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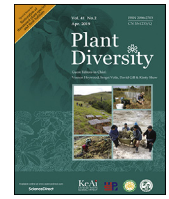

# Conserving plants within and beyond protected areas – still problematic and future uncertain

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ABSTRACT

Against a background of continuing loss of biodiversity, it is argued that for the successful conservation of threatened plant species we need to ensure the more effective integration of the various conservation actions employed, clarify the wording of the CBD targets and provide clearer operational guidance as to how they are to be implemented and their implementation monitored. The role and effectiveness of protected areas in conserving biodiversity and in particular plant species *in situ* are discussed as are recent proposals for a massive increase of their extent. The need for much greater effort and investment in the conservation or protection of threatened species outside protected areas where most plant diversity occurs is highlighted. The difficulties involved in implementing effective *in situ* conservation of plant diversity both at an area- and species/population-based level are discussed. The widespread neglect of species recovery for plants is noted and the desirability of making a clearer distinction between species recovery and reintroduction is emphasized. Key messages from a global overview of species recovery are outlined and recommendations made, including the desirability of each country preparing a national species recovery strategy. The projected impacts of global change on protected areas and on species conservation and recovery, and ways of addressing them are discussed.



## 1. Introduction

> '*The history of conservation is a story of many victories in a losing war*' E.O. Wilson (2018).

The recent trajectory of biodiversity conservation has gone from a phase of expectation and optimism, after the coming into effect of the Convention on Biological Diversity (CBD), and periods of intense conservation actions and even more outpouring of books and papers, reports, action plans, targets and strategies, to one of reluctant acceptance that none of this is sufficient. The loss of biodiversity at all levels continues at an alarming rate, faster than it is able to recover, and many of the CBD's Aichi Targets for biodiversity will not be met given current trends, as noted by the latest analysis of the progress towards the targets (CBD, 2016a,b). A review of biodiversity losses and conservation responses in the Anthropocene by Johnson et al. (2017) concludes that.

> 'Although conservation efforts have produced some encouraging results, these have done little more than forestall some losses by tackling symptoms of unsustainable use of environments. Our successes have been valuable in buying time that could allow recovery of species and ecosystems in the future and providing lessons on how conservation actions can be made effective. However, the problem of transforming the fundamental drivers of unsustainable use of nature remains largely unaddressed'.

This perspective is confirmed by the first regional assessments of biodiversity and ecosystem services (https://goo.gl/oJ4DRq March 2018) prepared by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) which indicate that biodiversity continues to decline in every region of the world, significantly reducing nature's capacity for resilience and adaptation to novel conditions, and its contribution to people's well-being. The CBD Executive Secretary comments 'These assessments are sobering. … if the current trends on biodiversity loss and ecosystems destruction are not reversed, the prospects for life on our planet become quite grim. At the current rate of destruction not

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only will it be difficult to safeguard life on Earth, but will jeopardize the prospects for human development and well-being' (quoted in https://www.cbd.int/doc/press/2018/pr-2018-03-23-IPBES-en.pdf).

The world and almost all regions are currently off course from achieving the Sustainable Development Goals (SDGs) (TWI 2050 – The World in 2050, 2018). The 2018 SDG Index and Dashboards report titled, 'Global Responsibilities: Implementing the Goals,' which track country progress towards the SDGs find that no country is on track to achieve all of the SDGs, and progress is slowest on the environment-focused goals, such as SDG 12 (responsible consumption and production), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land) (Sachs et al., 2018).

> 'While solutions to climate change remain elusive, at least the world's policymakers have demonstrated an understanding for the risks posed by rising temperatures. Unfortunately, there is no similar awareness of the threat posed by biodiversity loss – a shortcoming that scientists are urgently seeking to rectify. Many policymakers … have yet to recognize that biodiversity loss is just as serious a threat as rising sea levels and increasingly frequent extreme weather events.' R.T. Watson (2017).

In a telling comment at the meeting of the CBD Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA 22) in July 2018, the Global Youth Biodiversity Network (GYBN) 'called on governments to stop the vicious cycle of setting targets but failing to meet them. They reminded delegates that in 2009 former CBD Executive Secretary Ahmed Djoghlaf pledged that the mistake made in adopting the 2010 Biodiversity Target without identifying the means of implementation would not be repeated at COP 10 in Nagoya, when the Aichi Targets were adopted. Yet, the IPBES assessments … show that the measures implemented so far are not always in line with the ambition of the CBD Strategic Plan[1]'. Also, one of the delegates to the 2nd Meeting of the CBD's Subsidiary Body on Implementation (SBI 2) is quoted as saying 'Unless we raise the Convention's profile … and showcase how biodiversity sustains human well-being, most of the world's decision makers will continue considering conservation a "nice to have" luxury, when it really is a "must have" for sustainable development'.

On 14–15 May 2018, a biodiversity Expert Group Meeting evaluated progress towards the Sustainable Development Goal on life on land (SDG 15) and discussed ways to protect and restore biodiversity, in the lead up to the July 2018 session of the High-level Political Forum on Sustainable Development (HLPF).[2] Amongst the issues highlighted were[3]:

- raising the profile of biodiversity and SDG 15 in political discussions across the board;
- mainstreaming biodiversity in all sectors and across sectors;
- policy coherence and integration among all relevant sectors and actors;
- protecting customary land rights and securing land tenure for local populations;
- community-based management and participatory approaches, in which indigenous peoples and local communities are co-designers;
- gender mainstreaming in all policies and programmes; and
- cross-sectoral, cross-departmental, and multi-stakeholder collaboration, including through partnerships.

We are facing such an alarming situation despite the agreement by governments to implement the Global Strategy for Plant Conservation 2010–2020 and the Aichi targets of the CBD's Strategic Plan for Biodiversity 2011–2020. As Sharrock and Wyse Jackson (2017) comment, 'there is a continued lack of mainstreaming plant conservation at the national level and a lack of comprehensive information on which plants are threatened and where. With the GSPC reaching the end of its second phase in 2020, it is important to consider how plant conservation can enhance its visibility and generate support in the future'. Already, preparations are being made to develop a new strategy and targets for the period up to 2030.

The background to this situation is global change, including notably climate change, whose impacts are being increasingly noticed in virtually all aspects of conservation and sustainable development and which is driving large-scale shifts in the distributions of species and in the composition of biological communities (Monzon et al., 2011; Heywood, 2012; Stein et al., 2013; Thomas and Gillingham, 2015). The recently published paper by Steffen et al. (2018), 'Trajectories in the Earth System in the Anthropocene' which postulates that human-induced warming is rapidly approaching levels that may trigger positive climate feedbacks which could have devastating consequences for all of us, should serve as a wakeup call to even the most disinterested political or business leaders.

Current conservation strategies are still largely based on the assumption that we live in a dynamic but slowly changing world. Such an assumption has to be revised in the light of the rapid rate of climate change already being experienced and confidently predicted to continue, if not increase, over the coming decades. Both the projected scale and rate of climate change has wrong-footed us and is forcing us to rethink and recalibrate our conservation responses (Heywood, 2017). 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 also requires a drastic rethink of our planning horizons: we have to focus on the next 10–50 years during which critical actions will have to be taken to avoid irreversible changes. No longer can we take solace in the long-term view as a buffer against harsh reality nor indeed in view of the uncertainties can we usefully plan beyond, say, 25–50 years. On the other hand, the actions that we take today will have long-term effects on the lives of future generations.

Resolving the quandary of the continuing loss of biodiversity despite all the efforts and resources that have been invested in its conservation, is an enormously complex issue as it involves socio-economic and political issues as well as scientific and technical problems (Heywood, 2017; Johnson et al., 2017). As we start planning our post-2020 conservation strategies, we have an opportunity to address the failings of the previous CBD and SDG strategies, ensure the more effective integration of the conservation actions proposed, clarify the wording of the targets and provide clearer operational guidance as to how they are to be implemented and their implementation monitored.

In this paper, I shall address the difficulties involved in implementing effective *in situ* conservation of plant diversity both at an area and species/population-based level. Although *in situ* conservation is often interpreted as meaning principally conservation within a protected area, it covers a range of both area- and species-based approaches (Heywood, 2005, 2015; 2017; Heywood et al., 2018). I shall discuss the role and effectiveness of protected areas in conserving species *in situ* and also how species may be conserved or at least protected outside protected areas where most plant diversity occurs.

[1] Quoted in Earth Negotiations Bulletin (ENB)Volume 09 Number 701 – Wednesday, 4 July 2018. http://enb.iisd.org/vol09/enb09701e.html.

[2] http://sdg.iisd.org/news/sdg-15-experts-discuss-drivers-solutions-to-biodiversity loss/https://sustainabledevelopment.un.org/content/documents/18501SDG15_EGM_background_noteFinal.pdf.

[3] Ana Maria Lebada, http://sdg.iisd.org/news/sdg-15-experts-discuss-drivers-solutions-to-biodiversity-loss/.

## 2. Conservation approaches

Today's approaches to conservation are still basically those that were beginning to be practised as far back as 100 years ago. The main components are: developing a system of protected areas, identifying and listing threatened species, actions to conserve endangered species, storing germplasm *ex situ* of threatened species as an insurance policy, and when all this fails attempting to reintroduce species to areas from which they have been lost and restoring degraded or lost ecosystems. According Sutherland et al. (2004) much of current conservation practice is based upon anecdote and myth rather than upon the systematic appraisal of the evidence but of course we now have vastly greater knowledge and capacity and experience, sophisticated techniques to apply and a considerable body of accumulated experience. Also, as Adams (2004) commented 'The problems facing conservation at the start of the 21st century are… mostly … the same problems recognized and faced by conservationists a century ago. What is more worrying is that the same is true of conservation's solutions. … All of them are evolving, becoming more sophisticated, adapting to changing circumstances. However, none of them promises any kind of scale shift in the endless chess game of extinction'. The context in which conservation is practised today is of course dramatically different from its early days as we now live in a period, often labelled the Anthropocene, characterized by massive anthropogenic impacts on the environment and resources (Steffen et al., 2016; Seddon et al., 2016; Johnson et al., 2017). It is widely agreed that the need for a transformational approach to conservation has now become urgent although there is no unanimity as to how to proceed.

All the diverse approaches to conservation are interconnected, although this is not necessarily reflected in practice. Calls for integrated or holistic plant conservation, in the sense of applying whatever combination of conservation techniques is appropriate in any particular situation,[4] have been made since the middle of the last century (e.g. Falk, 1990) but are difficult to implement because of the way in which conservation as a discipline is organized, with species-based and area-based approaches usually undertaken by different groups of practitioners, each with their own traditions and experience. As I have noted elsewhere (Heywood, 2017), the fact that species management and protected areas represent different constituencies in both ecology and biodiversity conservation is partly responsible for the lack of coordination between the two approaches. This is largely a consequence of the way in which ecology developed as a science and practice and is reflected in the separation of *in situ* and *ex situ* in the Convention on Biological Diversity and of area-based targets from species-based targets in its Global Strategy for Plant Conservation (GSPC) and in national conservation strategies and action plans.

None of the main conservation approaches is fully effective, especially for plants (Havens et al., 2014; Heywood, 2017) and there is often a failure of interdisciplinarity during their implementation. The overall picture is one of:

- an extensive global system of protected areas which is underperforming in terms of biodiversity conservation,
- a tentative and inchoate adoption of 'other effective area-based conservation measures',
- a growing momentum for the application of community conservation approaches,
- considerable efforts to identify Key Biodiversity Areas (KBAs) (IUCN, 2016) and in the case of plants Important Plant Areas (IPAs) and their alignment with KBAs (Darbyshire et al., 2017); and all this is combined, at the species level, with:
- substantial investment in Red Listing of threatened species (still with highly incomplete coverage), although not in itself a conservation action,
- species conservation and recovery planning and implementation on a very limited scale in most countries (Heywood, 2015)
- species reintroduction, likewise limited, and as with species recovery supported by:
- extensive *ex situ* collections of both wild species in botanic garden living collections and in seedbanks of botanic gardens, environment agencies and in the global network of agricultural gene banks (especially for crop wild relatives, medicinal and aromatic plants and other economically important groups)

A characteristic of much conservation is that more resources are often spent on planning than on implementation. Examples of this can be found in all areas and at all levels. For example, species conservation and recovery plans that are prepared and even approved but not implemented (Dorey and Walker, 2018), the considerable effort that has gone into IUCN Red List training and the preparation of national red lists[5] without much consequential conservation action taken, the vast sums of money spent every year in organizing and servicing international UN, IG or NGO meetings and supporting the attendance of hundreds or even thousands of delegates and the preparation of conclusions and recommendations, many of which are soon forgotten,[6] the countless pilot projects that have no follow up, and so on.

## 3. Repairing the damage

The large-scale destruction and degradation of ecosystems and loss of species throughout the world presents us with an enormous challenge. There is great pressure, to invest massively in ecological restoration and in restoring our forests (Lamb, 2018; Shaw, 2019) and other ecosystems that provide us with a range of ecosystem goods and services. The Global Partnership on Forest and Landscape Restoration has just produced a document 'Restoring forests and landscapes: the key to a sustainable future' (Besseau et al., 2018), which reports on the growing momentum for restoration and notes that 'we now have political commitments from dozens of countries to bring over 160 million hectares of degraded land under restoration as part of the Bonn Challenge. That is a good start toward attaining the global goals of bringing 150 million hectares into restoration by 2020 and 350 million hectares by 2030 – an area almost the size of India'.

Other ambitious goals have been set by the CBD: the Aichi Biodiversity Target 14 aims to restore and safeguard, by 2020, ecosystems that provide essential services, while Target 15 calls for the restoration of at least 15 per cent of degraded ecosystems by 2020 (CBD, 2016) and the UN SDG Goal 15 is to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss, and Target 15.3 aims to achieve a land-degradation neutral world by 2030 (http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-15-life-on-land/targets.html).

[4] Today the term integrated conservation is also frequently applied to conservation in association with rural development.

[5] Not to mention the costs of setting up and annual costs of maintaining the IUCN Red List (Juffe-Bignoli et al., 2016).

[6] It would be a useful exercise to assess and publish the costs of a meeting of the Conference of the Parties to the CBD and the prior SBSTTA and related meetings, or those of the IUCN General Assembly, and then attempt to assess what the measurable impacts on biodiversity conservation have been.

Restoration covers a wide variety of aims and approaches. The CBD's Short-Term Action Plan on Ecological Restoration (CBD, 2016) is wide-ranging: 'The overall objective of this action plan is to promote restoration of degraded natural and seminatural ecosystems, including in urban environments, as a contribution to reversing the loss of biodiversity, recovering connectivity, improving ecosystem resilience, enhancing the provision of ecosystem services, mitigating and adapting to the effects of climate change, combating desertification and land degradation, and improving human well-being while reducing environmental risks and scarcities'. In today's rapidly changing world, restoration plays a critical role in assisting ecological communities and ecosystems to adapt (Harris et al., 2006; Wiens and Hobbs, 2015; Timpane-Padgham et al., 2017).

Clearly, restoration is context-specific and each of these various goals will have specific planning requirements. In the past much restoration, especially of forests, has been undertaken using well-established reforestation techniques which are not specifically aimed at restoring biodiversity or ecosystem services but rather with timber production as a goal and such approaches are still being adopted in some countries such as China and Vietnam even though the aim is to improve ecosystem services, notably watershed protection (Lamb, 2018). Various approaches to ecological restoration such as natural regeneration, full ecological restoration and reforestation using only a limited number of species are discussed by Lamb (2018). Another factor that needs to be taken into account is the ability of restored forests to persist long-term. As Reid et al. (2018) note, with reference to secondary restored forests in Costa Rica, the benefits of restoration depend on their persistence. They found that on average secondary forests there last 20 years which is a shorter period of time than is needed to reap the benefits such as carbon absorption.

Volis (2016, 2017) takes the view that in the Anthropocene, the future of conservation lies in habitat restoration and wide-scale plant introductions, not only within, but also outside the known historical range of the species and has proposed a novel approach which he terms 'conservation-oriented restoration' that includes *inter situs* and *quasi in situ* conservation as necessary components. It is based on two principles:

- There is no alternative to active management of populations of threatened species to prevent their extinction.
- Wide-scale plant introduction of threatened species, not only within but also outside their known species historical range. Traditionally, introduction outside historic ranges has been discouraged. For endangered species without undisturbed reference habitats, introduction into multiple suitable habitats both inside and outside their known range seems to have no alternative.

Undertaking ecological restoration on the vast scale now being proposed requires solutions to the many technological, economic and social problems involved and would need an enormous financial investment, as Lamb (2018) notes. Ecological restoration is a complement to not a substitute for conservation and while both conservation and restoration are needed, the balance of effort and resources between them should be kept under review and, given budgetary limitations, difficult choices will have to be made about the allocation of resources and societal priorities.

## 4. The conservation role of protected areas

Most countries regard Protected Areas as the underpinning of their national conservation policy and most conservationists would agree. They are regarded as the primary defence against biodiversity loss, provided they are well maintained and managed. The growth of protected areas in number in the past 25 years to 202,000 at the present day, covering 14.7% of the world's terrestrial area, is rightly acknowledged as an outstanding achievement in global conservation (Jones et al., 2018) and many countries have met or are on course to meet the Aichi Biodiversity Target 11 [By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape].

There are, however, serious caveats to this apparent success story. For one thing, most biodiversity occurs outside protected areas and it is now widely accepted that the present coverage of such areas is inadequate in terms of extent, ecological representation and key biodiversity areas.[7] As Maron et al. (2018) note, even if Aichi Target 11 is fully achieved, it would leave much of 83% of the land surface without appropriate protection and put at risk its ability to provide the ecological functions and ecosystem goods and services on which we depend. Moreover, as they point out, 'Achieving the objectives reflected in the other Aichi Targets, and the SDGs, depends heavily on what happens in that 83–90%' and they regard bolder retention targets as essential. In fact, there is no scientific or logical basis for the 17% target and it has already been bypassed by the 2014 IUCN World Parks Congress which recommended a much higher total area of protected land and connectivity lands than those of current agreed targets.

Another limitation to the effectiveness of protected areas is that about half of them are inadequately managed and as a consequence, their ability to provide a safe and secure haven for the species of biodiversity concern that they contain is compromised, even more so if actions to prevent or mitigate other harmful or threatening factors are not undertaken. Extensive human activity within their boundaries can undermine their role and one-third of global protected land is under intense human pressure according to Jones et al. (2018) who also found that for protected areas designated before the Convention on Biological Diversity was ratified in 1992, 55% have since experienced increases in human pressure. Not surprisingly, large strictly protected areas suffered least human pressure. They also note that while designated protected areas currently account for about 14.7 percent of land globally, if areas subject to intense human pressure are subtracted, the protected area percentage drops to 10.3 and only 37 of the 111 countries that have met the 17 percent target would still meet that threshold if areas under heavy pressure were removed. It should be noted that the methodology used by Jones et al. may not fully cover invasive species which are considered a key threat for almost one-quarter of endangered species (Maxwell et al., 2016) and the fourth most frequently reported threat globally according to an analysis by Schulze et al. (2018) who undertook an assessment of threats to terrestrial PAs, based on *in situ* data from 1961 PAs across 149 countries, assessed by PA managers and local stakeholders. Unsustainable hunting was the most commonly reported threat and occurred in 61% of all PAs, followed by disturbance from

[7] An analysis by Butchart et al. (2015) showed that only one-fifth of key sites for nature are fully covered by protected areas and one third lacked any protection. In the United States, there is a serious mismatch between the configuration of protected areas and the patterns of endemism in the country, with most protected areas in the west. and the majority of vulnerable species in the southeast (Jenkins et al., 2015). In Kenya, East Africa, the bulk of protected areas are located in areas that are low in species richness while those areas with remarkably high species richness are not adequately covered by nature reserves (Habel et al., 2016).

recreational activities occurring in 55%, and natural system modifications from fire or its suppression in 49%.

In addition to the above, it should be noted that there are considerable differences in the ways in which the planning process for protected areas is decided at national level and it varies considerably, especially between developed and developing countries. Problems arise from unclear management systems and lack of consistent legislation, as noted by Cao et al. (2015) in China where protected area management depends on different sectors and levels and can lead to ineffective results.

### 4.1. Impacts of global change on protected areas and their biodiversity

Today, potentially the greatest threat to protected areas is accelerated climate change. How far protected areas will continue to be effective in protecting biodiversity under projected climate change scenarios is still uncertain. It is clearly difficult for a system of PAs with fixed geographical boundaries to respond to the dynamics of global change, in particular climate change, which was not a consideration when they were designed. Protected areas as such cannot migrate, even though some of their component species can do, either within the area or beyond it, nor can they be moved. The impacts will vary from region to region and from country to country. Some protected areas may even virtually cease to function, with catastrophic species loss, while others may survive relatively unscathed and their complement of species even increase in some cases. Many protected areas will suffer moderate to substantial loss of their current biota while other species will migrate into them (including alien invasive species), leading to changes in the assemblages of species that they house.

Just as we have little idea of the latitudinal and altitudinal migration capacity of most individual species to migrate (or not) in the face of climate change, or of their likelihood of persistence under the new ecoclimatic conditions or in the new species assemblages, we simply do not know how far the essential components of protected areas will be able to reassemble in the new ecoclimatic envelopes and in the face of human population pressure and other factors. What is clear is that novel species assemblages or ecosystems will become increasingly common in response to human activity and climate change and these will pose problems for conservation (Lindenmayer et al., 2008) and for protected area policy and practice. Even assuming that new viable ecological assemblages are established, they may not have any status of protection so that the whole legal, social, political, scientific and financial process of reserve establishment, would have to be reinitiated.

The evidence of the impacts on protected areas 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 and a lack of detailed local assessments. There is no doubt, however, that it adds a considerable level of uncertainty to all aspects of conservation assessment and planning, including the protection of species *in situ*.

> '… a number of barriers challenge the ability of protected area managers and policy makers to manage the changes they face, both now and into the future. These include a lack of appropriate information about the nature of change and projections of future threats to biodiversity; a mismatch between scale of the changes taking place and existing governance frameworks; and a lack of capacity to support decision making in the context of uncertainty and change' (Luc Hoffmann Institute, 2014).

A more optimistic view is presented by Thomas and Gillingham (2015) who considered 'empirical evidence on the observed performance of PAs during the last 40 years of anthropogenic climate change. Despite some losses of populations and species, PAs have continued to accommodate many species, which have shifted to higher elevations, to polewards-facing aspects, and into cooler microhabitats within PAs as the climate has warmed. Even when species have declined in some PAs, they often remain more abundant inside than outside PAs. The 40-year track record of species responding to environmental change in PAs suggests that networks of PAs have been essential to biodiversity conservation and are likely to continue to fulfil this role in the future. The challenge for managers will be to consider the balance between retaining current species and encouraging colonization by new species'.

Climate change will affect the distribution of species in different ways (Monzon et al., 2011; Heywood, 2012; Garden et al., 2015). In the case of plants, areas of suitable habitat may contract within or expand beyond previously occupied areas, so that some species will adapt and survive, sometimes with reduced populations, and some may expand their distributions; or the location of suitable habitat may shift out of the areas and some species will be able to migrate, tracking the changing climate, while those that are unable to adapt or migrate will suffer severe population decline and eventually become extinct or be ousted by invasive alien species. Those species that occur within protected areas may fare better than those without but not necessarily so.

Most projections of the future migrations of species are derived from bioclimatic modelling (also known as single-species bioclimatic 'envelope' models). These are a special case of ecological niche or distribution models, in which the current native range of species is related to climatic variables so as to enable projections of distributions under various future climate change scenarios (Guisan and Thuiller, 2005; Elith and Leathwick, 2009) and while considerable advances have been made in this field, it has severe technical limitations (Heikkinen et al., 2006; Pearson et al., 2006; Heywood, 2012) and is hampered by the lack of available georeferenced distribution points for many species, failure to take into account various factors other than climate, such as biotic interactions, evolutionary change and dispersal abilities, and using too coarse a scale to be ecologically meaningful for the species being studied (Hampe, 2004; Garden et al., 2015). Ehrlén and Morris (2015) make the point that a disproportionate amount of effort has focused on distribution only, either documenting historical range shifts or predicting future occurrence patterns, and they recommend that simultaneous projections of abundance and distribution across landscapes would be far more useful. Despite these shortcomings, bioclimatic modelling plays an important role in providing a first approximation of likely species' movements in response to climate change and as we understand better the limitations of the models and are able to integrate into them other factors such as biotic interactions, land cover and dispersal mechanisms, we will be in a better position to interpret the results obtained from them. Much further work needs to be done and more empirical data gathered. If more reliable and acceptable modelling approaches are developed, and applied on a much wider scale, we should be able to obtain a more accurate picture of the likely effects of climate change on future species' distributions and ecosystem composition.

As a consequence of range shifts of species, the composition of the biodiversity in protected areas will change and their effectiveness, not just for conservation of biodiversity but for the provision of ecosystem services, may be reduced (Hole et al., 2009). Innovative approaches to conservation will be required to meet these challenges (Tingley et al., 2014). It may be possible to modify the management of protected areas to maintain or increase ecosystem resilience so as to mitigate some of the effects of climate change and also facilitate the adaptation of ecosystems and species to these changes (Halpin, 1997; Shafer, 1999; Hannah and Salm, 2003; Lovejoy, 2006; Hannah et al., 2007; Stein et al., 2013). This may include more flexibility in size and scale so that a connected network of patches of habitats at various scales is created to allow species the possibility to migrate and adjust their ranges in response to climatic and other change. IUCN has published detailed guidance for protected area managers and planners for adapting to climate change (Gross et al., 2016). Adapting individual species to climate change is becoming an important research field and it has been suggested that to achieve successful conservation, 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).

### 4.2. Calls for the massive expansion of protected areas

Some conservationists have called for at least half of the Earth to be allocated for nature conservation so as to prevent further biodiversity loss – notably the so-called 'Half-Earth' concept proposed by E.O. Wilson (2016), that might conserve 85% of species in such a restricted area. While an attractive proposition, this proposal has become embroiled in the current Anthropocene vs Ecocentrism debate about the future of conservation and has attracted both strong support and vehement critiques. Thus Kopnina et al. (2017) strongly endorse and defend the 'Nature Needs Half' proposal and an ecocentric approach to nature conservation and Dinerstein et al. (2017) have proposed a scientific rationale for achieving this goal, noting that one of next steps needed should focus on ensuring that the last remaining intact forests of the world, such as those found in the Congo Basin, are conserved. It is ironic that as I write this, reports have been published on a new threat to two of Congo's UNESCO protected sites, Virunga and Salonga national parks as the Congolese government has intensified its efforts to remove legal protection from areas of these parks and open them up to oil exploration.

Critics of the Half Earth model include Wiersma et al. (2017) who are dismissive of the notion that such an aspirational goal can be codified into a single, scientifically based target. Büscher and Fletcher (2016) in a commentary entitled 'Why E O Wilson is wrong about how to save the Earth' make the point that already 20–50 million people have been displaced by previous waves of protected-area creation and that 'to extend protected areas to half of the Earth's surface would require a relocation of human populations on a scale that could dwarf all previous conservation refugee crises'. An innovative study by Pimm et al. (2018) notes that 85% of plants occur entirely within a third of the Earth's surface so that it would be theoretically possible to conserve them in such an area if it were optimally selected to capture them. It also considers how effective the strategy of protecting half of the Earth's wild areas might be in conserving biodiversity and finds it far from sufficient, although its conservation may be valuable for other reasons, largely because '… very few wild places house concentrations of small-ranged species not already protected by existing protected areas … Simply, achieving conservation goals by creating more protected areas in current wilderness might locally be helpful, but it is not sufficient to protect biodiversity at large'.

Then there is the vital issue of reconciling such an expansion of protected areas with the territorial demands of sustaining an agricultural system that would provide food and nutrition for the growing global population (Mehrabi et al., 2018).

Already there has been strong opposition to the 'Earth needs half' proposal by communities, industry groups, and governments in various countries and as Lindenmayer et al. (2018) who examined case studies of such resistance in Victoria, Australia, Bavaria, Germany, and Florida, United States, comment, unless this resistance to expanding the protected area system is addressed conservation targets will not be met.

Maron et al. (2018) argue that we should focus on global retention targets for natural systems rather than on a system of formal protected areas if we are to achieve the multiple nature conservation goals that we need. A more radical solution is proposed by Dudley et al. (2018) who believe that other effective area-based conservation (OECMs), or some equivalent approach, would not only help but be essential if ambitious conservation targets such as the Half Earth are to be achieved although this would require a major recalibration of our approaches to protected area planning and the very concept of what we mean by conservation. The role of OECMs and other off-reserve areas in conserving biodiversity are discussed further below.

Gavin et al. (2018) review these debates and argue that 'they impede conservation progress by wasting time and resources, overlooking common goals, failing to recognize the need for diverse solutions, and ignoring the central question of who should be involved in the conservation process'. However, despite such reservations, these debates are useful in that they bring some of the issues into clearer focus but so far, they appear to have had disappointingly little effect in changing conservation approaches and practice on the ground. There seems little prospect of reconciling these opposing visions of the conservation narrative, and it may well be that in this and similar debates in other areas of biology (e.g. the species concept), an important factor is that they involve important societal values (Heywood, 1998). Marked divergence of views is common on issues affecting the values held by our societies and the ways that people live.

### 4.3. Conservation benefits of protected areas

As noted above, while there is a strong case to be made for a major expansion of protected areas, it has to be carefully planned if they are to provide specific conservation benefits that adequately address the complex challenges outlined here. A study by Kuempel et al. (2018) showed that on average, it was more effective to invest more in enforcement of existing protected areas rather than on their expansion and they noted that 'expansion alone, without additional enforcement, can actually reduce conservation outcomes'. And as Maron et al. (2018) state, more than formal protection of areas is needed if we are to conserve biodiversity as well as maintaining essential ecosystem services for human survival. This is confirmed by Barnes et al. (2018), who note that there is little evidence that expansion of the global protected area network brings real biodiversity gains and argue that we should shift the focus of protected area target development from quantity to quality. Likewise, a study by Pimm et al. (2018) emphasises that it is the quality, not just the quantity, of land we protect that matters and that 'to preserve biodiversity more fully, especially species with small ranges, governments should expand their conservation focus and prioritize key habitats outside wildernesses and current protected areas' (Duke University, 2018).

Although it would appear counter-intuitive, the effectiveness of protected areas in conserving biodiversity is poorly known and the available evidence is at best equivocal, especially for plants (Rodrigues et al., 2004; Mora and Sale, 2011; Geldman et al., 2013; Barnes et al., 2014; Crofts, 2014; Coetzee et al., 2014; Polak et al., 2015). One of the authors of the study by Coetzee et al. is reported as saying 'Our work has now shown that protected areas have significant biodiversity benefits. In general, plant and animal populations are larger, and more species are found inside rather than outside protected areas. In other words, protected areas are doing their job[8]'. For plants, such a conclusion is still debatable, given that most of the evidence reported is from animal groups not plants.

### 4.4. Protected areas and species protection

> '*Although ecosystems never have been in a steady state and species distributions have always been on the move at one timescale or another, it is now more clear than ever that it is impossible to statically conserve current biodiversity patterns, in hotspots or anywhere else*'
>
> Ibisch et al. (2005)

Referring to protected areas, terms such as 'conservation benefits' and 'biodiversity gains' are open to many different interpretations and impossible to assess and quantify unless clearly defined. In terms of the effectiveness of protected areas in conserving threatened species, the evidence is largely lacking although some studies address this issue specifically. A Zoological Society of London report (Milligan et al., 2014) which used the Living Planet Index (LPI) to measure the global impact of protected areas on species found increases in populations to be evident in many protected areas but also many cases of population declines. The report found that:

> 'The establishment of protected area s 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 protected areas 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'.

It is generally assumed that the presence of a species in a protected area implies that it will receive some degree of protection and many conservationists claim that protected areas are our best hope for meeting global targets such as preventing species extinctions. Indeed, it is quite likely that for species which are not known to be threatened, the very fact that they are present in a protected area will afford them some degree of protection, provided no major climatic or disturbance regime changes occur. However, it must be stressed that the protection afforded by a well-maintained protected area is not enough by itself to achieve conservation or recovery of threatened species which grow in such areas: what we need to aim for is not just their presence in a protected area but persistence and recovery over time (Heywood, 2015, 2017; Heywood et al., 2018). Stein et al. (2013) propose that we should manage for change[9] not just persistence. In the case of threatened species where there is a likelihood of shifts in climate affecting the area in which they are conserved, the aim should be to attempt to ensure persistence in the face of future climatic or other change. Greenwood et al. (2016) consider that successful conservation will increasingly depend on our ability to help species cope with climate change and note that 'While there has been much attention on accommodating or assisting range shifts, less has been given to the alternative strategy of helping species survive climate change through *in situ* management'.

The hands-off or passive approach to species conservation in protected areas is unlikely to ensure the survival of many species and, certainly, for those that are threatened, unless the threatening processes are removed or contained, the species' populations risk eventually becoming extinct. This is confirmed by a study by Ventner et al. (2014) which showed that our existing protected areas do not perform very well in protecting the most threatened species[10]'. They found that protected areas are simply unable to achieve the conservation of species unless they are established with that aim in mind. Even if 30 percent of the globe were to be covered by protect areas, 'using a business-as-usual approach, many threatened species will miss out. But when imperilled species are targeted, we found that many cost-efficient options emerged for including them within new parks'.

Although the CBD in its Preamble notes that 'the fundamental requirement for the conservation of biological diversity is the *in-situ* conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings', since coming into force its decisions and actions to implement this have focused mainly on the area-based measures with scarcely a mention of species recovery. This has been carried over into the CBD GSPC: the failure to integrate the area-based and species-based targets and the lack of clarity in their formulation and interpretation have been largely responsible for the widespread failure to meet the *in situ* species recovery targets and continuing loss of threatened species from protected areas as I have discussed in detail elsewhere (Heywood, 2015, 2017).

This issue has been explored by Polak et al. (2015) who tested the CBD's strategy of using environmental surrogates, such as ecosystems, as a basis for planning where to locate new protected areas, in Australia. They found that planning simultaneously for species and ecosystem targets delivered the most efficient outcomes for both while planning first for ecosystems and then filling the gaps to meet species targets was the most inefficient conservation strategy. They comment that 'Our analysis highlights the pitfalls of pursuing goals for species and ecosystems non-cooperatively and has significant implications for nations aiming to meet their CBD mandated protected area obligations'.

## 5. What lies without?

> *With the world entering the biggest mass extinction since the dinosaurs disappeared 65 million years ago, it is time for ...the global conservation community it represents to prioritise the right conservation actions. National parks and other protected areas should be central to our efforts, but with poorer countries unable to pay to protect them it is essential we find effective solutions involving both private and public lands* — Richard Leakey (2018).

[8] Reported in https://phys.org/news/2014-06-aichi-biodiversity-areas.html#nRlv.

[9] I have long espoused the view and taught that conservation is management for change (cf. Heywood and Iriondo, 2003). Conservation practitioners need to consider themselves 'global change managers' rather than museum keepers (Ibisch et al. 2005) although the latter still have a role to play. On the other hand, how effectively we will be able to manage such dynamic systems is an open question. As Walker and Steffen (1997) warn 'The bottom line is that we will probably never be able to predict, with a high degree of certainty, precisely how terrestrial ecosystems will interact with accelerating environmental change. Thus, the analogy that ecosystems can be "managed" in the same way that much simpler human-designed industrial systems can, is misleading and dangerous.'

[10] Reported in https://www.sciencedaily.com/releases/2014/06/140624215107.html.

Most biodiversity exists outside formally protected areas and although attention is frequently drawn to the problems that its conservation poses, generally the biodiversity conservation community has shown reluctance to engage with this issue. A range of measures is in place in some countries such as the USA and Australia 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 (Mackey et al., 2008; Kamal et al., 2015; Hunter and Heywood, 2011, chapter 11) but most countries have paid little attention to this issue although many have espoused community conservation practices.

The widespread destruction and fragmentation of habitats has led to calls for area conservation and sustainable use to be undertaken within the framework of a bioregional approach, whereby all kinds of land use within the landscape matrix are taken into account. As Miller (1996) comments, 'Since the landscape is fragmented and much wildland has been converted to other use, the boundaries and coverage of some protected areas may not conform to the size and shape of the ecosystems that are to be maintained and managed. ... Moreover, in landscapes where protected areas have not been established, key genetic, taxonomic, and ecological elements of diversity that once may have been found in wildlands, or extensive farm or forest operations, are now relegated to isolated patches in intensively managed farms, pastures, timber-harvesting sites, and suburban, urban, and industrial areas'.

In the CBD Strategic Plan for Biodiversity 2011–2020 Target 11 under Strategic Goal C, aims to improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity: 'By 2020 at least 17% of terrestrial and inland water and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and *other effective area-based conservation measures* [my emphasis], and integrated into the wider landscape and seascape'. This recognition by the CBD that some areas outside the recognised protected area networks also contribute to the effective *in situ* conservation of biodiversity and act as an important complement to conventional protected areas is an important advance although it did not provide clear guidance about what these other measures are or how they may be assessed, identified or reported (Leadley et al., 2014; Jonas and MacKinnon, 2016). The IUCN World Commission on Protected Areas (WCPA) established a Task Force in 2015 to develop guidance on the definition and application of the concept of 'other effective area-based conservation measures'. It developed draft 'Guidelines for Recognising and Reporting OECMs', which were reviewed by a range of stakeholders including CBD National Focal Points, and proposed defining an OECM as "A geographically defined space, not recognised as a protected area, which is governed and managed over the long-term in ways that deliver the effective *in situ* conservation of biodiversity, with associated ecosystem services and cultural and spiritual values" (IUCN WCPA, 2018). The draft IUCN-WCPA Guidelines were considered two expert workshops hosted by the CBD Secretariat in February 2018 and the resulting revised definition of OECMs and voluntary guidance for identification and management were submitted to CBD SBSTTA 22 which adopted a draft decision on 'Protected Areas and Other Effective Area-Based Conservation Measures', including the following definition of an OECM: "A geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the *in situ* conservation of biodiversity, with associated ecosystem functions and services and where applicable, cultural, spiritual, socio–economic, and other locally relevant values" (Jonas and McKinnon, 2018).[11]

If this draft decision is ratified by the 14th Meeting of the CBD Conference of the Parties (COP14) in November 2018, it remains to be seen how effective the implementation of OECMs will be and what contribution they will make to the conservation of plant diversity. Their relationship with the other offsite measures mentioned above (conservation easements etc.) will also have to be explored. Dudley et al. (2018) argue that OECMs 'provide the opportunity for formal recognition of and support for areas delivering conservation outcomes outside the protected area estate' and offer 'a chance to conserve a large proportion of the planet without causing a humanitarian crisis, undermining human rights or creating massive political resistance, leading to a politically unstable and practically non-viable protected area system'.

## 6. Conservation *in situ* targeted at species

The maintenance and recovery of viable populations of species *in situ* is regarded by the CBD as one of the fundamental requirements of biodiversity conservation (Interim Secretariat CBD, 1994) and is covered by Articles 8 *In situ* conservation clauses (d) and (f) and 9 *ex situ* conservation clause (c). It is addressed by the revised GSPC Target 7: At least 75 per cent of known threatened plant species conserved *in situ*' and Aichi Target 12 'By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained'. The guidance provided for these targets is inadequate or misleading (Heywood, 2015, 2017) and it is not surprising that targeted species conservation *in situ* is only undertaken on a substantial scale in few countries. Most countries tend to measure their progress in meeting the above targets by citing the number of threatened species that are recorded from protected areas but as discussed above, presence alone in a protected area is no guarantee for the survival of threatened species unless supplemented by actions to maintain the habitat and targeted actions to remove or contain the threats to which the species' populations are exposed.

The main general aim and long-term goal of *in situ* conservation of target species is to protect, manage and monitor selected populations in their natural habitats so that the evolutionary processes are maintained which will allow new variation to be generated in the gene pool that will help ensure their continued survival under changing environmental conditions.

The term **species recovery** (derived from the US Endangered Species Act) applies to the procedures whereby species as a whole or targeted populations of species, which have become threatened, for example through loss of habitat, decrease in population size, or loss of genetic variability, are recovered to a state where they are able to maintain themselves without further human intervention (Heywood et al., 2018). Given that a wide range of interventions may need to be taken aimed at conserving or recovering threatened species so that they no longer need management, it is appropriate to use the terms 'recovery' or recovery plans' in a general sense to refer to such actions.

A review of the literature shows that the process of species recovery is not well understood (Heywood, 2015) and the terminology used can be confusing and is not consistently applied (Westwood et al., 2014). Another complication is that a distinction

[11] H. Jonas and K. MacKinnon, Updates on 'Other effective area-based conservation measures' https://www.iucn.org/news/protected-areas/201808/updates-%E2%80%98other-effective-area-based-conservation-measures%E2%80%99 (accessed 5 August 2018).

is often not made between the terms species recovery and species reintroduction and the two processes are frequently conflated in practice: although in both cases many of the actions needed are the same and the target area is within the indigenous range of the species, the key distinction is that species recovery refers to situations where there are still conspecific population individuals in the target area whereas in the case of species reintroduction, no conspecific individuals remain in the target area (see discussion in Dalrymple et al., 2011; Heywood, 2015). The IUCN Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013) do not cover species recovery as such but only those cases where population reinforcement (augmentation) is required. It applies the term conservation translocation for both reinforcement and reintroduction within the indigenous range of a species, and conservation introductions, comprising assisted colonisation and ecological replacement, outside the indigenous range.

Despite the clear mandate under the CBD, species recovery in the wider sense remains a poorly understood process and has been practised on a substantial scale in only a few countries and scarcely at all in the tropics. Consequently, it has been undertaken for only a small percentage of threatened plant species. Species recovery can be complex and multidisciplinary and involves a series of procedures and actions which ideally should be undertaken in a logical sequence as part of an action plan (Heywood, 2014, 2015; Heywood and Dulloo, 2005; Heywood et al., 2018). It often involves both *in situ* and *ex situ* actions and may be directed at a single species or at a group of species in the same area. The preparation and implementation of recovery plans may be carried out under the auspices of a wide diversity of bodies such as various government departments, national or regional environment agencies, other government services, forestry institutes, university departments, botanic gardens, national or local environment or conservation associations, intergovernmental agencies, nongovernmental organizations (NGOs), the armed forces and civilian society. No global compilation of recovery efforts has been made and little information is available about success rates.

To be fully effective, species recovery planning should be undertaken by a team (Box 1) and it is good practice to involve, or at least consult, all interested and knowledgeable parties in the preparation of conservation and recovery strategies and action plans. Local knowledge may be important and when available should be taken into account. Unfortunately, many recovery plans are prepared and implemented by people without the necessary knowledge or expertise.

**Box 1**
Recovery planning needs teamwork

Recovery plans require teamwork, involving specialists from various disciplines as well as concerned stakeholders and the general public. The drafting of a recovery plan is normally undertaken by a team of experts although it may be carried out in some cases by an individual expert or a small number of experts. The US ESA guidelines suggest that recovery teams are often appropriate for more wide-ranging species, those that raise more controversial issues, and larger-scope plans. In some circumstances, it may be appropriate to engage a contractor to prepare the plan, especially when the necessary expertise is not available in-house to the agency commissioning the work.

Source Heywood et al. (2018).

Another common problem is that in the absence of a national recovery strategy, there is often a lack of coordination between different species recovery programmes and actions with the result that a single species may be the subject of more than one independent recovery or reintroduction interventions. There is also a need for coordination of recovery programmes with any *ex situ* actions that are being undertaken independently for the same species.

In the last 25 years, a considerable effort has been invested in the genetic conservation of agriculturally important species such as crop wild relatives (e.g. Maxted et al., 1997, 2008; 2013; Hunter and Heywood, 2015) There is also a long-standing tradition of targeted *in situ* conservation and recovery of forestry trees dating back 50 years or more. Yet, this substantial body of experience and practice, much of it pioneering, built up by the forestry community and more recently the agricultural crop wild relative sector in conserving and managing wild species *in situ* is seldom cited by the conservation biology community.

Paradoxically, the practice of reintroduction biology seems to have had more resonance than does species recovery, with conservationists and governments and a considerable body of both theoretical and practical information has been gained in the last 25 years. Various guidelines have been published for species reintroductions, e.g. those of the Center for Plant Conservation (Falk et al., 1996; Maschinski et al., 2012); the Guidelines for the Translocation of Threatened Plants in Australia, 2nd edition (Valee et al., 2004); Linee Guida per la Traslocazione di Specie Vegetali Spontanee (Rossi et al., 2013); the IUCN/SSC Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013); and the CPC Best Reintroduction Practice Guidelines (Maschinski et al., 2012, Maschinski and Albrecht, 2017). A database of plant reintroductions has been initiated by the Center for Plant Conservation (Center for Plant Conservation, 2009) and a database of the information obtained during a global overview of reintroductions by Godefroid & al. (2011) is maintained at National Botanic Garden of Belgium, Meise (see also Godefroid and Vanderborght, 2011). The reintroduction of rare and endangered plants is very challenging and often with low rates of success (Godefroid et al., 2011; Ren et al., 2014) and only a few hundred attempts have been recorded. There is so far little evidence that plant reintroductions will be successful over the long term (Dalrymple et al., 2011, 2012; Godefroid et al., 2011).

If the poor level of global implementation of plant species recovery continues, especially for threatened species, many plant species will remain at risk of extinction whether or not they are in protected areas. Concerted action is needed and, as proposed below, the opportunity should be taken to revise the relevant post-2020 CBD biodiversity targets and provide appropriate operational procedures to stimulate the actions necessary to ensure effective *in situ* species conservation and recovery is undertaken by all countries.

## 7. Rapid response or detailed planning?

As discussed below, the better prepared any recovery actions are, the greater is the chance of success. This presents us with a dilemma in that it is often tempting when faced with the need for urgent action to save a species that is clearly threatened by human activities, such as overexploitation or habitat destruction/conversion, to intervene rapidly to attempt to rescue the species without adequate planning. While this may provide a short-term solution, it may just be buying time as it will usually be necessary to follow it up sooner or later with a proper assessment of the conservation situation in terms of distribution, demography, ecology, genetic variation, and a comprehensive threat assessment so that an effective recovery plan can be drawn up and implemented. Of course, one would not wish to discourage rapid conservation action and often guidance as to what is appropriate may be obtained from the local population who can also participate in the work but ultimately there is no substitute for proper assessment and planning. Resources are limited and failure to diagnose correctly the factors that threaten the species can lead to wasted investment.

In practice, once a comprehensive threat assessment has been carried out and the threatening processes identified, it may be found that little conservation action is needed other than active monitoring of the population *in situ*, unless or until the situation changes, through climate change, for example; or some degree of management intervention may be needed, ranging from habitat weeding, fencing, soil improvement, predator control, control or elimination of invasive alien species, through to full scale recovery which may include a combination of actions, for example genetic rescue and population augmentation, assisted pollination to increase seed set, or improvement of associated mycorrhizal populations.

## 8. Key issues in species recovery and adaptation

As the above discussion has emphasized, it is likely that many species and their habitats will be affected by climate change, but as we have also seen, it is not possible at this stage to know with certainty which areas will be impacted or to what degree. Similarly, our knowledge of the ability of individual species to adapt to climate change or to migrate and track the changing climate is generally poor. Under these circumstances, in planning species recovery programmes, when reliable information is available about climate change and species' reactions to it, appropriate actions should be included to facilitate either the adaptation of species or their migratory capacity. In the absence of such information, it is essential to put proper monitoring programmes in place, both during the recovery process and afterwards so that any changes in the status of species' populations as a result of climate or other aspects of global change are detected and remedial action planned.

Not all species can be saved as viable populations in the wild but that is no reason for not making every effort to attempt to conserve and recover as many as we can with the information and techniques available to us today. We need to cooperate closely with area managers and plan for conservation, persistence, resilience and adaptation and try to minimize the risk of species extinctions from existing protected areas and also plan our reserves so that provision is made for future dispersal needs of species.

To provide clear guidance on how to plan and implement species conservation *in situ*, a manual of good practice on plant species recovery has been produced by BGCI and IABG (Heywood et al., 2018) which it is hoped will facilitate appropriate action.

Some of the key issues that have emerged from this work and a critical review of the literature are as follows:

### *8.1. Species recovery is multidisciplinary and requires teamwork*

Species recovery is essentially an *in situ* procedure but may also involve *ex situ* facilities. It usually requires the participation of specialists from various disciplines and actors (Box 1). Responsibility for species recovery at national level is not always clear and may be shared by different ministries and agencies.

### *8.2. A national species recovery strategy is desirable*

There is evidence to indicate that species recovery tends to be better developed and resourced when undertaken by or under the auspices of specialised governmental or state agencies and when there is national legislation that provides a legal framework. It is recommended that all countries should prepare a national strategy and action plan for species recovery, either stand-alone or as part of its National Biodiversity Strategy and Action Plan (NBSAP) to enable it to meet its commitments to national and global targets.

A list of candidate species that require *in situ* conservation or recovery action should be prepared. There is, however, generally no agreed procedure for deciding upon which species to prioritize and each country may have its own system. A common error is to rely primarily on the state of endangerment using the IUCN categories of threat without taking into account other scientific, economic or social criteria. Although the IUCN threat categories are not intended as a triage system for deciding on conservation priorities they are widely used as such. As noted below, a proper threat assessment may well reveal other unsuspected threatening factors than those recorded in the IUCN Red List or for that matter national priority lists.

### *8.3. Distinction between species recovery and species reintroduction*

There is no internationally agreed terminology associated with species recovery, and usage may vary from one country to another, leading to confusion. In addition, recovery and species reintroduction are often conflated in the literature and so as to avoid confusion it is recommended that they be distinguished as follows:

**Species recovery** is the process whereby native species or populations within their indigenous range that have become endangered as a result of habitat loss, decrease in population size or loss of genetic variability, are recovered to a state where they are able to maintain themselves without further human intervention.

**Species reintroduction** is the deliberate translocation of individuals of a species to parts of its natural range from which it has been lost, with the aim of establishing a new viable population.

### *8.4. The better the preparation, the more chance of success*

One of the keys to success of species recovery is a thorough review of all the relevant information about the species and its habitats – essentially, the taxonomy and nomenclature, ecology, growth requirements, reproductive biology, distribution, demography, genetic variation – so as to provide a knowledge baseline against which recovery can be planned, implemented and monitored. The information may be obtained as a desktop exercise and through fieldwork.

### *8.5. Detailed threat analysis is essential*

A common failing in planning species recovery is the lack of a detailed threat assessment. Without a detailed understanding of the nature of the threats affecting threatened species and how to manage them, recovery efforts may be ineffective and valuable resources wasted. As stated by Lawler et al. (2002), 'No matter how much ecological theory, natural history, and monitoring sophistication we bring to bear on threatened and endangered species recovery, the science will be squandered without detailed insight into the threats that are putting the species at risk'. The range of potential threats to species is extremely diverse and while some of them are obvious such as overexploitation and habitat loss, others can be quite subtle such as changes in phenology and their impact on pollinators. A common error is to rely too much on the information on threats in the IUCN Red List which although a very valuable resource is not intended to provide a detailed threat analysis for the purposes of species recovery.

In some cases, the cause of the threat to a species may appear obvious, such as over-collecting as in the case of some cacti and succulents, medicinal, aromatic and culinary plants, and removal of the threat may allow it to recover without additional action. In many cases, however, it will be found that after eliminating the threat the species is still at risk and a detailed investigation reveals other threatening factors not previously identified. It is probable that most species are affected by a complex of multiple threats whose control or elimination will require considerable effort. These threats may interact in ways that are not easy to predict, and this may only become apparent through monitoring the impacts of recovery actions. Also, as discussed above, we need to take into account as far as possible with available knowledge, the potential impacts of climate change on areas, habitats and species.

### 8.6. *Recovery may be undertaken under a variety of land management regimes*

It is widely considered that species recovery should be undertaken within a protected area. This is neither ubiquitously correct nor possible. While it is true that a majority of recorded cases of plant species recovery have been in protected areas, this is largely because it is easier to undertake as it avoids having to negotiate access to or purchase of land and establish a protection regime. However, the majority of species (threatened or not) do not occur in protected areas, especially in tropical regions, and then it has to be decided whether it is possible or appropriate to create a new protected area for target species or whether there are alternative ways of ensuring their effective recovery in areas that are not subject to formal protection but have a different kind of management regime as in the case of conservation easements. Smaller scale measures such as small reserves (Parker, 2012), plant micro-reserves or the protection of vegetation fragments containing the target species may be suitable (Miandrimanana et al., 2019) and even fencing off an area on otherwise unprotected land to protect it from grazing can play a role.

### 8.7. *Genetic knowledge is critical*

Adequate genetic knowledge is important for the determination of best practice in conservation and potential recovery of species. Genetic variation is at the very heart of species recovery. As a general rule, the more genetic variation that can be captured in the recovery population, the more likely is its long-term survival and contribution to successful recovery of the target species although many plant conservation and recovery initiatives do not include the necessary genetic information (Pierson et al., 2016). On the other hand, care should be taken to ensure that the detailed genetic research and analyses are tailored to providing practical guidance for conservation measures and are not just an academic study. Guidelines for including sufficient genetic diversity of threatened species in recovery programmes are generally inadequate and often simplistic measures which rely largely on intuition are employed. This issue has been addressed for tree species by Hoban et al. (2018) who have developed a new, evidence-based approach to designing *ex situ* collections that effectively preserve a target species' genetic diversity by deciding which and how many populations and individuals to include. They claim that it can be tailored for successful conservation of any species although it is unlikely to be practical for the majority of threatened species given the amount of work, including intensive modelling involved.

### 8.8. *Wide range of management interventions*

Just as there is a great diversity of threats, so there is a very wide range of corresponding management interventions (Monks et al., 2019; Albrecht & Long, 2019), and like them, they may interact with each other leading to unforeseen consequences. They range from fairly simple actions such as habitat weeding to quite unusual or unexpected actions such as resolving complex seed dormancy mechanisms that may be needed following detailed investigation. The commonest interventions include habitat protection, fencing, habitat weeding, control or eradication of invasive species, control of unregulated livestock grazing or browsing, control of illegal collection of plant material, assisted pollination to increase seed set, control of pests and disease, managing disturbance regimes, predator control, soil improvement, population augmentation. Even apparently simple interventions such as exclusion fencing need to be carefully planned – in terms of location, coverage, height, material, potential impact on other species, etc. – if they are to be effective.

Management interventions may require considerable resources and are sometimes very costly. In the case of population augmentation to improve population viability by increasing the number of individuals in a population, the choice and location of source materials is critical. The seed or other material used for translocation may be collected from the existing populations or more often from *ex situ* conservation material such as seed from gene banks or from living collections in botanic gardens. In some cases, the numbers of translocated individuals are too low to be effective and insufficient use is made of facilities for the multiplication of individuals from seed. In fact, it has been found that for some species the quantities required for translocation may be very high – in some cases tens of thousands – and when outplants need to be raised from the seed, or if vegetative propagules have to be multiplied, nurseries are needed for this purpose. Depending on the quantities needed, some botanic gardens have the capacity to grow on such material, but often dedicated conservation nurseries are needed. For example, the Native Plant Biodiversity Conservation Nurseries in North Caicos and in Providenciales, (Dani Sanchez et al., 2019) nursery and the horticultural expertise acquired by them over the years in growing native plants were crucial to the successful rescue of the Caicos pine *Pinus caribaea* var. *bahamensis*. The Hawaiian Rare Plant Facilities which are part of a state-wide programme Plant Extinction Prevention Programme (PEPP) play a major role in saving Hawai'i's rarest native plants from extinction by propagation and outplanting. They include rare plant nurseries on Hawai'i Island, O'ahu, Kaua'i, and Maui. Also, when micropropagation is needed to produce material for outplants, appropriate cell or tissue culture facilities are required.

Examples of the enormous diversity of management interventions that have been employed in recovery programmes can be obtained from published recovery plans, e.g. by the US Fish & Wildlife Service.[12] Apparently, no global database of management interventions has been compiled and urgent consideration should be given to preparing one so as to provide more ready access to the enormously important body of information that has been amassed over the years.

### 8.9. *The state of the translocation habitat is critical*

It is important not to neglect the state of the habitat at the translocation site(s). The detailed conditions of the site such as the topography, soil conditions, hydrology and overall health of the ecosystem and its state of management need to be considered and any necessary remedial actions, such as weeding are undertaken. This is essential to ensure that the outplants have the best possible

[12] Endangered Species Recovery Plans Search www.fws.gov/endangered/species/recovery-plans.html.

chance of establishment. Also, it would be pointless attempting to recover a species by population augmentation if there is not sufficient critical habitat available.

### 8.10. Monitoring is essential at all stages of recovery

Monitoring plays a vital role at all stages in the conservation and recovery process yet it is often neglected, and many monitoring programmes are poorly designed and ineffective.

### 8.11. Success is not guaranteed

Species recovery is not a short-term process. It may take 10 years or more before the success or failure of recovery programmes can be assessed. It is important to agree recovery objectives and how they are to be measured as a critical part of a recovery plan. It is very difficult to say what percentage of recovery actions are successful since failures tend not to be reported. Many of the failures that are reported are due to inadequate planning. Even when the recovery objectives appear to have been met, it may be found that to maintain viable populations of the target species, continuing management intervention may be needed. Such species have been termed 'conservation-reliant'. As discussed above, future climate change will have an impact on the effectiveness of some recovery programmes and require additional action.

## 9. Conclusions

Conservation of plant biodiversity will continue to fail to meet national and global targets unless and until the various approaches are coordinated from the planning stage to implementation, and effective partnerships established with the necessary stakeholders and landowners, including local communities. The widespread failure to integrate species-based and area-based conservation planning, policies and actions is one of the key factors responsible for the continuing loss of biodiversity.

Many countries rely on protected areas as the primary strategy for conserving threatened species *in situ* without any further targeted action to remove threats to species within them and as a consequence, many threatened species continue to be on a trajectory to extinction. All countries need to recognize the need for targeted *in situ* species conservation and invest much greater effort and resources in the recovery of threatened or other important species. Even in countries with well-developed recovery programmes, many action plans for species recovery remain to be completed or even implemented in a timely manner (Dorey and Walker, 2018).

Calls for a massive expansion of the existing protected areas estate are seductive although it is difficult to imagine circumstances under which the recently proposed 50 percent target could be reached in the foreseeable future, in view of the massive logistic, political, legal and economic issues that would need to be overcome (Dudley et al., 2018); but even if it were to happen and the areas were properly protected and maintained – also an improbable scenario – we would still continue to lose biodiversity within them unless actions were also taken to make as thorough as possible a scientific study of the threats to species at risk and their habitats, followed by actions to remove or contain these threats so that recovery is possible (Heywood et al., 2018; Monks et al., 2019). This in turn would require a radical shift in the balance of actions to conserve plant diversity.

Whatever the reasons for the poor articulation and lack of coordination of the area- and species-based 2020 biodiversity conservation targets, it is to be hoped that in the new iteration of post-2020 targets now under consideration these matters will be remedied. The opportunity should be taken to thoroughly revise and integrate the CBD targets for area- and species-based conservation, and coordinate the actions proposed for their implementation so that they are mutually supportive. As they stand, targets such as 'at least 75% of known threatened species conserved *in situ*', are doubly defective: many of the 75% of threatened species do not occur in protected areas and so would require an unspecified expansion of the protected area estate, if they were to be included, as well as OECMs. That is not the goal of this target but of other targets and even in the unlikely event that the 50% or Half Earth goal were to be achieved, many threatened species would still fall outside. The omission of the need for conservation actions at the species level, notably to eliminate the factors that cause them to be threatened, is another failing of such targets. There is no ascertainable basis for the requirement in Target 8 of the GSPC for at least 20% of *ex situ* collections to be available for recovery or restoration programmes. This is not to imply that *ex situ* collections are not needed for recovery or reintroduction and indeed for other purposes – on the contrary they are essential, even though existing collections are hardly utilized at present. Accordingly, in revising the targets for species- and area-based conservation, I would propose that a key requirement for the implementation of *in situ* species conservation should be '*In situ* conservation or recovery plans should be prepared and implemented for 75% [or whatever figure is agreed] of threatened species' and in the technical guidance it should be made clear that while this may take place largely in protected areas, other effective measures may be needed for species that occur outside formally protected areas. The requirement for *ex situ* material to be available for *in situ* actions should be for all species deemed to be in need of recovery or reintroduction programmes, rather than setting an arbitrary target, and ideally collected in coordination with the relevant *in situ* agencies, Hanging over all our conservation actions is the threat of climate change and we are still in the throes of learning how to manage it. In the meanwhile, it is important to ensure that our conservation strategies at all levels are as effective as possible so as to slow significantly the current loss of biodiversity and enable our ecosystems and species to adapt to future change.

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