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Review

Restoration, Reintroduction, and Rewilding in a Changing World

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The increasing abandonment of marginal land creates new opportunities for restoration, reintroduction, and rewilding, but what do these terms mean in a rapidly and irreversibly changing world? The 're' prefix means 'back', but it is becoming clear that the traditional use of past ecosystems as targets and criteria for success must be replaced by an orientation towards an uncertain future. Current opinions in restoration and reintroduction biology range from a defense of traditional definitions, with some modifications, to acceptance of more radical responses, including assisted migration, taxon substitution, de-extinction, and genetic modification. Rewilding attempts to minimize sustained intervention, but this hands-off approach is also threatened by rapid environmental change.

Trends

Abandonment of agricultural land provides an opportunity for creating new ecosystems, but the traditional use of past ecosystems as targets is likely to be inappropriate in a time of rapid environmental change.

There is no agreement among conservationists about how to replace the historically based reference frame, with opinions ranging from minor modification to the acceptance of increasingly radical alternatives including moving species outside their current native ranges, using non-native taxon substitutions to maintain key functions, and the acceptance of novel ecosystems that are different from any past analogs.

New technologies will facilitate the genetic modification of threatened species and make the 'de-extinction' of at least some species possible, providing new, controversial options for conservationists.

Future debates seem likely to increasingly focus on the degree of human intervention that is desirable as 'wildness' is seen as an increasingly important attribute. Rewilding attempts to minimize sustained intervention, but this approach is also threatened by rapid environmental change.

Restoration, Reintroduction, and Rewilding

The abandonment of marginal agricultural land in response to economic development [1] creates new opportunities for restoration, reintroduction, and rewilding, but what do these terms actually mean in a changing world? The prefix 're', meaning back or again in English, can be attached to almost any verb and appears in many terms used for active interventions in conservation biology. These include: reconnect, recover, recreate, reforest, rehabilitate, reinforce, reintroduce, remediate, repair, restock, restore, revegetate, and rewild. Most of these have obvious meanings, although some, such as rewild, are newly coined whereas others, such as restore, were imported into English with the prefix already in place. Thus ecological restoration is returning an ecosystem back to the way it was, reintroduction is returning a species back to where it used to live, and rewilding is returning a managed area back to the wild. These terms came into common use during the nostalgic phase of conservation biology, when the initial, preservationist phase was running out of pristine areas to protect and the main task facing conservationists was seen as returning degraded ecosystems to their previous state, or as close to this as possible [2,3].

Inherent in the use of the 're' prefix, however, is the question 'back to when?' and this has become increasingly difficult to answer. The idea that the environment is changing unidirectionally, rapidly, and irreversibly is not new, but it is only in the past decade that it has become widely accepted, and its consequences widely understood, in conservation biology [4,5]. In statistical terms, most environmental parameters of relevance to the distribution and abundance of organisms are now clearly non-stationary [4]. Natural systems at all levels have an inherent degree of resilience, but there are thresholds of environmental change – generally unknown in advance – beyond which system changes can become irreversible [6]. The impacts of anthropogenic climate change are largely responsible for this shift in viewpoint, but irreversible environmental changes also arise from other human impacts, including land-use legacies such

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as soil erosion, nutrient enrichment, population and species extinctions, and invasive alien species – all markers of the proposed new geological epoch, the **Anthropocene** (see Glossary) [4]. If we cannot go back, the traditional use of present and past ecosystems as targets and criteria for success in ecological interventions must be replaced by an orientation not just towards the future, but towards an uncertain future. Nostalgia is no longer an option, but what should replace it?

A Taxonomy of Terms

Three clusters of related terms are widely used in the recent (2010–2015) conservation literature (Table 1). One group fits under the umbrella of restoration in the broad sense of 'assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed' [7] and includes restoration in the strict sense of restoring species composition, structure, and function to an approximation of a historical reference system, as well as the less ambitious targets of reforestation, revegetation, rehabilitation, and reclamation and the more human-focused approach of ecological engineering. A second group of terms fits under the IUCN's definition of conservation translocation, which is the movement and release of organisms for conservation reasons, including reintroduction and reinforcement, where the organisms are released within their indigenous range, as well as conservation introductions outside this range, to avoid extinction (assisted colonization) or to restore ecological function (ecological replacement or **taxon substitution**) [8]. Assisted migration, the most widely used term for overcoming dispersal limitations in species that will be harmed by climate change, is best understood as a subcategory of assisted colonization [9]. Two additional terms are not used in the IUCN guidelines: assisted

Table 1. A Taxonomy of the Major Terms Mentioned in this Review with a Brief Explanation of Their Recent Usage

Umbrella Term	Term	Key Element in Usage	Refs
Restoration	Restoration (in a strict sense)	Restoring original composition and function	[60]
	Functional restoration	Prioritizing function over species composition	[25]
	Reforestation	Restoring forest cover	[21]
	Revegetation	Restoring vegetation cover	[21]
	Rehabilitation	Returning highly degraded sites to usefulness	[60]
	Reclamation	Returning highly degraded sites to usefulness	[60]
	Ecological engineering	Creating sustainable ecosystems with both human and ecological value	[60]
Conservation Translocation	Reintroduction	Release within previous native range	[8]
	Reinforcement	Release into an existing population	[8]
	Assisted gene flow	Release within native range to assist adaptation	[61]
	Pleistocene reintroduction	Release within the Pleistocene range	[55]
	Conservation introduction	Release outside the native range	[8]
	Assisted colonization	To avoid extinction	[8]
	Assisted migration	To keep up with climate change	[9]
	Ecological replacement	To restore an ecological function	[8]
	Restocking	Mostly of harvested wild populations	[62]
Rewilding	Trophic rewilding	Introductions to restore top-down trophic interactions	[12]
	Pleistocene rewilding	Restoring to a pre-human Pleistocene baseline	[55]
	Ecological rewilding	Allowing natural processes to regain dominance	[13]
	Passive rewilding	Little or no human interference	[12]

Glossary

Anthropocene: a proposed geological epoch following the Holocene that began when human activities started to have a major impact on the global environment. Various starting dates have been suggested, with around 1800 or 1950 having the most support currently.

De-extinction: the process of bringing a species – or something closely resembling it – back from extinction. Advances in genetics and reproductive technology make it likely that this will be possible for some species within the next few years.

***Ex situ* conservation:** literally 'off-site conservation' that is, protecting an endangered plant or animal species outside its natural habitat, in zoos, botanical gardens, seed banks, or gene banks.

Taxon substitution: the replacement of an extinct species by a functionally similar substitute to restore ecological processes. The substitute may or may not be closely related to the extinct species.

Virtual fences: the reliance on techniques other than physical barriers to modify animal behavior at boundaries. Examples include sensory deterrents, biological barriers, training collars, and real-time tracking systems.

Box 1. A Brief History of Rewilding

The term rewilding was coined 25 years ago in North America for the restoration of large, connected wilderness areas that support large, wide-ranging animals, with an emphasis on carnivores [45]. When it was adopted in Europe, however, large carnivores were de-emphasized, while the focus on large connected areas and other large animals remained [63]. Another transatlantic difference in current usage is that the absence of sustained human intervention is central to European rewilding; indeed, rewilding in Europe can be entirely passive [31]. This aspect has not usually been emphasized in North America, although a major justification for rewilding there has been that the resulting ecosystems are expected to be self-sustaining. Much of Europe also lacks the existing wilderness areas that form the core of most North American rewilding proposals. These differences to a large extent reflect Europe's higher human population density and longer history of intensive human land use. The maintenance of diverse early successional anthropogenic habitats following the abandonment of the agricultural practices that created them has been a major focus for European conservation [37,64].

This has also led to significant philosophical differences. While the aim in North America was initially to restore the pre-Columbian wilderness, with all of its large vertebrates, the major aim in Europe has been to create 'wildness' (autonomy, spontaneity, self-organization, absence of human control) in areas that have been managed for millennia [65]. Pre-Neolithic Europe is often cited as an example of what this wildness could look like [66], but more as an inspiration than a target, and most European projects are explicitly future oriented [31,40]. Of course, pre-Columbian North America was also inhabited, a fact that has prompted the suggestion of an earlier historical reference state before the megafaunal extinctions of the Late Pleistocene, to be achieved by introducing extant conspecifics and related taxa [55]. One consequence of these differences is that objections to rewilding in North America have often focused on the perceived risks that large carnivores pose to people and their livestock, whereas in Europe the loss of traditional biocultural landscapes has been of greater concern [64]. However, carnivore populations have recovered dramatically in Europe without help from deliberate rewilding and now pose a potential threat to the 'no intervention' paradigm [35].

geneflow involves reinforcement with conspecifics carrying genes that can help adaptation to environmental change, whereas restocking is mostly used for boosting populations of harvested species.

A distinction that is not inherent in the nomenclature is that restoration has traditionally focused on vegetation, with a largely passive approach to restoring animal populations [10], whereas reintroduction and related activities have been dominated by animals, particularly vertebrates. Were it not for these divergent traditions, these two clusters could probably be merged. A recent proposal to use routine translocations of dispersal-limited animal species (termed 'wildlife restoration') to keep common species common by infilling gaps in their current distributions bridges this gap [11].

Rewilding has not yet achieved the maturity and respectability of restoration and conservation introduction and has been used in various different ways, but it is clearly distinct in both philosophy and methods (Box 1). It is useful to distinguish two extreme approaches: trophic rewilding, where the aim is to restore ecosystem functions by restoring top-down trophic interactions, and passive rewilding, where human interference is minimized from the start [12]. An additional term, ecological rewilding, has been applied to an intermediate approach that might be most appropriate in highly modified landscapes, such as most of Europe [13]. Both rewilding and reintroduction can be prefaced by Pleistocene to indicate a historical baseline – or, at least, an inspiration – in the late Pleistocene, before widespread megafaunal extinctions.

Most other 're' words in common use in conservation, such as reconnect, recreate, and repair, are usually used in their everyday senses rather than as technical terms, so they are not considered further here. However, their frequent use reinforces the impression that conservation is fundamentally about nostalgia: a longing for the past [3]. Reconciliation (Latin: bring back together) has a specific meaning in reconciliation ecology, which refers to attempts to encourage biodiversity in human-dominated landscapes – in many ways, the opposite of restoration and rewilding [14]. Despite the 're' prefix, this usage does not imply a return to a former state, reflecting the broad use of this word in everyday English. Resilience (Latin: jump back) is another 're' word, but is often used as a system property without reference to a historical state, so even novel ecosystems can be resilient.

Adjusting to the Anthropocene

Historical baselines have always been contentious in conservation, with fears of 'shifting baselines' when systems are compared with earlier reference states that themselves differ significantly from the original state of the system [15]. Pleistocene rewilding in North America was an attempt to avoid this problem by choosing a baseline before human arrival (Box 1) and there have been similar arguments in Australia and Europe, where modern humans arrived even earlier. What has changed in the past decade, however, has been an increasing recognition that the accelerating and effectively irreversible environmental change of the Anthropocene puts any historical baseline out of reach [4,6]. Climate change has received most attention, partly because it is most easily modeled, but other changes are the focus in some cases (e.g., soil nutrients [16]).

The widespread awareness of environmental change has not, however, led to widespread agreement on how conservation should respond. Hobbs [17] suggests that the polarization of responses reflects different stages of grief in response to the ongoing loss of biodiversity, from initial denial to final acceptance, but obviously those he considers to be in the earlier stages would not accept this diagnosis. Conceptual tensions resulting from the new perspectives are clearest in restoration ecology, which has traditionally been defined by a historically based reference frame [10,18]. Some have argued that this frame needs to be modified rather than abandoned, since it is what distinguishes restoration ecology from revegetation for erosion control or aesthetic reasons [19–21]. Suggested modifications include recognizing the contributions of past human impacts to the reference frame and aiming to construct resilient assemblages of native species that have a better chance of adapting to future changes. Others express a willingness to tolerate and, in some cases, manage for novel ecosystems (Box 2) with no historical analogs [22–24]. These shifts in attitudes have coincided with, and been reinforced by, a reorientation away from species composition as a goal and towards a focus on ecosystem function [10,25].

Box 2. Dealing with Novel Ecosystems

Novelty defines the Anthropocene [4] and biotic novelty – extinctions and invasions – is a major challenge to restoration, reintroduction, and rewilding since it can put traditional conservation targets beyond reach. The term novel ecosystem has been used in various ways, but most often for ecosystems that differ from historical ecosystems as a result of human impacts [33]. Most authors restrict it to ecosystems that will persist without human intervention, thus excluding croplands, and some require that they have crossed an ecological threshold that makes the changes impossible to reverse [24]. Ignoring novel ecosystems is no longer an option since, depending on the definition, they include much to all of the land newly available for conservation. Indeed, the human role in 'historical ecosystems' is widely underestimated [20]. Recognizing that we inhabit an 'anthropogenic biosphere' [48] does not, however, mean accepting that 'anything goes', since ignoring the ecological memories in a landscape (e.g., remnant vegetation, soil properties, seed banks) is neither practical nor desirable [18]. If restoration is defined as moving from an undesired ecosystem state to a desired one, it is easy to broaden the concept from restoration to a desired historical reference state to achieving other goals, including restoration of desired ecosystem functions such as water infiltration and conservation of one or more desired species [67]. Rather than evaluating success against a fixed baseline, the results of conservation interventions would then be compared with a counterfactual; that is, what would have occurred without the interventions [68].

Deviation from historical models has proved easier to accept on oceanic islands and in Australia, where extinctions and invasions have had a dominant influence on present-day ecosystems. Non-native tortoises have been introduced to control invasive plants on Round Island, Mauritius [69], while in Australia it has been suggested that introduced dingoes should be viewed favorably for their impact on invasive cats and foxes and that elephants could be introduced to control invasive grasses [70]. If restoration is thus freed from its traditional constraints, the difference from rewilding is only the level of intervention, ranging from a continued high level to maintain a desired state through initial species introductions to push an ecosystem in a desired direction [70] to embracing whatever nonintervention brings [31]. As with all conservation interventions, however, experimental tests of optimistic forecasts are essential.

The traditional focus of reintroduction on the species themselves rather than their ecological roles has made it easier to incorporate some nontraditional targets, such as assisted migration to sites outside the native range that are projected to have a suitable climate in the future, but more difficult for practitioners to accept proposals for substituting functionally important extinct native species by related or functionally similar non-natives [5,8]. However, there are already 'shades of nativeness' in landscapes with a long history of human impacts, even before functional substitutions for extinct species are considered [26], and non-native taxon substitutions could potentially reduce the need for other interventions by restoring ecological processes [27]. Taxon substitutions have many similarities with deliberate introductions for biological control – which, it should be remembered, were the source of many highly invasive species – and could usefully adopt the same stringent guidelines, including initial quarantine, small-scale field trials, and post-release monitoring [27]. Similar issues will undoubtedly arise in the future as it becomes practical to apply new molecular tools to genetically modify threatened and functionally important native species to accelerate their adaption to changing environments [25]. **De-extinction** of at least some extinct native taxa might soon be another option [28]. Although this is likely to be less controversial than taxon substitution, concerns about unplanned impacts are reasonable when the original extinction was back in the Pleistocene or early Holocene.

Rewilding's origins were explicitly nostalgic, but the recent literature, particularly in Europe, focuses on 'future wildness' rather than recreating the past (Box 1). Despite the range of different approaches included under the rewilding umbrella, a common feature is a belief that natural processes can achieve conservation objectives, including adjustment to environmental change, better than active human management. Trophic rewilding is based on a belief in the power of top-down ecological control through trophic cascades, although there is little direct evidence for the generality of this mechanism with large carnivores [29]. In Europe, it has been suggested that grazing by large herbivores might be able to maintain the open habitats that forest recovery would otherwise threaten [12]. While there is evidence that the diverse and abundant large herbivore guild in the last interglacial (including extinct species of elephant and rhinoceros) achieved this, the depleted herbivore assemblage of the early Holocene, which is a better model for what is achievable in modern Europe, apparently did not [30]. Passive rewilding is also based on a 'leave it to nature' philosophy, although the justifications in this case tend to be more philosophical than scientific [31].

To Intervene or Not to Intervene

The recent literature suggests that a major axis of variation in conservation, which is not adequately reflected in the current terminology, is the question of if and when to intervene [6,32]. A good illustration of this is the range of attitudes to invasive species, which vary from elimination or control whatever the costs, as has been traditional in restoration ecology, to tolerance and even encouragement of novel ecosystems where they are impossible or impractical to eliminate [33] (Box 2). Restoration was traditionally the active side of conservation, but conservation as a whole is now becoming more interventionist [34]. All interventions have associated risks, however, and can have unintended consequences. Future management will often need to be anticipatory, with actions aimed at how the system is expected to be in the future. Moreover, conservation actions on larger spatial scales cannot practicably be scaled up from local actions [34].

Rewilding's emphasis on little or no sustained management – with or without initial introductions of keystone species – contrasts strongly with the increased level of intervention implicit in many visions for the future of conservation biology. However, while some rewilding advocates favor simply letting ecosystems evolve out of human control [31], there is an ongoing debate in conservation on the need for sustained intervention to minimize human–wildlife conflicts [35], to control invasive species that can transform ecosystems [25], to restore 'natural' disturbance regimes [36], to maintain open habitats for species that are threatened by the encroachment of forest [36,37], to overcome dispersal limitation in plants and animals [38], and to adapt to rapid climate change [39].

In densely populated regions, compromises are unavoidable [40]. These compromises will most often involve active interventions in specific areas to maintain particular species and their habitats, while other areas are left alone. Fencing between unmanaged areas and intensively managed, human-dominated landscapes is an option [41], particularly for experimental purposes, but fences are unselective and intrusive and '**virtual fences**' of various forms are a little-explored alternative [42]. Some problems, however, might require intervention across the entire landscape. Plant invasions are already a massive problem on oceanic islands and now a growing one in continental protected areas [43]. Highly invasive pests and diseases, such as chytridiomycosis in amphibians and chestnut blight in the American chestnut, also provide a major challenge to a 'hands-off' approach on any scale, since it might be impossible to maintain ecological functions and prevent extinctions without sustained, intensive intervention [21,25,44]. Climate change in areas with a high projected climate change velocity is another problem that will require more than local intervention [39].

The need for interventions to maintain biodiversity and ecosystem functions, and the aggressiveness of these interventions, will be greater the faster the rate of environmental change (Figure 1). The need is also likely to be much greater in smaller, more isolated areas than in the very large, connected ecosystems envisaged by the originators of the rewilding concept [45], but rapid environmental change can overwhelm the capacity of even the best-connected ecosystems to adapt [39]. Where rapid changes lead to phenotype–environment mismatches, as is likely to occur in many long-lived, poorly dispersed species, possible management interventions include modifying the local environment (for example, by reducing soil nutrient levels [16]), assisted migration to areas with a more suitable environment [9], or genetic modification to improve the fit to the new environment [25,46]. The last of these options has not been practical in the past but seems likely to become so in the near future, judging by recent progress in agriculture [47].

The enhanced dichotomy between nature and human culture implied by rewilding has not always been welcomed, particularly in Europe, where nature and culture have interacted for millennia [37]. At the opposite end of the intervention spectrum from that occupied by large-scale rewilding are attempts to maximize biodiversity in multifunctional landscapes that include agriculture and human settlements [14,48]. Success in this endeavor to reconcile people and nature will depend on both land sparing, where urbanization and agricultural intensification free land for wild species, and land sharing, where wild species live within the urban and agricultural matrix. Many sensitive wild species do poorly in such landscapes [48,49], but those that thrive contribute more to human experiences of nature – and some components of human

Low → Rate of environmental change → High

Restoration and reintroduction with historical reference state	Native species and genotypes adapted to future conditions	Assisted migration of species beyond their native ranges	Non-natives and genetic modification of natives

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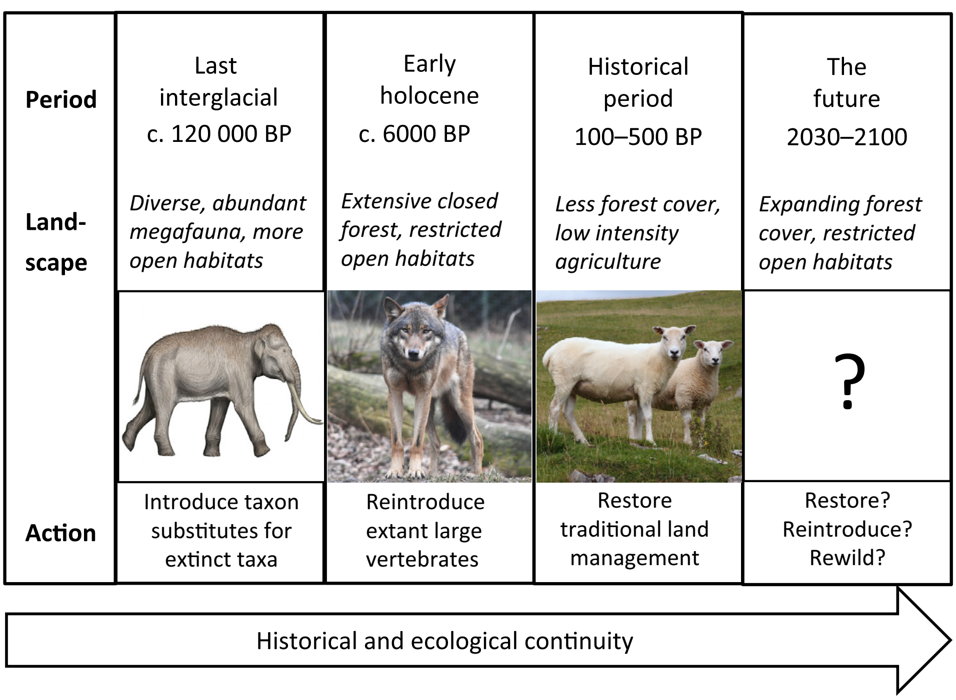
Figure 1. Possible Conservation Interventions in Relation to the Rate of Environmental Change. Traditional restoration and reintroduction assume little or no environmental change since the historical baseline. Careful selection of native species and genotypes can increase resilience to greater rates of change, but if the rate exceeds the capacity of the local biota to adjust, intervention in the form of assisted migration of species beyond their native ranges might be necessary. At the highest rates of change, it might be necessary to use non-native species or to genetically modify native species.

well-being [50] – than those in remote and more extensive wild areas. Although the philosophies of rewilding and reconciliation ecology are opposites, there is no ecological reason why large, low-intervention rewilded areas and biodiversity-rich multifunctional landscapes cannot coexist at regional and continental scales.

The Way Forward

Many of the questions raised by rapid environmental change do not have purely scientific answers. In particular, the move away from historical reference systems, the rewilding of ancient cultural landscapes, the use of taxon substitutions, and the potential use of genetic modification raise important ethical issues that cannot be ignored [10]. Modern conservation has always had an ethical basis, but as the issues becomes greyer and less tidy in the Anthropocene the underlying imperative to preserve and protect nature will not always lead to a single, simple, optimal solution. Looking forward is necessarily more difficult than looking backwards, although history also has biases and uncertainties that increase the further back in time you go [3]. If historical continuity is completely abandoned as a goal, conservation risks becoming merely a form of landscaping, driven by aesthetic and engineering considerations [18]. Even the most forward-looking of conservationists agree that interventions – and nonintervention – need to be historically informed, with historical knowledge used as a guide, not a template [18,24,33]. The past – or, ideally, a range of pasts – reflects the environmental conditions to which the regional species pool is adapted and shows the local species assemblages that are possible with this biota (Figure 2). Moreover, the most plausible futures in most places are likely to be only incrementally different from today, so a complete break with the past is unnecessary [51].



Trends in Ecology & Evolution

Figure 2. Possible Conservation Baselines in Europe and Related Conservation Interventions. The last interglacial represents the potential landscape under a modern climate but without modern humans [30], the early Holocene represents a human-occupied Europe before agriculture, the historical period represents a human-dominated landscape before industrialization, and the future is the remainder of this century. The dates are years before present (BP). Images of a straight-tusked elephant, Eurasian wolf, and domesticated sheep are from Wikimedia Commons, reproduced under a Creative Commons License.

It is not possible to separate consideration of timescales from those of space. Conservation has traditionally thought big, but intervention-intensive restoration projects are limited to small areas by practical considerations, and often contracts. Unless care is taken, this can result in isolated patches that are vulnerable to all of the problems that affect fragments of natural ecosystems [52]. To avoid these problems, local projects must be seen as embedded in landscape, regional, and global settings [53]. Where conservation action is needed on regional scales, rewilding, with or without vertebrate introductions, is probably the only practical option at present. A global perspective is particularly necessary for long-distance migrants whose survival depends on conditions at multiple sites [54].

A focus on ecological functions and processes can make it much easier to project historical models into an uncertain future [10,51], but this approach also has its risks. The use of trait-based models to achieve functionally defined targets has been proposed [51] but requires that the measured traits are adequate proxies for ecological functions. Moreover, the range of functions and processes displayed in recent landscapes in much of the world is only a subset of those seen before the megafaunal extinctions of the past 50 000 years [30,55] (Figure 2). Also, whereas most functions and processes in natural systems are dominated by common species, and could thus be replicated in much simpler systems, less common species can possess unusual combinations of functional traits that provide a degree of insurance against environmental changes in the longer term [56]. Moreover, biodiversity has other values – aesthetic, cultural, and ethical – that are independent of its ecological functions.

Finally, it is important to note that the Anthropocene has not been the only driver of changes in conservation practice over the past decade. There has also been an increasing recognition of the need for greater efficiency and cost-effectiveness in response to the scale of the problems to be tackled [10,21,57], a greater awareness of the importance of social and cultural factors in conservation [10], and calls for greater public involvement in conservation activities [10,11]. Opposed to these drivers of change are institutional inertia, social resistance, and lack of experience in the necessary technologies [58], as well as the continued uncertainties in the projections of environmental change. It is also clear that conservation practitioners on the ground tend to be more conservative than the writers of academic articles [59].

Concluding Remarks

A continuing worldwide decline in fertility rates, coupled with economic growth and increasing urbanization, suggests that land abandonment will increase globally over the coming decades as agricultural activity becomes concentrated on the most productive land. Some of this land will have been relatively lightly impacted but much of it will be like recently abandoned land in Europe, with altered soils, a depleted native biota, well-entrenched aliens, and poor connectivity. Along with climate change, these impacts have put many traditional conservation targets out of reach and demand a comprehensive rethink of conservation aims and strategies. In response, there has been an explosion of radical new ideas in conservation over the past few years and this is likely to continue. Many of the recently proposed interventions have been – and often still are – controversial and there is a danger that policy makers will pick actions from the expanding menu on grounds of cost, convenience, perceived 'coolness', or political acceptability, whereas the risks of unforeseen consequences are overlooked. The uncertainties need first to be reduced by further research (see Outstanding Questions), including large-scale trials in fenced enclosures. However, the most important conservation debates in the coming decades will probably not be about baselines, targets, and techniques, but about if and when to intervene, and we need agreed criteria to facilitate these decisions. Meanwhile, it may be useful to develop a new vocabulary for the developing forward-looking conservation paradigms, rather than trying to stretch the meanings of terms that are inherently backward looking.

Outstanding Questions

What happens if large areas of former agricultural land are simply left alone (i.e., passively rewilded)? Are the results desirable from a biodiversity and ecosystem services perspective and are they acceptable to local and regional stakeholders?

When is human intervention necessary to prevent species extinctions in natural areas? Is intervention necessary in response to rapid climate change and species invasions even in large, connected areas?

How can the restoration techniques used in small patches be scaled up to landscapes and regions? Conversely, can rewilding be scaled down?

Is wildness a reasonable and attainable goal? How can we measure it? Is maximizing wildness compatible with the traditional goals of protecting biodiversity and maintaining ecosystem services in a rapidly changing world?

How can the new molecular technologies contribute to conservation goals? When should we genetically modify wild species, if ever? Is de-extinction useful?

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