai, 2016), a proviso that has had serious consequences as discussed later.

It is legitimate to question how effective the CBD has been in achieving its main goals as a legal instrument of global governance (Harrop and Pritchard, 2011). It was originally envisaged as a 'hard law' instrument (Abbott and Snidal, 2000) with the potential to enforce implementation through legally binding protocols. In practice, it has relied largely on the obligation of the Parties to submit National reports and prepare Biodiversity Strategies and Action Plans as a means of implementation but only two protocols have been negotiated – Cartagena (biosafety) and Nagoya (access to genetic resources). It has effectively adopted a 'soft law' approach, as in the case of its recent focus on global biodiversity targets which are not backed up by obligations on the Parties to take action. Most articles of the CBD, say Harrop and Pritchard (2011) 'contain provisions which are expressed in imprecise language or over-qualified terms which enable member states to implement these provisions in virtually any manner they wish, whether challenging or not'. As Billé et al. (2010a) note 'It is widely recognised that the main weakness of international environmental law is the lack of general non-compliance procedures'. This has also been a key factor in the failure to achieve conservations targets as discussed below.

[6] Indeed, as I write this, a joint Pontifical Academy of Sciences and the Pontifical Academy of Social Sciences workshop on 'Biological Extinction' is being held in Rome – http://www.acistampa.com/story/ridurre-le-disuguaglianze-per-evitare-lestinzione-biologica-5545#.WLgiIAyxAD8.twitter and amongst its conclusions were that 'based on comparisons with the fossil record, … the current rate of loss of species is approximately 1000 times the historical rate, with perhaps a quarter of all species in danger of extinction now and as many as half of them may be gone by the end of the present century'.

The CBD is also, a 'framework' convention, giving the Parties considerable flexibility about how its provisions are to be implemented. Most articles of the CBD are 'beleaguered by vague commitments, ambiguous phrases, and escape clauses that permit avoidance of obligations' (Glowka et al., 1994; Harrop and Pritchard, 2011) that can be summarized in the CBD's own words as 'as far as possible and as appropriate'.

Later in 2000, the CBD then adopted a targets approach by deciding to develop a Strategic Plan aimed at more effective and coherent implementation, followed by a commitment called the 2010 Biodiversity Target and then after its failure to meet most of its goals, agreed the 2020 Aichi Targets. The 20 Aichi Biodiversity Targets are organized so as to help achieve the goals of the Strategic Plan. Given the need to take unique national situations into account, the Parties to the Convention agreed to set their own targets to meet strategic goals by 2012 with the consequence that the 20 Aichi Biodiversity Targets are considered more aspirational than binding. In the event, many countries failed to set national targets in a way that would lead to the achievement of the Aichi global targets and some of the targets were omitted altogether from their Strategic Plan, even by countries such as Canada with well developed and resourced conservation programmes (MacKinnon et al., 2015).

While the political will for implementation of the provisions of the CBD may exist in many if not most of the signatory countries, biodiversity conservation has of course to compete for resources with many other equally if not more demanding priorities such as health, education, industrial development and so on. This has led some commentators (e.g. Laikre et al., 2008) to express their concern about the undue politicization of the instruments of the Convention, notably the SBSTTA where some delegations comprise largely politicians and professional negotiators, rather than scientists, to ensure that trade and economic growth are not jeopardized by the decisions of the Convention. As a result, adequate resources may not be made available for effective implementation of many of the provisions of the Convention. These considerations apply to all countries, not just those in the developing world, although the latter may have much more justification than more developed countries for failing to meet their commitments, such as their lack of resources, infrastructure and the disproportionate burden of biodiversity that many of them are forced to deal with. It is difficult to disagree with Harrop and Pritchard's (2011) assessment that biodiversity conservation still does not rank very high on the international policy or regulatory agenda of global diplomacy.

3.2. The data gap

'*Few experts like or bother to write terra incognita on their maps. Yet, disclosing the limits to our knowledge is often among the most useful of acts*'

Jesse H. Ausubel (2008)

Plant conservation still suffers from a lack of baseline data. At all levels and all scales our knowledge of plant diversity remains very limited, in terms of its identity, distribution, ecology, demography, dynamics, function, social or economic value. For most species, there are serious gaps in our knowledge of taxonomy, distribution, ecology, population biology and demography, threat analysis and conservation status (Havens et al., 2014). Without such data, we cannot generate the information and build the knowledge and map and model it to allow us to meet our biodiversity goals and targets. Knowing what we don't know is also important to place our achievements in context.

When the data have been acquired, they have to be stored in some form of information system and numerous plant databases, online portals, and information systems have been developed at local, national, regional and international levels. Various 'knowledge products' (assessments of authoritative information supported by standards, governance, quality control, data, tools, and capacity building mechanisms) that support plant conservation have been developed but these require considerable finance for their support and maintenance (see Juffe-Bignoli et al. (2016) for estimates of the costs and funding sources for developing the IUCN Red List of Threatened Species, Protected Planet, and the World Database of Key Biodiversity Areas, all of them secondary data sets, built on primary data collected by extensive networks of expert contributors worldwide). The rise of big data and cloud technology and the increasing use of crowd sourcing afford exciting new potential for conservation and sustainable use of plant diversity but also presents us with considerable challenges such as devising appropriate structured decision-making tools that enable us to make sense of such complex data sets.

A greatly neglected area in plant conservation is monitoring, both short term and long-term. Although monitoring has been described as a centrepiece of nature conservation across the globe, in practice, many monitoring programmes lack a sound ecological basis, are poorly designed, do not lead to management interventions or responses and are often disconnected from decision-making (Heywood, 2011). Monitoring is often given low priority because it can be difficult and expensive to implement and monitoring programmes are often inadequately funded and inadequately implemented. Yet monitoring is an area where citizen scientists can and are making important contributions and this should be strongly supported by the plant conservation community.

3.2.1. How many species?

It is remarkable that there is still no agreement on how many species of plants[7] there are, both those known to science and those yet to be described. For most of the last century the number of known flowering plants was commonly cited as 250,000 although the basis for this estimate was never given. In 1994, Heywood and Davis (1994) observed that the cumulative total number of endemic species estimated to occur in the 15 regional surveys covering the world, prepared in consultation with local specialists, in their IUCN/WWF Centres of Plant Diversity, project (Davis et al., 1994, 1995, 1997) was 230,900 which is not far short of the 250,000 figure. If allowance is then made for those species that occur in two or more regions, in more than one continent or are even more widespread, the inescapable conclusion was that 'the total number of flowering plants and fern species must be at least of the order of 300,000–350,000'. Subsequently, a series of estimates was published in the first decade of the 21st century, ranging from 223,000 (Scotland and Wortley, 2003) to 422,127 (Govaerts, 2001) species, based on different methodologies and extrapolations (see discussion in Chapman (2009) and Pimm and Joppa (2015)).

Another basis for an estimate is The Plant List (www.theplantlist.org), a collaboration between the Royal Botanic Gardens, Kew and Missouri Botanical Garden, to compile a working list of all known plant species that aims to be comprehensive for species of Vascular plant (flowering plants, conifers, ferns and their

[7] The situation is complicated by the fact that plants may be interpreted widely, so as to include flowering plants (Magnoliophyta), gymnosperms (Coniferophyta, Cycadophyta, Gnetophyta and Ginkgphyta), ferns and allies, mosses and allies (Bryophyta) and plant algae, or in a more restricted way to cover essentially flowering plants and ferns. This makes comparisons of estimates difficult.

allies) and of *Bryophytes* (mosses and liverworts). The latest version (1.1, September 2013) lists 350,699 accepted names (33%), 470,624 synonyms (44.2%) and 242,712 (22.8%) unresolved names. As Pimm and Joppa (2015) point out, given that the accepted names were 38%[8] of those resolved, it would be reasonable to assume that the same percentage of unresolved names would eventually be accepted, thus adding some c.100,000 species to the accepted total of 288,900. If, however, the figures in the current version 1.1 are used (as explained in footnote 2), the percentage would be 42.6% of 242,712 unresolved species giving 103,365 and when added to the 350,699 accepted species gives a total of c.473,000 species. Even though the detailed content of The Plant List has been widely criticized and is not continually updated online, it is a species by species view and so has a more credible and testable basis than the other estimates and so one could conclude that, allowing for differences in taxonomic interpretation, the total number of known and accepted plus likely-to-be-accepted plant species is of the order of 470,000 ± 10%.

On the other hand, the report published by RBG Kew, *State of the World's Plants 2016* (https://stateoftheworldsplants.com/report/sotwp_2016.pdf) estimates that there are 391,000 vascular plants and 369,000 flowering plants known to science. These estimates are derived from a modified version of the methodology devised by Paton et al. (2008) based on the observation that there is a strong linear relationship in the World Checklist of Selected Plant families (WCSP, http://apps.kew.org/wcsp/) between the number of species recognised in a particular plant family and the number of plant names which have been used for these species currently found in The International Plant Names Index (IPNI, http://www.ipni.org).

What conclusions can then be drawn from these various initiatives? Of course, a definitive list will never be possible because differing taxonomic opinions, the continual process of taxonomic revision and reassessment and the gradual addition of species discovered that are new to science whose validity will then have to be assessed over time. The best we can aspire to is a comprehensive consensual list of plants and until this is completed, i.e. all the synonymy resolved and a critical review made of the list of accepted species to reach a consensus,[9] what we can say is that in light of all the available evidence, the best estimate is that there are 400,000 vascular plant species ±10%. This is a remarkable increase on the 250,000 species previously accepted for so many decades.

The increase in the number of recognized species of plants has a direct implication for various strategies and conservation targets that have adopted lower baselines, notably the IUCN Red List which currently estimates the total number described plant species as 310,442, mainly based on Chapman (2009). Accepting the 400,000 figure has some interesting consequences: it does not of course change the number of recorded threatened species but does reduce the percentage that have been assessed so that recent progress towards the target will be reversed (from 7% to 5.45%). On the other hand, it does increases the total number of species which are potentially candidates for various kinds of conservation action.

Although species richness (the number of species) is the most frequently and widely applied measure of biodiversity, which would justify our concern to establish how many plant species known to science (or more accurately accepted by current taxonomic opinion), it is important to remember that there is still no universal agreement on how to define a species. The actual named species we handle in biodiversity studies are comparable only by designation not in terms of their degree of evolutionary, genetic, ecological or phenetic differentiation and there is no agreement between the different practitioners on how to develop a coherent theory of systematics at the species level. In addition, species concepts differ from group to group and there are often national or regional differences in the way in which the species category is deployed which make comparisons difficult. The implications of the use of diverse species concepts in setting conservation priorities based on species numbers are generally overlooked or even ignored and the reluctance of conservation biologists and planners to engage with these issues, as highlighted by Rojas (1992), continues today.

3.2.2. *How many plant species are threatened?*

Estimating the number or percentage of species 'threatened with extinction' is a topic that has become almost an obsession with conservationists over the past 50 or so years. As Wilcove (2010) notes, for many people around the world, the conservation of endangered species is synonymous with the conservation of biodiversity and they are 'amongst the most visible and easily understood symbols of the ongoing loss of biodiversity'. The published estimates of threatened species not only range widely, from 10 to 60% (Kew, 2016) but tend to lump together species which range from being only slightly threatened to those that are critically endangered and whose demise is imminent.

As noted above, the IUCN Red List provides a global overview, albeit limited in value because of the poor level of sampling of most groups – with about 5.5% of plant species assessed. What is more important for practical conservation is that countries take steps to ensure that the status of their own flora, and in particular the species that are country endemics, is much better known and the threats to them identified so that they can plan and undertake on-the-ground conservation and management. This is especially true of tropical countries with very speciose floras. The Sampled Red List Index for Plants,[10] a global analysis of extinction risk for the world's plants, conducted by the Royal Botanic Gardens, Kew together with the Natural History Museum, London and IUCN, indicates that one in five of the world's plant species are threatened with extinction and the same figure is repeated in the first 'State of the World's Plants 2016', compiled by the Royal Botanic Gardens Kew (Kew, 2016).

Does it matter that we cannot put a precise figure on the actual or potential number of global plant extinctions? The conservation community is well aware of the seriousness of the situation and more precise figures would have few practical consequences. Likewise, most governments are more concerned with what is happening in their own country than with the global picture. Also, the message that we are losing species at an unprecedented rate has been conveyed effectively to the public, although somewhat weakened by the array of different predictions that has been made, but there is little evidence that there is any particular threshold at which the public would be galvanized into action or indeed of what any effective action might be, other than to lobby governments for more investment in conservation but probably not at the expense

[8] Although their paper was published in 2015, Pimm and Joppa quote the figures given in the Plant List as at May 2013 whereas they were substantially changed in version 1.1 in September 2013.

[9] The issue of achieving consensus in taxonomy is highly controversial Stevens (1990). I have suggested using 'standard names' in conservation to overcome the problems of synonymy (Heywood, 1994) and such a system was adopted in Europe by the Member States of the Council of Europe, whereby the names given in *Flora Europaea* would be used as Standard Named for European conservation databases and lists, notably the species listed in Appendix 1 of the Bern Convention. The automatic standardisation of plant names using The Plant List as a basis has been proposed by Cayuela et al. (2012).

[10] http://threatenedplants.myspecies.info/.

of say, health, education, poverty alleviation. For example, the headline 'Biologists think 50% of species will be facing extinction by the end of the century' coming from the recent (March 2017) Vatican workshop on Biological Extinction[11] appears to have had little impact, probably because similar dystopian statements are issued at regular intervals but with no readily identifiable consequences.

In any event, when the likely consequences of accelerated global, and in particular climate, change are added to the equation, it is clear that a majority of species are at risk to a greater or lesser extent, and attempts to assign a precise figure are of academic interest but of little practical value, except at local level.

3.3. The effectiveness of global biodiversity governance

> '*Many of the Aichi Biodiversity Targets cannot be met without the right institutional structures, capacity and governance in place - irrespective of the availability of resources. Therefore, in assessing resource needs it must be stressed that resource mobilisation should be accompanied by the development of appropriate capacity (including institutional and infrastructural arrangements) supported by political coherence across governments and national institutions*'.

High-Level Panel on Global Assessment of Resources for implementing the Strategic Plan for Biodiversity 2011–2020 CBD (2012)

It is altogether remarkable that while the notion of biodiversity conservation has been widely endorsed both nationally and internationally, little attention has been paid to the basic question of whether we had the necessary institutions and trained specialist staff to implement the articles of the Convention and the subsequent decisions of the Conference of the Parties. It became the responsibility of everyone and no-one. Protected Area systems were one conspicuous exception but for other areas, such as *ex situ* conservation, no attempt was made to put in place the necessary global institutional structure. This contrasts with the situation for agriculture and forestry which when faced with the widespread erosion of genetic diversity in crops, a gene bank system and appropriate protocols for the collection, storage and access to seed was developed by organizations such as the FAO, CGIAR and IBPGR (now Bioversity International) and a number of national and regional gene banks were also created. For *ex situ* conservation of wild species, no serious efforts were made to address the issue of capacity and it was left to botanic gardens to attempt to take on the role of *ex situ* conservation of plants although in most cases without the necessary staff, support or finance (Heywood, 2009). Spain was one of the few countries – in fact a pioneer– to recognize this need and the environment agencies of some autonomous governments helped to create or support seed banks in some botanic gardens or other centres. Even more critical is the situation for the conservation of target species *in situ* for which no dedicated institutional arrangements have been put in place with the consequence that the relevant 2020 targets are unlikely to be met.

In fact, the failure to put in place appropriate institutional arrangements to achieve its goals has been one of the most curious aspects of the CBD. In effect, a new discipline, biological diversity, was created but little thought was given to how the obligations of the CBD were to be implemented, which institutions would do the work, how much it would cost and who would pay. While no funding mechanism was established by the CBD, the Global Environmental Facility (GEF) took on the major role of helping developing countries in funding some biodiversity actions: as at 2015 it had invested $4.2 billion to conserve and sustainably use global biodiversity and this investment has leveraged over $12 billion in additional funds. It is the largest funding mechanism for protected areas (PAs) worldwide and has invested in over 3300 Protected Areas (GEF, 2015).

25 years after the CBD came into force, the report of the High-Level Panel on Global Assessment of Resources for implementing the Strategic Plan for Biodiversity 2011–2020 notes, 'Many of the Aichi Biodiversity Targets cannot be met without the right institutional structures, capacity and governance in place – irrespective of the availability of resources. Therefore, in assessing resource needs it must be stressed that resource mobilisation should be accompanied by the development of appropriate capacity (including institutional and infrastructural arrangements) supported by political coherence across governments and national institutions' (CBD High-Level Panel, 2012). The Report estimates that the resources needed to implement the twenty Aichi Biodiversity Targets at between US $150 billion and US $440 billion per year and gives details broken down by each Aichi target.[12] A Second Report published in 2015 (CBD High-Level Panel., 2014) reiterates that barriers to meeting the Targets may have as much to do with a lack of the appropriate institutional frameworks and decision-making processes, as with a lack of resources and notes that the 2012 estimates are broadly consistent with current assessments at the national, regional and global levels and for some targets probably underestimates.

3.4. Too many strategies, goals and targets?

One of the most remarkable features of the past 30–40 years has been the proliferation of reviews, assessments, strategies and action plans published by UN agencies, by IGOs, by the various environmental conventions and treaties, by NGOs and private bodies. Aside from the phenomenal cost of producing these documents, many of which are beautifully printed and illustrated, it is not entirely clear in many cases who the audience is, and what steps are taken to ensure that they reach it. The tragedy is that many of them gather dust on the shelves – both in the store room unsold and undistributed, and in one's offices unread – and their very existence is known to only a few. My experience of teaching advanced courses on biodiversity to international groups of biodiversity officials and practitioners over many years has revealed just how little of this vast literature is known by those at whom much of it is presumably aimed. One of the consequences is that valuable research is overlooked and this in turn may lead to expensive duplication of effort. It would appear that cost-effectiveness is not a prime consideration. With some exceptions, the process by which of these various documents come across one's desk is largely serendipitous.

Information overload is now a characteristic of all fields of research and learning but is particularly concerning in the field of

[11] http://www.acistampa.com/story/ridurre-le-disuguaglianze-per-evitare-lestinzione-biologica-5545#.WLgiIAyxAD8.twitterMarch2017.

[12] An estimate by McCarthy et al. (2012) gives the cost of reducing the extinction risk of all globally threatened (Red List) bird species as 'U.S. $0.875 to $1.23 billion annually over the next decade, of which 12% is currently funded'. By incorporating threatened nonavian species the total increases to U.S. $ 3.41 to $4.76 billion annually and protecting and effectively managing all terrestrial sites of global avian conservation significance (11,731 Important Bird Areas) would, they estimate, cost U.S. $ 65.1 billion annually. If sites for other taxa are added, the total increases to U.S. $ 76.1 billion annually. To achieve these targets, they say, would require conservation funding to increase by at least an order of magnitude. While substantial additional funds have subsequently been pledged, they still fall far short of what is needed.

biodiversity conservation as its scope is continually widening, increasing in complexity and interconnectedness. It now embraces not only the science and practice of conservation assessment, practice and monitoring, themselves transformed by molecular and bioinformatic developments, but the sociological, economic, legal and social context. It is difficult enough to keep abreast with developments in one's own specialist field and our limited ability to read and digest no more than a fraction of these assessments and reports forces us to rely more and more on digests of information which may often allow us little more than a superficial understanding of the issues involved.

The need to specialize has also led to the development of a series of epistemic communities on particular topics, with sometimes competing agendas and conflicting perspectives, which develop interconnections within their field but not with other epistemic groups. There is a risk, that some such epistemic groups may exert undue influence on policy makers and stifle dissent and thereby give purvey a false sense of agreement where none exists. As Thompson et al. (2008) observes with reference to biodiversity assessments, ‘It is … a valid criticism that the scientists and others participating in each iteration of these assessments have become increasingly self-selected in a manner that overstates consensus and downplays dissent’.

One has to ask if we are not beginning to suffer from ‘assessment fatigue’, not from the those who are involved in preparing them but the recipients and donors. Nonetheless, the recently created Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), which has interpreted the concept of biodiversity assessment in such a way that it does not just synthesize and report the evidence but also evaluates the different options for action by policy makers, has initiated a new series of assessments. An example is that on Pollinators, Pollination and Food Production (IPBES, 2016), which has been described as already providing the basis for informed policymaking at the international level, as well as at the national level.[13]

3.5. *Lack of clarity in formulating conservation targets and ways to measure their fulfilment*

The adoption of targets in biodiversity governance and conservation has grown considerably in recent years and they now occupy a central role in the implementation of the CBD and its strategies such as the Strategic Plan for Biodiversity 2011–2020 (including the Aichi goals) and the Global Strategy for Plant Conservation and also in the 2030 Agenda for Sustainable Development. One of the bases of systematic conservation planning is that it is based on explicit goals which are capable of being translated into quantitative, operational targets (Faith et al., 2001).

Until recently, little attention has been paid to the effectiveness of targets in achieving their goals or indeed on whether the targets are appropriate and insufficient effort has been paid to the formulation, design and purpose of targets (Pressey et al., 2003; Heywood, 2006a,b; Perrings et al., 2010; Bridgewater, 2011; Maxwell et al., 2015). As a result, many of targets are virtually meaningless, non-operational or unachievable: as Bridgewater (2011) puts it ‘Examining the approaches taken by conventions dealing with biological diversity with respect to targets, we find a terminological soup, where targets, goals, objectives and strategies are often mixed in the same paragraphs, and sometimes even in the same sentence!’ and in a critique of the formulation of CBD's Aichi targets, Butchart et al. (2016) suggest that the complexity and lack of clarity in the wording of the targets presents challenge for those implementing actions to achieve them and also makes it difficult to stimulate and quantify progress. They argue that the Aichi Targets would be more effective if they were simpler and less ambiguous:

> ‘The magnitude of required commitments under some targets is rendered ambiguous by the use of imprecise terms (e.g., “substantially”), while many targets contain poorly defined operational terms (e.g., “essential services”). Seventy percent of targets lack quantifiable elements, meaning that there is no clear binary or numeric threshold to be met in order for the target to be achieved. Most targets are excessively complex, containing up to seven different elements, while one-third of them contain redundancies. In combination, these four issues make it difficult to operationalize the targets and to ensure consistent interpretation by signatories. For future policy commitments, we recommend the adoption of a smaller number of more focused headline targets (alongside subsidiary targets) that are specific, quantified, simple, succinct, and unambiguous’.

Criticism has also been made of the actual numerical values proposed for some of the targets, notably the Aichi target 11 which calls for the protection of 17% of terrestrial and inland water ecosystems through “effectively and equitably managed” systems of protected areas by 2020. This target has no scientific basis (Butchart et al., 2015; Wilson, 2016; Dinerstein et al., 2017) and has already been bypassed by the 2014 IUCN World Parks Congress which decided that the total area of protected areas and connectivity lands needs to be far higher than currently agreed targets. Dinerstein et al. (2017) have proposed ‘An ecoregion-based approach to protecting half the terrestrial realm’ which aims to sets out the scientific rationale behind the recent advocacy for the concept ‘Nature Needs Half’, notably by Wilson (2016). To achieve this, they propose a ‘Global Deal for Nature—a companion to the Paris Climate Deal—to promote increased habitat protection and restoration, national- and ecoregion-scale conservation strategies, and the empowerment of indigenous peoples to protect their sovereign lands. The goal of such an accord would be to protect half the terrestrial realm by 2050 to halt the extinction crisis while sustaining human livelihoods’. However, Wiersma et al. (2017) contest the basis of this rationale and comment that it is ‘unreasonable to suggest that highly variable data and general statements such as “about half” can be codified as a single, scientifically based target’ and go so far as to say ‘the suggestion that there is a scientific basis for what the authors admit is an “aspirational goal” is irresponsible’. On the other hand, Pollock et al. (2017), with reference to birds and mammals, propose that a slight expansion of protected areas could remedy the large gaps that exist in the coverage for each facet of diversity: ‘just an additional 5% of the land has the potential to more than triple the protected range of species or phylogenetic or functional units’.

Although it is unlikely, if all the Aichi and GSPC targets were to be met on time, it would represent a major and very welcome achievement but we would still continue to lose significant amounts of biodiversity because of the various loopholes and deficiencies that have been pointed out.

Various proposals have been made regarding the criteria to be adopted in target setting:

- Great care should be taken to ensure that the targets are clear and unambiguous, bearing in mind the difficulties of defining biodiversity in a precise and measurable manner. If the goals are ambiguous or susceptible to different interpretations, there is a serious risk of debate as to whether in due course they have been met or not (Di Marco et al., 2016).

[13] https://www.cbd.int/doc/speech/2017/sp-2017-03-06-ipbes-en.pdf.

- They should be based on the best available scientific knowledge and there should be sufficient information about them to allow the baseline status of the target to be properly determined and meaningful goals set.
- There should also be a reasonable expectation of the goals being met, although equally they should not be set at such a level so as not to represent a challenge. For example, referring to conservation of land types, Pressey et al. (2003) state that it is a basic requirement of targets that they 'should not be constrained or revised downward to accommodate perceived limitations on the feasible extent of conservation areas'. They consider the notion of 'achievability' to be counterproductive at the stage of formulation of targets although it can be usefully applied at later stages in the process.
- On the other hand, unless adequate information is available and the nature and implications of the targets have been well thought through, there is a risk of setting targets that are unachievable at all or within an acceptable time-frame.
- Not only should the targets be thought through but the means of delivery taken into account.
- A distinction needs to be drawn between global and national/local targets in this regard: a global target may appear reasonable or even modest when seen in the abstract but represent an unacceptable burden at the individual country level.
- Unless targets are effectively monitored, it will be impossible to know if targets are feasible nor what progress is being made to halt the decline in biodiversity (EASAC, 2005).

In general, the experience of governments in setting targets to measure policy achievements in fields other than biodiversity is a very mixed one, with many targets having to be abandoned as unworkable or, worse, leading to data being distorted so as to make the targets achievable. Targets have also been criticized on various grounds, including:

- Lack of clarity in formulating the targets and ways to track progress and measure their fulfilment
- Failure to make an assessment of the capacity needs for implementing the individual targets (institutional capacity, personnel etc.) and make provision for the mobilization of the necessary resources (CBD, 2012)
- Failure to put in place an appropriate institutional structure to oversee the implementation of the individual targets (Billé et al., 2010a,b)
- Lack any legal requirements regarding implementation (Harrop and Pritchard, 2011)
- The lack of methodology for measuring and monitoring progress in meeting targets (Paton and Lughadha, 2011).
- Lack of coordination between targets in conservation planning, especially between area-based and species-based actions.
- Limited attention paid to coordination of targets across agreements and agencies (Perrings et al., 2010)
- Most global biodiversity conservation targets have not been costed (Heywood, 2006a,b, 2013)
- Failure to fully appreciate the implications of setting global targets and implementing them nationally.
- Failure to recognize that numerical indicators on their own are insufficient to measure how far targets are being met.

3.6. *Lack of coordination between targets in conservation planning*

One of the causes for the failure to meet conservation targets is a marked lack of coordination in the setting, formulation and implementation of those that are closely interconnected and a failure to take into account the potential synergies and trade-offs between targets (Butchart et al., 2016). This is especially true of targets relating to area-based and species-based actions as I have reviewed in depth elsewhere (Heywood, 2015). There I have argued that the failure to harmonize the Aichi and GSPC targets, together with the ambiguities in their formulation, have been an important factor in the poor progress in achieving effective *in situ* conservation of plant species and the strong likelihood that the targets will be missed substantially by 2020. Due to the scattered information sources, it is difficult to estimate the global number of species for which targeted *in situ* conservation action, such as management, recovery, and monitoring, has been undertaken or planned but is probably of the order of 1500–2000. This represents only a small percentage of the species known to be threatened, let alone those whose conservation status has not yet been assessed. Moreover, the number of species for which conservation or recovery plans have been actually implemented is smaller; and an even smaller number has been completed and shown to be successful (Heywood, 2015). What is even more disturbing and challenging is the fact that very little action has been undertaken in the megadiverse countries in the tropics to undertake species conservation or recovery. In a survey of *in situ* species conservation, Heywood and Dulloo (2006) noted how difficult it had proved to find examples of *in situ* conservation or recovery programmes, actions or plans for species in tropical countries in the developing world. Over ten years later, a few more examples can be cited, but there is little evidence that the situation has changed appreciably, although more inventory and survey work has been reported.

One of the reasons for this neglect of targeted *in situ* species conservation in the tropics is the excessive reliance on protected areas alone for the conservation of plant diversity, as discussed below. Another reason is the lack of trained conservation biologists and practitioners in these countries, perhaps in part because conservation biology and nature conservation cannot compete with molecular biology and bioinformatics in attracting students. Much of the literature published on conservation biology tends to pay lip service to the need for the *in situ* or *ex situ* conservation but fails to address the issues in a practical way.

The origin of this confusion around these conservation targets lies in the original CBD articles that address the conservation of species and their habitats (Articles 8 and 9). It is amply clear that for the CBD, the establishment of a protected area system is primary and a great deal of attention has been paid to implementing this policy in subsequent decisions of the CBD, while *ex situ* conservation occupies a secondary and supporting role, although, as noted above, the importance of *ex situ* approaches is now being recognized. The conservation of species and their populations *in situ* is included in Article 8(d) 'Promote the protection of ecosystems, natural habitats and the *maintenance of viable populations of species in natural surroundings*'[14] [my emphasis] and *both* Articles 8 and 9, somewhat confusingly, contain clauses referring to species recovery.[15] Subsequently, *in situ* conservation and recovery of species, both for plants and animals, have largely slipped through

[14] Note that clause 8 (d) is not restricted to threatened species and would appear to apply to all known species.

[15] As noted elsewhere (Heywood, 2015). It seems as though the CBD cannot quite make its mind up where species recovery fits in. 'A charitable interpretation would be that the CBD recognizes that species recovery may involve *ex situ* as well as *in situ* measures. On the other hand, it should be noted that the focus of species recovery and similar actions such as population reinforcement is essentially on species populations in the wild (*in situ*) and with *ex situ*, if involved at all, acting as a source of material not as a conservation measure'.

the net and have been effectively passed over by the CBD (Heywood, 2010). It may be that the procedures involved in *in situ* species conservation and recovery are either poorly appreciated or alternatively are regarded as too onerous for them to be widely implemented by the Parties although there are some notable exceptions such as Australia, New Zealand, Canada, USA and many European countries.

Targets that address the conservation of ecosystems and species, are included in the CBD's revised Global Strategy for Plant Conservation: Target 4 (ecosystem conservation), Target 5 (protecting important areas for plant diversity), Target 6 (conservation within production areas) and Targets 7 and 8 (species-level conservation) (Sharrock et al., 2014). For species-level conservation, the key targets are: Target 7: 'At least 75% of known threatened plant species conserved *in situ*' and GSPC Target 8: 'At least 75% of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20% available for recovery and restoration programmes'. The technical rationale for Target 7 (*in situ* conservation) is given as: '"Conserved *in situ*' is understood to mean that biologically viable populations of these species occur in at least one protected area or the species is effectively managed outside the protected area network, through other *in situ* management measures" (CBD, 2012). Such a rationale is non-operational: either the species occurs in a protected area or it does not. There is no action that can be taken that will alter this, other than to extend an existing area or create a new one that contains the target species, but that is the concern of Targets 4 and 5 of the GSPC, which of course reinforces the point that these targets need to be considered alongside Targets 7 and 8.

But surely, how many threatened species occur in protected areas is the wrong focus. The aim should not to be to *increase* the number of threatened species that are found in protected areas (to 75% or whatever number one choses), but to *reduce* it by effective conservation in protected areas and of course elsewhere in the wild. As it stands, the GSPC target will be met if, by 2020, 75% of threatened species are represented by a biologically viable population in at least one protected area which of course is a nonsense if the species are still threatened. If, however, the understanding is that simply presence of a biologically viable population of a threatened species in a protected area means that the species is no longer threatened, then that is equally naïve. The aim of *in situ* conservation of target species is to *remove* the threats that cause them to be endangered. If a species in a protected area is threatened, and the area is properly protected, then action needs to be taken to eliminate or contain the factors that threaten the species other than loss of habitat.

An increasing amount of effort is now being invested in restoration biology and greater attention should be paid to exploring the possibility and effectiveness of integrating restoration ecology with the conservation of threatened species. Coordination at the conceptual, practical and agency levels should be improved. Good examples of linkages between reintroduction and landscape restoration are now available, such as the Plant Extinction Prevention Program in Hawaiʻi, a consortium of over 60 public and private land management agencies and landowners with a common goal to protect islands' rarest and endangered plant species. A remarkable case study is the collaborative reintroduction efforts with the endangered Kaʻū silversword (*Argyroxiphium kauense*) and Pele lobeliad (*Clermontia peleana*) in Hawaiʻi Volcanoes National Park. For both species, the reintroduction programme, which has involved rediscovery, rescue of remnant founders, assisted dispersal, *ex situ* cultivation and propagation, managed breeding and outplanting, have been linked to large scale landscape restoration in the Park and in adjacent State and private lands (Robichaux et al., 2017).

3.7. Plant blindness

'...*most people in developed nations tend to see plants as merely a green, blurry backdrop for the animals and human-made objects that populate their visual field.*'

Wandersee and Clary (2006)

'*Plant conservation initiatives lag behind and receive considerably less funding than animal conservation projects*'.

Balding and Williams (2016)

It is somewhat paradoxical that the widespread enthusiasm in many cultures for gardens and gardening, parks and other urban plantings such as street trees and plant displays and more recently green roofs and living walls, together with the aesthetic appreciation of flowers in art, literature and society, and in the home as cut flowers and potted plants, is not reflected in a public appreciation of the role and importance of plants in the natural environment.[16] The tendency among humans neither to notice nor value plants in the environment nor their vital role in the economy has been termed 'plant blindness' (Balding and Williams, 2016). Journalists often have difficulty in writing about plants and in using the correct terminology about them – like the public they tend to call plants 'flowers' – while even natural history films and videos gloss over plants which are regarded as background and seldom name them, while attention is commonly focused on animal species. The underlying reasons for this have been well discussed and will not be pursued here.

How to address plant blindness is a major challenge. Certainly, botanists need to be much more proactive in challenging, in all forums, the under-investment or under-representation of botanical science. Many botanic gardens have well developed educational and outreach programmes that highlight the importance of plants and the need for their conservation although only a small percentage of the population has the opportunity to profit from such initiatives. Also, the distribution of botanic gardens is heavily skewed in favour of the less biodiversity rich countries. The conspicuous absence of any posters, leaflets or other information explaining the role of plants in the vast number of public parks around the world is a great missed opportunity. A hands-on approach to the problem is likely to be effective. For example, we should build on community involvement in urban greening and sustainable living movements through urban allotments, community gardens and similar initiatives (Iaquinta and Drescher, 2010; Heywood, 2017). There are some remarkably innovative approaches, involving community participation such as the 'Incredible Edible Bristol' community food growing movement which includes over 30 edible gardens in parks, street corners and station platforms that have been built and planted with volunteers and partners (http://ediblebristol.org.uk/).

A related issue is the widespread decline of botany as a separate discipline and the closure of botany departments and institutes across the world, despite the growing recognition, at least in some quarters, of the need for training and research in plant science as to support developments in agriculture and horticulture, to meet the challenge of growing sufficient food to feed a rapidly expanding population in a period of climate change. A similar fate has not, however, befallen zoology which continues to flourish and attract students.

[16] The membership of the Royal Horticultural Society is around 450,000. Plant life International has 11,000 members and supporters. Bird Life International has more than 10 million members and supporters.

One of the most serious consequences of plant blindness is that it has contributed to underinvestment in plant conservation activities compared with animal conservation. In general, plant conservation initiatives lag behind and receive considerably less funding than animal conservation projects. For example, in the United States, while most federal listed endangered species (57%) are plants in 2011, they received less than four percent of federal endangered species expenditure (Havens et al., 2014). Plants fare poorly in the conservation literature where many journals focus largely on papers on animal groups. In terms of taxonomic groups, our knowledge of biodiversity is very selective and a disproportionate amount of research is undertaken on some animal groups. As a consequence, many of the conservation models, protocols, procedures and assessments are based on experience of animals, notably mammals and birds, and do not necessarily apply to plants.

A related issue is that public concern in environmental issues including global warming, the loss of species and air pollution appears to be declining and, according to a Globescan international poll released at the end of February 2013[17] (Globescan, 2013), has dropped to its lowest level in two decades' 'Evidence of environmental damage is stronger than ever, but our data shows that economic crisis and a lack of political leadership mean that the public are starting to tune out'.[18]

As I have noted elsewhere (Heywood, 2013), although the public has not fully comprehended the issues or implications of biodiversity loss, it has seized upon climate change as it is something with which people can empathize and to some degree experience at first hand. For climate change the messages seem fairly clear and comprehensible to the public, even if grossly oversimplified – in some parts of the world it is going to get hotter or wetter, the permafrost will melt, the sea levels will rise, etc. as a result of increases in greenhouse gases and carbon emissions, largely caused by human activities. On the other hand, the take-home messages for biodiversity are so diverse – habitat loss or fragmentation, Red Lists and loss of species, genetic erosion, spread of alien invasive organisms, loss of ecosystem function, valuation of ecosystem services, access to genetic resources and the fair and equitable sharing of benefits, the ecosystem approach, overexploitation of resources, impacts of expansion of tourism, loss of cultural diversity including traditional knowledge and languages, reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) and so on. Even the terminology can be off-putting: while Climate Change Panel (IPCC) is understandable, the choice of name of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) for the recently established intergovernmental biodiversity body is not the most felicitous.

3.8. The significant deficit of conservation and funding of biodiversity-rich countries

One of the biggest challenges facing biodiversity conservation is also one of the most obvious: biodiversity-rich countries continue to face high biodiversity loss rates, despite the recognition of their key importance and the very substantial allocation of conservation funding and support they have received over the past few decades. However, inadequate funding levels continue to be recognized as one of the main impediments to effective global biodiversity conservation (Waldron et al., 2013). For many developing countries, overseas aid is and will continue to be the main source of biodiversity conservation funding so there is an urgent need for substantial increase in biodiversity-linked aid as well as the mobilisation of financial resources from domestic and other sources.

Inadequate funding interacts with a number of other factors which exacerbate the situation, such as poor governance, lack of adequate infrastructure and management, as well as political and policy considerations which also play a considerable role (Eklund et al., 2011). A recent study (McClanahan and Rankin, 2016) of conservation spending showed that greater biodiversity occurs in the tropics where cultures tended to spend relatively less on conservation and tended to have higher collectivism, formalized and hierarchical leadership, and weaker governance. And in a detailed analysis of State governance of protected areas in sub-Saharan Africa, Wicander (2015) shows how governments there 'heavily rely on international donor support, which can fluctuate and may be linked to certain sectors or projects that have no relation to PAs. Many states also struggle with internal corruption and a general lack of financial transparency, which can mean that the political willingness to create mechanisms of accountability might be low. Furthermore, government processes are often slow and heavily bureaucratic, which makes them very costly and involves high overheads'.

Another related factor is the relative lack of participation by local conservationists in biodiversity-rich countries in research activities. An analysis of publishing trends has shown that comparatively less research is undertaken in the most biodiverse countries and that often the research that is undertaken there is not led by in-country researchers and biodiversity rich countries are under-represented in the peer-reviewed literature (Wilson et al., 2016). This may be partly explained by the large number of conservation projects funded by international agencies and NGOs who engage expatriate staff to organize and often lead the work when suitable local staff cannot be identified for this purpose, and expatriate staff may be more accustomed to publishing in international peer-reviewed journals. On the other hand, results published in local journals or other publications tend not to be widely read outside the country and do not get picked up by science citation indexes. A related issue is the pressure on conservation biologists in universities and other scientific institutions to publish in scientific journals with high Impact Factors, given that scientific 'success' and career progression are largely determined by this criterion. In developing countries, this presents researchers with a dilemma: publishing their results in international journals with in a low Impact is an unattractive proposition because they will receive little recompense for the substantial efforts required in preparing a manuscript according to international standards, while their chances are poor of having papers containing conservation case studies being accepted by journals with high impact factors, which tend to be dominated by an elite minority of authors, 'generally with high-level English language skills and predominantly working in North America, Europe and some of the English-speaking countries of the Southern Hemisphere (Milner-Gulland et al., 2010). As a consequence, the results of many conservation projects are published in local journals, with the drawbacks noted above, or remain unpublished. Given that the success of conservation actions is often largely determined by interactive learning through the exchange of information by conservation practitioners. A detailed and more nuanced view of the causes and consequences of such inequities in terms of the publication of ecological science is given by Livingston et al. (2016).

[17] The findings are drawn from the GlobeScan Radar annual tracking poll of citizens across 22 countries. A total of 22,812 people were interviewed face-to-face or by telephone during the second half of 2012. Twelve of these countries have been regularly polled on environmental issues since 1992.

[18] In December 2016 GlobeScan's tracking shows that the American public now believes more than ever that climate change is a 'very serious' problem.

Another, handicap is that scientists from biodiversity-rich countries are less likely to participate in international meetings and forums. Those organizing international meetings need to be more proactive in inviting the participation of developing world scientists, not just through financial assistance but by providing mentoring in the preparation of presentations and papers for publication. Many of us do provide such assistance informally but it should be much more widely available than at present. Scrutiny of the National Biodiversity Action Plans (NBSAPs) and the Fifth National Reports submitted by countries[19] to the CBD to assess progress towards meeting the Aichi targets reveals the difficulties faced by many of these countries in meeting their obligations. Although the situation is an improving one, notably so in some countries such as China (Huang, 2011), the trajectory is such that many of the 2020 conservation targets will be unattainable by most biodiversity-rich countries and, as a consequence, the global targets will again be missed (Krupnick, 2013). For example, there is an almost complete lack of recovery measures for species or habitats in most tropical countries: in Brazil, for example, with a flora of some 46,000 species, only one official recovery plan (for a tree species) has been published (Martins et al. 2015) and a similar situation is found in Mexico: with a flora of 23,314 species, 50% of which are endemic, only two of the 16 projects for the recovery of priority species are for plants (as at 2012).[20] In Nigeria, despite having various institutions (botanic gardens, arboreta, genebanks) that focus on the conservation of genetic resources, little has been done to conserve the rich plant diversity *ex situ* (Borokini, 2013), while many of its protected areas are not adequately managed, a situation that is found in other sub-Saharan African countries (Wicander, 2015) and in other biodiverse countries.

It should be emphasised that lack of funding is not the sole factor in restricting conservation actions in developing countries. Even when resources are available, they are often invested in activities that have little direct impact on conservation. For example, the protection afforded by many protected areas is compromised by the lack of adequate management plans or implementation of them when they do exist, and by failure to prevent detrimental activities by local communities (Liu et al., 2001; Qian et al., 2017). *Ex situ* collections in genebanks and botanic gardens are often of limited value because of the lack of a focused accessions policy, failure to follow established sampling and storage protocols; and many action plans for target species are either poorly prepared or are not implemented.

Of course, such failings are also widespread in the developed world but the growing tendency today in biodiversity-rich countries to allocate a disproportionate amount of conservation funding into more fashionable techniques such as genetic studies and phylogenetic analyses, without full regard to their relevance or value to practical conservation in particular cases, is short-sighted. When this is done at the expense of the population demographic and eco-geographical studies needed to provide a proper understanding of the conservation needs of threatened species, expensive resources may be wasted. While genetic analysis plays a critical role in many conservation operations such as recovery and reintroduction, it should form part of a comprehensive conservation strategy. Funding agencies should consider if their guidelines are sufficiently explicit and appropriate to achieve the best conservation outcomes. Recognition of the problem of inadequate levels of funding and support for biodiversity-rich countries and poor targeting of resources has not so far led to proposals for a comprehensive action plan to address this issue. Part of the problem lies in the lack of detailed information on the current situation and a realistic assessment, country by country, of what is needed to achieve the key biodiversity conservation targets, together with a cost estimate. This has been partly addressed by Waldron et al. (2013) who assembled a global database of annual conservation spending[21] and then developed a statistical model that allowed them to identify countries where funding is robustly below expected levels. They list the 40 most highly underfunded countries for biodiversity conservation which, surprisingly includes Finland, France, Australia and Austria and omitted others that one might have expected on the basis of other evidence to be included. This may be partly explained by the fact that they used mammalian diversity as their surrogate for levels of threatened global biodiversity and this may not be sufficiently effective for other groups such as plants. Also, given the relative underfunding of plant conservation, already discussed above, their conclusion that 'very modest increases in international assistance would achieve a large improvement in the relative adequacy of global conservation finance' would probably not apply to plant conservation.

It would be reasonable to conclude that until a detailed audit of the conservation needs and the financial costs of meeting them for all groups in all biodiversity-rich countries is undertaken and action agreed and implemented under the CBD, the significant deficit will persist with the inevitable consequence of continuing failure to meet the United Nations biodiversity targets. Moreover, even if the financial deficit were to be met, mobilizing the necessary infrastructure and trained personnel would be a major challenge.

4. Specific conservation issues that need to be addressed

In addition to the factors discussed above, several of the underlying causes of plant diversity loss are due to the poorly conceived or technically inadequate conservation actions. During the past 50 years, enormous advances have been made in developing conservation protocols, guidelines, methodologies, and codes of good practice. But while some sectors such as the management of Protected Areas, management of invasive species, *ex situ* conservation, and reintroduction biology have benefitted greatly from this work, others still need considerable attention. Some of these are discussed by other papers in this issue. Here the role of protected areas in the conservation of plant diversity and other area-based conservation measures will be addressed.

4.1. Excessive reliance on protected areas alone for the conservation of plant diversity

It is generally accepted that systems of protected areas are the underpinning of our efforts to conserve biodiversity, both nationally and globally. However, despite the substantial increase in protected area coverage in recent years, they still provide an inadequate representation of the ecoregions and areas considered critical for biodiversity, many of them lack management plans or suffer from inadequate management, lack comprehensive biodiversity inventories and fail to undertake proper threat assessments of key biodiversity such as target species and the necessary actions to contain or eliminate these threats. In addition, they are subject to

[19] More correctly, those of such countries that have actually submitted reports.

[20] Conabio, Conanp, INE, DGVS-SEMARNAT y Profepa. Propuesta de lista de especies prioritarias para la conservación en México. México. 2012. Available at: http://www.biodiversidad.gob.mx/especies/pdf/EspeciesPrioritarias/PropuestaEspPrioritarias_ago2012_VerAct_Sept2013.pdf.

[21] They collated 'country-level conservation funding flows from multiple sources including government, donors, trust funds, and self-funding via user payments, and then calculated average annualized spending 2001–2008 (in constant 2005 US dollars)'.

the vagaries of political commitment and control, corruption, downgrading, downsizing and degazettement (PADDD[22]) (Mascia et al., 2014; Mascia and Pailler, 2011; Pack et al., 2016 [23]). And of course, protected areas themselves are subject to a diversity of threats which have to be combatted if biodiversity in them is to persist. The widespread and massive deforestation that is occurring in the tropics also affects protected areas. For example, a study by Leisher et al. (2013) based on six years of remote sensing data, estimated land and forest degradation inside 1788 protected areas across 19 countries in Latin America, and showed that 'from 2004 to 2009, the rate of land and forest degradation increased by 250% inside the protected areas, and the land and forest degradation totalled 1,097,618 ha. Of the protected areas in our dataset, 45% had land and forest degradation'.

It is common belief that protected areas are more effective in protecting habitats than non-protected areas although this has been called into question. For example, Clark et al. (2013) show that in South Asia (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka), a major centre of population and economic growth, 'the trajectory of habitat conversion rates inside protected areas is indistinguishable from that on unprotected lands, and habitat conversion rates do not decline following gazettement of a protected area'. Another example is Wolong National Nature Reserve in China, established to protect the giant pandas, where the rate of loss of high-quality habitat after the reserve establishment was much higher than before the reserve was created and was even higher than outside the reserve (Liu et al., 2001). As Clark et al. (2013) conclude, '…protection is not an automatic consequence of protected area gazettement' let alone effective conservation.

There is also a general assumption that protected areas are more effective in maintaining biodiversity than non-protected areas, partly based on the belief that habitat loss is often the main threat to species and this has been one of the main justifications for expanding the protected area estate and the large investment in such areas, both nationally and globally. The belief that protected areas preserve biodiversity has in turn led to the assumption that conservation of target species can be achieved if they occur in a protected area, although as has been frequently stressed (Possiel et al., 1995; Maxted et al., 1997, 2008; Heywood, 2005, 2015; Heywood and Dulloo, 2006; Hunter and Heywood, 2011; Havens et al., 2014), the presence of a species in a protected area is no guarantee of its effective long-term conservation, especially if it is threatened. As Dopson et al. (1999) note, 'Securing legal land protection in itself does not help conserve and recover the plants in question, but is often the first step required to conserve and restore plant populations by immediately limiting the number of potential threats'. The widespread failure to distinguish between presence and persistence of species in a protected area and between protection and conservation is a key factor in the continuing loss of biodiversity from such areas (Heywood, 2015). As Donaldson et al. (2017) note, 'Whether or not conservation managers are directly focussing on single or multiple species, recognition of the dynamic responses of populations and metapopulations to environmental change calls for the siting of reserves to support the persistence of species rather than simply the representation of as many as possible…'

It is remarkable how few detailed assessments of the effectiveness of PAs in terms of conservation of biodiversity in general or of species persistence or population size in particular have been made. As Barnes et al. (2016) comment, 'wildlife abundance changes in PAs are patchily documented and poorly understood'. The evidence from those analyses that have been made is often equivocal (Barnes et al., 2014; Crofts, 2014; Geldmann et al., 2013; Mora and Sale, 2011), with some even suggesting that presence of species' populations in PAs confers no advantage over those outside.[24] Most of these analyses have tracked mainly animal groups: in that by Geldmann et al. (2013), of the 42 studies evaluating PA effectiveness for habitat extent that met their requirements for analysis, none was specifically on plants, most of them referring to mammals or birds. A study, using a new global biodiversity database with 'unprecedented geographic and taxonomic coverage', found that globally, species richness is 10.6% higher and abundance 14.5% higher in samples taken inside protected areas compared with those taken outside but suggested that 'protection does not consistently benefit species with small ranges or increase the variety of ecological niches' (Gray et al., 2016). Another report (Milligan et al., 2014), on the conservation status of PAs, specifically the outcomes for biodiversity and the status and trends of species living within protected landscapes (although again only for certain animals groups), detailed the status and trends of wildlife populations within protected areas globally, assembling population trends for 4326 populations of 1654 species, and showed that of 130 monitored countries, 39% have declining populations within protected areas. As they note, previous research has assessed such conservation outcomes for protected areas based on how they represent different aspects of biodiversity (Rodrigues et al., 2004), and how they affect habitat cover and/or species populations (Geldmann et al., 2013) and species composition (Barnes et al., 2014). Another way to assess the impact of protected areas for species globally is to use indices of population abundance change over time, such as the Living Planet Index (LPI) which is the main statistic from the Living Planet Report (WWF, 2016) as a proxy for the effectiveness of PAs to conserve biodiversity and present a continuous measure that can be tracked over time. The report shows that the 'establishment of PAs should protect against some threats to the populations within them. Populations of species that are recorded as threatened (at the population level) are declining even inside PAs with an average decline of 12%. Populations of species with no recorded threats increase up until 2009 (154% increase) after which there is a sharp decline resulting in an average increase since 1970 of 124%. The remaining populations (classified as unknown) have experienced overall a 61% increase'.

The evidence for the effectiveness of protected areas in ensuring the persistence of species remains sparse and the ability of the current protected areas system to stem the current loss of biodiversity has been called into question by Mora and Sale (2011) who call for a radical rethink by the conservation community of the strategies needed to meet this challenge.

The fact that species management and protected areas represent different constituencies in both ecology and biodiversity conservation (Maxted et al. 2008; Heywood, 2015) is partly responsible for the lack of coordination between the two approaches. Moreover, in most countries, the management of national parks and protected

[22] Protected area downgrading, downsizing, and degazettement.

[23] In a study of PADDD in Brazil, Pack et al. (2016) identified '67 enacted PADDD events, which affected 112,477 km^2 and eliminated 6% of Brazil's total potential terrestrial PA estate. Hydropower (39%) and rural human settlements (20%) were associated with most of these enacted PADDD events, which have increased in frequency since 2005. Another 27 active PADDD proposals currently threaten to eliminate 60,555 km^2 of protected lands'.

[24] In a study of the effectiveness of the current reserve network at protecting species at risk in Canada, Deguise and Kerr (2006) concluded that 'Existing reserve networks rarely performed better than randomly selected areas and several included fewer endangered species than expected by chance, particularly in the most biologically imperiled regions'.

areas is the responsibility of different ministries or agencies from those charged with *ex situ* and *in situ* conservation and species recovery.

Given that the conservation *in situ* and recovery of threatened species can be a very costly and labour-intensive process, requiring considerable human and financial resources (Heywood, 2015), many would argue that such an approach is not possible because of the sheer numbers involved and would instead advocate a habitat/ecosystem-based conservation approach which allows a large number of species to be given some form of protection at the same time. While this might well become the default position, I have not seen it argued that the CBD mandate which specifically embraces a species-based approach should be changed. As we have seen, providing some degree of protection for threatened species in protected areas is a poor substitute for adequate conservation action aimed at their long-term persistence through the management or elimination of the threatening processes but given the lack of resources, some passive protection provided by protected areas is better than none. There is, however, 'an increasing tendency today to shift the focus away from species and to view biodiversity conservation and sustainable use through the lens of the ecosystem, with an emphasis on maintaining the healthy functioning of the system and its capacity to produce ecosystem goods and services' (Heywood, 2015). However, as McNeely and Mainka (2009) point out:

> 'Paradigms of ecosystem services, pro-poor conservation and rights-based approaches to conservation are taking centre stage but these approaches all call for continued attention to the fundamental role that species play in underpinning those paradigms. In the brave new world of conservation, species approaches remain core business. We must continue to pursue all of the tools in the species conservation toolbox, from development and implementation of species action plans to re-introduction, *ex situ* management and more'.

Despite their shortcomings, protected areas, in addition to the other roles they occupy, will continue to be a critical component of biodiversity conservation – in maintaining the integrity and quality of habitats and species diversity. But ensuring that they provide benefits for the conservation of threatened species is likely to require ongoing investments in the containment, abatement or removal of pervasive threats and continual monitoring of their effectiveness (Heywood, 2015; Milligan et al. 2015). The challenge for governments is whether they are prepared to make such investments and focus them on actual needs.

4.2. Role and effectiveness of other area-based conservation measures (OEABCMs)

While the global protected area estate has grown considerably over the past few decades and, as have seen offers some degree of protection to the species diversity it houses, most biodiversity remains outside such protection and insufficient attention has been paid to addressing the question of how far some degree of effective conservation of biodiversity can be achieved in areas that are not formally protected. A wide range of actions is being undertaken outside of and complementary to the formal protected areas system, including conservation easements, covenants, trusts, partnerships, incentive-based schemes, habitat conservation planning (HCP) and mitigation banking (Hunter and Heywood, 2011, chapter 11).

The role and effectiveness of these and other area-based conservation measures (OEABCMs) in conserving biodiversity (including Private Protected Areas, Indigenous Peoples' Conserved Territories and Areas Conserved by Indigenous Peoples and Local Communities (ICCAs), and Sacred Natural Sites (SNS) many of which house significant areas of cultural and biological diversity) varies considerably from case to case and needs careful assessment.

It should also be noted the Aichi Biodiversity Target 11 contains a significant policy alteration that allows countries to include 'other effective area-based conservation measures' (OEABCMs) along with protected areas in meeting national targets, although no clear guidance was given regarding what these other measures are or how they may be assessed (Jonas and MacKinnon, 2016; MacKinnon et al., 2015). To address this, the IUCN World Commission on Protected Areas (WCPA) set up a Task Force in September 2015 to provide guidance on this issue (Jonas and MacKinnon, 2016).

5. Impacts of global change on plant conservation

Biodiversity conservation has until recently been predicated on the basis that we live in a dynamic but slowly changing world. Such an assumption has to be reconsidered in the light of global change and in particular the rapid rate of climate change already being experienced and confidently predicted to continue, if not increase over the coming decades, according to the latest reports and assessments. Both the projected scale and rate of climate change has wrong-footed us and is forcing us to rethink and recalibrate our conservation responses. In fact, we face a dilemma regarding the time-scale of actions needed. Recent realization of the scale and likely consequences of global change (demographic, land use and disturbance regimes, climatic) on the maintenance and sustainable use of biodiversity and agrobiodiversity has led to a drastic rethink of our planning horizons: we are facing a foreshortening the timescale of concern and have to focus on the next 10–50 years during which critical actions will have to be taken to avoid irreversible changes. As former UNEP Director General Klaus Töpfer reminded us, '… a central fact of our time is the collapse of the long-term view as a buffer against harsh reality'. No longer can we take solace in the long-term view nor indeed in view of the uncertainties can we often usefully plan beyond, say, 25 years.

Global change affects all aspects of conservation. It is driving large-scale shifts in the distributions of species and in the composition of biological communities (Thomas and Gillingham, 2015). The political boundaries of protected areas are fixed but the biological landscape is not (Lovejoy, 2006; Garden et al., 2015) and many species will migrate, tracking the changing climate, while others will be able to adapt to the changing conditions, and those that can do neither will become extinct. The ability of species to adapt to climate change is becoming an important research field and it has been suggested that we should focus more attention on the ability of species to cope with change and to help them survive through *in situ* management (Greenwood et al., 2016).

It is clearly difficult for a fixed system of protected areas to respond to global change and considerable rethinking in the design of such areas will be needed if they are to survive and remain effective. There will need to be more flexibility in size and scale so that a connected network of patches of habitats at various scales is created so as to allow species the possibility to migrate and adjust their ranges in response to climatic and other change. Many protected areas will suffer moderate to substantial species loss while other species will migrate into them (including alien invasive species), leading to changes in the assemblages of species that they house, and some protected areas may disappear altogether with catastrophic species loss. The evidence is still equivocal and is likely to remain so while there is still uncertainty as to the scale and extent of climatic and other change.

6. Conclusions and recommendations

The past 30 years have witnessed a transformation in the progress of plant conservation, in terms of infrastructure, institutional building, methodologies and approaches. As regards conservation on the ground, the protected area estate has been expanded considerably, most countries now have Red Lists of threatened species, *ex situ* facilities have grown considerably, especially in botanic gardens, as has the number of accessions of wild plant species in gene banks, and some countries have well developed programmes of species recovery. In common with areas of conservation, strategies with time-limited targets have been introduced, notably by the CBD's Global Strategy for Plant Conservation and the Strategic Plan with its 20 Aichi Biodiversity Targets.

Across the world, heroic acts of conservation are being performed, such as the Plant Extinction Prevention (PEP) programme[25] to protect Hawaiʻi's rarest native plants from extinction, mentioned above, which demonstrates how effective planning and cooperation can make an impact.

Yet despite these achievements, we are still very far from even approaching a no-extinction scenario. Moreover, the targets we have set, even if they were all to be met, are incompatible with such an outcome. There are major gaps in our knowledge of nearly all aspects of plant life and this affects our ability to conserve it effectively. There is still a large gap between promise and achievement: too much aspiration, too little implementation (Knight et al., 2008).

The CBD itself has acknowledged the lack of progress in meeting the GSPC and Aichi targets but has not yet come up with an effective operational plan to tackle this. Exhortations to governments to do better are not sufficient and more stringent monitoring of their progress in meeting their commitments is needed; even sanctions for non-compliance might have to be considered. If the present trajectory continues and we fail to achieve a substantial part of the 2020 targets, the very credibility of the CBD risks being called into question.

The following proposals are aimed at improving our chances of meeting the conservation goals that have been agreed:

- The CBD Conference of the Parties should consider introducing more rigorous reporting requirements to encourage all countries to meet their commitments under the CBD and if they are unable to do so, they should provide a detailed explanation of the factors preventing this.
- Many of the conservation targets are too poorly formulated to be effective but even at this late stage, the CBD's GSPC and Aichi targets should be critically reviewed and where necessary, the actions needed to meet them should be clarified and clear criteria for measuring success should be set out.
- In particular, clearer guidance is needed on ways of integrating the species-based and the area based targets, notably for protected areas management and species recovery.
- The international community needs to acknowledge the continuing lack of sufficient support to biodiversity-rich countries which is preventing them from taking the necessary actions to meet their obligations under the CBD and other biodiversity-related treaties; and in association with the GEF and other funding agencies, should as a matter of urgency prepare and support a comprehensive and realistic strategy and action plan to address these deficiencies.
- Greater participation by developing countries scientists in international meetings should be encouraged and facilitated and assistance given to them in preparing papers for publication in international peer-reviewed journals.
- Policies should be introduced to enable conservation literature to be made freely available, especially in developing countries.
- Conservation journals should encourage authors to include guidance on how their papers will help conservation practice on the ground.
- Plant conservation biologists and conservation practitioners should collaborate in the preparation of recommended guidelines and manuals of good practice for those areas of conservation where none currently exist.
- Every country should as a matter of high priority, prepare a national strategy and action plan for the conservation of **all** globally threatened species that occur within their territory (unless of course this is already included in their national biodiversity strategy and action plan).
- Community conservation/citizen science should be strongly encouraged and at the same time careful monitoring of its effectiveness should be carried out.
- Conservation outside protected areas is still largely neglected and should become a priority focus of the CBD work programme.

Without such actions, and until the fundamental and intrinsic failings in global governance of biodiversity and national compliance are effectively addressed, so that effective action on the ground can be undertaken on a sufficient scale, the enormously rich diversity of plants on which our very civilization depends will continue to be degraded.

[25] http://www.pepphi.org.

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