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Review

Allowing Space for Nature: Rewilding to Heal the Earth

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ABSTRACT: The term "rewilding" often elicits strong emotions, especially as presented in the media. Thus, anger is provoked that farmers will be forced to waste precious cropland, letting it return to the wild, or from fear that dangerous animals will be released into the urban environment. With equal fervour, others, taking an approving view, comprise the growing movement of guerrilla rewilders, secretly breeding butterflies, birds and beavers, and illegally releasing them (e.g., "beaver bombing") across the countryside. In truth, rewilding is a complex and widely encompassing proposition, which can be considered as a strategy within the natural climate solutions (NCS) [nature based solutions (NBS)] approach, aimed to restore and enhance wetlands, grasslands, forests, agricultural lands, seascapes *etc.* While exact definitions may vary, a key feature is that (after some initial support) it minimises the level of human intervention/management in a given region, *instead encouraging natural processes to take the lead and self-manage,* in the restoration, shaping and enhancement of natural ecosystems and of critical ecosystem functions. The resilience of such ecosystems should also be considered, especially in regard to how the impacts of a changing climate may prevail upon them. Rewilding is informed by science, traditional ecological knowledge (TEK), and other local (indigenous) knowledge. It is a long-term process with dynamic changes occurring over time, and rather than focussing on reaching a fixed endpoint, provides a continuous journey of letting nature's processes unfold. This can lead to increased biodiversity, amelioration of and resistance to climate change, and the provision of ecosystem services, benefitting both nature and people, including economic opportunities for local and indigenous communities, along with improved overall health and well-being. Despite its manifold and clear benefits, rewilding (along with other NCS) is not a pancea for all our troubles, many of which are rooted in the systemic issue of human ecological overshoot, and it is this that must be addressed to begin fixing the current global polycrisis.

Keywords: Rewilding; Climate change; Biodiversity loss; Natural climate solutions; Nature based solutions; Ecological overshoot; Behavioural crisis; Marine rewilding; Food security; Polycrisis

"There is a pleasure in the pathless woods,
There is a rapture on the lonely shore,
There is society, where none intrudes,
By the deep sea, and music in its roar:
I love not man the less, but Nature more."—George Gordon Byron (1788–1824).

1. Introduction

"Rewilding" can be a dangerous word, tending to elicit strong emotions, especially as presented in the media. Thus, anger is provoked from farmers, in the belief that they will be forced to waste precious cropland, returning it to the wild, or that their livestock will be predated upon, e.g., by wolves or lynx. More generally, there is the fear that, once introduced, such dangerous animals might make their way into towns and cities [1]. With equal fervour, others, taking an approving view, comprise the growing movement of guerrilla rewilders, who are secretly breeding butterflies, birds and beavers, and illegally releasing them (e.g., "beaver bombing") across the countryside [2].

In truth, rewilding is a complex and widely encompassing proposition, which can be considered as a strategy within the natural climate solutions (NCS) [nature based solutions (NBS)] approach [3,4], aimed to restore and

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improve wetlands, grasslands, forests, agricultural lands, seascapes *etc.*, and while exact definitions may vary (Section 5), a key feature is that (after some initial support) it minimises the level of human intervention/management in a given region, *instead encouraging natural processes to take the lead and self-manage,* in the restoration, shaping and enhancement of natural ecosystems and of critical ecosystem functions.

It sets an advance from nature protection to recovery, restoration and regeneration, aiming to strengthen the adaptive capacity of ecosystems by restoring natural processes and minimising human management [5]. The resilience of such ecosystems should also be considered, especially in regard to how the impacts of a changing climate may prevail upon them. It is not merely land abandonment, although the level of management intensity tends to be related inversely to the size of the area being rewilded [6].

Rewilding is informed by science, traditional ecological knowledge (TEK), and other local (indigenous) knowledge. It is a long-term process with dynamic changes occurring over time, and rather than focussing on reaching a fixed endpoint, provides a continuous journey of letting nature's processes unfold. This can lead to increased biodiversity, amelioration of and resistance to climate change, and the provision of ecosystem services, benefitting both nature and people, including economic opportunities for local and indigenous communities, along with improved overall health and well-being.

Rewilding provides a large-scale approach for enabling natural processes to shape land and sea regions and repair damaged ecosystems. For example, Rewilding Britain aims to restore and interconnect rich natural habitats across at least 30% of Britain's land and seas by 2030. This would involve at least 5%, targeted as core rewilding areas, which focus on restoring and reinstating a wide range of natural processes, habitats, and (where appropriate, and when the time is right) missing species, forming *mosaics* of native forests, peatlands, heaths, and other natural ecosystems. It is proposed that an additional 25% be used for other nature-friendly land and marine activities—including farming, forestry, and fishing—to reverse biodiversity loss and create sustainable nature-based economies [7].

(Re-)wilding is not necessarily bringing back what was there before (e.g., Pleistocene rewilding), but "making wild again" so that new, thriving, regenerative ecosystems can arise and flourish. It is a loose, systems-based approach aiming to give nature the space and freedom to recover, grow and adapt on its terms, expecting only that natural processes will drive change, leading to better functioning ecosystems and increased resilience. It looks to the future, not the past [8].

2. Nature Degradation and "Half Earth"

Before the dawn of agriculture, the Earth was in a "wild" condition, but since then, humans have encroached upon most of the global land surface. The current extinction crisis is a testament to human impacts on wilderness [5], and now half of the world's habitable land is mainly used for food production. Over three-quarters of global agricultural land is occupied by livestock, despite meat and dairy making up a much smaller share of the protein and calories consumed by humans [9]. Evidence has been presented that, globally, habitat destruction is a greater threat than climate change, in terms of pushing species toward extinction [10], although, the two are interrelated [11] and are symptoms of human ecological overshoot [12]. However, a recent study places climate change as the major factor driving species loss in the United States and US territories [13].

It has long been known that the actions and progress of human civilization are primary drivers of habitat change/degeneration; for example, in the 5th century BC, the Greek historian Herodotus noted that: *"Man stalks across the landscape and desert follows his footsteps."* [14]. In the 19th century, George Perkins Marsh proposed that ancient Mediterranean civilisations collapsed due to land degradation: deforestation caused soils to become eroded, so declining in their productivity, and he observed that the same trends were occurring in the USA [15].

The renowned American biologist, Edward Osborne Wilson (generally known as E.O.Wilson), regarded mass extinction as the greatest threat to Earth's future, and once said that "destroying a rainforest for economic gain was like burning a Renaissance painting to cook a meal" [16]. Wilson coined the term "biophilia" to suggest that humans have an intrinsic affinity ("love") for other species [17]. He was one of the first ecologists to estimate that we need to rewild roughly half of the Earth, an aim he called "Half-Earth" [17]. This drew upon his research from half a century before, published in *The Theory of Island Biogeography* [18], and co-written with Robert MacArthur, which showed that biodiversity declines according to a median fourth root of the habitable land area. Since only 15 percent of the world is protected as nature preserves, 50 percent of all species will go extinct by the end of the century. Alternatively, protecting half of the world will help 85 percent of species survive [19].

However, in a later interview, Wilson argued that "setting aside half the Earth doesn't mean moving people out, but being creative with park designations, restoration, and encouraging private-public partnerships." [20]. Indeed, since relatively little of the Earth's land surface is free from human activities [21], people must be integrated into much of the rewilding process, living alongside and allowing space for "wildness" [5]. Rewilding Britain has presented an excellent flow-graphic that illustrates how rewilding might be used to heal the degraded British uplands landscape, building complexity, biodiversity and resilience, over a period of perhaps 50 years. Here, people are critical partners and beneficiaries of the overall plan [22]. However, cities can also be included as an essential part of the Half Earth approach [23], since while more people are shifting from rural areas to cities, the ecological footprint of the latter is many times their geographic area, drawing in resources from wider regions [24]. Hence, "Half Earth Cities" should also include "the wild" [25], and indeed others have proposed that to conserve the bulk of Earth's ecological heritage across the Anthropocene, setting aside half of Earth's land is only a beginning. Thus, to preserve biodiversity over the long term, across an increasingly human dominated planet, conservation measures must become as integral to the global human enterprise as those of social and economic development [26].

Rewilding Europe has emphasised the importance of rewilding Europe's cities and surrounding areas, especially through the protection and enhancement of natural forests, in regard to ameliorating rising global temperatures, biodiversity decline and the impact of such pandemics as COVID-19 [27]. Forests are expected to play a critical role in meeting the target of around one billion hectares of land pledged for carbon removal projects [28].

The rewilding of urban environments is discussed in more detail in Section 11.

3. History of Rewilding

The concept of rewilding originated in North America in the 1980s, stemming from "landscape ecology and conservation biology", with Dave Foreman as a key player, who had worked alongside other "heavyweights" in the field of conservation biology [29]. The overall emergence of the subject was led and propagated by both scientists and activists, who carried the spirit of the movement and brought it into practice [29]. *Rewilding*, as a specific scientific term, has its beginnings as a reference to the Wildlands Project (now called Wildlands Network), which was founded in 1991 and aimed to create North American core wilderness areas, absent of human activity, that would be connected by corridors. The earliest use of the word rewilding in print was in 1991, in the magazine *Wild Earth*, which was connected to the project [30]. In 1998, conservation biologists Michael Soulé and Reed Noss described the scientific basis for rewilding in terms of the "3Cs" model of cores, corridors, and carnivores: with large core protected areas, ecological connectivity, and keystone species [31]. This is based on the theory that large predators play regulatory roles in ecosystems [32], and hence core areas of wild land should be protected, but linked together by corridors so that carnivores can roam throughout the landscape to perform their functional purpose [33]. The most common types of core areas are national parks and wilderness reserves, within which human development is strictly limited, especially building roads.

In their edited book, *Continental Conservation*, Soulé and Terbough proposed that different corridor sizes are necessary. So, while some smaller species can pass along narrow, linear pathways, for large carnivores, these need to be made sufficiently wide that both herds of prey and packs of their predators can undertake their daily and seasonal migrations [34]. Later refinements were made, with the addition of other "Cs", including climate resilience [35], compassion [36], and coexistence [37].

Rewilding schemes have been adopted by various individuals, small land owners, local non-governmental organizations, local authorities, national governments and international non-governmental organizations such as the International Union for Conservation of Nature. Such initiatives can be controversial [33], having aroused criticism among academics, practicing conservationists, government officials and business people, especially in regard to large-scale projects, while origins of the idea of "wilderness" (which is primarily a modern Western concept) are still argued over, as part of the "Great Wilderness Debate" [38]. Nonetheless, the United Nations has listed rewilding as one of several critical methods intended for the massive scale restoration (over 1 billion hectares) of natural ecosystems, which they say must be accomplished by 2030 [39].

4. Types of Rewilding

Rewilding approaches may be classified under three main headings.

4.1. Passive Rewilding

Passive rewilding (also called ecological rewilding) aims to restore natural ecosystem processes by minimising or removing direct human management of the landscape, and allowing ecosystems to regenerate largely on their own. Examples include abandoning land, removing fences for ecological succession, or allowing natural processes to shape the landscape [40,41].

4.2. Active Rewilding

Active rewilding is an umbrella term used to describe a range of rewilding approaches, all involving more direct human intervention. These might include reintroducing or translocating species, including carnivores or herbivores, and/or habitat engineering, the removal of man-made structures like dams or weirs, and managing grazing to promote certain plant species [40,42]. Active rewilding can include planting trees, removing invasive species, or restoring wetlands.

4.3. Pleistocene Rewilding

Pleistocene rewilding aims to recreate the ecosystems of the Pleistocene epoch, often by reintroducing large herbivores like bison (even extinct species such as the woolly mammoth, through genetic engineering [43], or close ecological equivalents), to restore ecosystem functions. This approach is controversial, as it may be neither feasible nor desirable to recreate ecosystems from the past in their entirety. Proponents of the approach contend that ecosystems which evolved in response to Pleistocene megafauna, but now lack large mammals, may be in danger of collapse [44]; however, its critics maintain that it is not reasonable to assume that ecological communities today are functionally similar to those that existed 10,000 years ago [45].

Other types of rewilding have been identified, but these involve elements of the above strategies, e.g., trophic rewilding and urban rewilding, which are discussed in more detail in Sections 7 and 11.

5. Definitions and Controversies

The term "rewilding" sounds straightforward, presumably meaning "to make wild again", whereas it actually has a complex and controversial history and encompasses a whole host of definitions and intentions, where the proverbial devil is in the details. Jorgensen [30] has identified six uses of the word rewilding: (1) cores, corridors, carnivores; (2) Pleistocene mega-fauna replacement; (3) island taxon replacement; (4) landscape through species reintroduction; (5) productive land abandonment; and (6) releasing captive-bred animals into the wild. Moreover, as reported in the scientific literature, each of these definitions is associated with reference points both in time and geographical applicability: thus, for the most part, each definition has been anchored to a particular geography, for example, North America, the Pacific islands, or Europe [30].

Jorgensen argues that the word has become too "plastic", with discourse over rewilding often attempting to erase the history of human involvement with the land and flora and fauna, and that trying to divorce nature from culture may prove unfruitful and possibly damaging [30]. Hayward et al. have suggested that the lack of clarity in defining rewilding (at least 12 versions being identified) may have hindered scientific dialogue over the topic and hence its development, and that the older term "restoration" should be used instead [46]. The article [30] elicited a number of reactions, emphasising that although rewilding may be a subdiscipline of restoration, all restoration is not rewilding [47,48].

Prior and Ward have challenged [49] Jorgensen's allegation of "plasticity", and provide examples of rewilding programs which "have been developed and governed within the understanding that human and non-human world are inextricably entangled". They propose that it is the aspect of "non-human autonomy" which occupies the core of all rewilding definitions and efforts, and sets them apart from other forms of ecological restoration practices, contending that [rewilding is]: *"A process of (re)introducing or restoring wild organisms and/or ecological processes to ecosystems where such organisms and processes are either missing or are 'dysfunctional'"*. As the authors note, this definition covers rewilding at different scales and also different sites, including efforts to rewild in urbanised places [49].

This view resonates with a study [50] by Massenberg et al., who conclude that: "*Based on a synthesis of current scientific publications, we argue that rewilding should be understood as an increase in wildness, that is restoring the autonomy of natural processes and self-sustaining ecosystems to overcome the improper dualistic understanding of human-nature relationships in which humanity is outside of nature*".

Schulte to Bühne et al., have considered the policy consequences of defining rewilding, and conclude that what rewilding looks like in practice depends on how stakeholders define ''wild". Accordingly, they aver, defining rewilding is ultimately a political and social process informed by ecological knowledge rather than entirely determined by it [51].

Hence, the matter is undoubtedly complex, but for practical purposes, the working definition [52] presented by Rewilding Europe conveys a succinct and effective encapsulation of rewilding and its aims:

> *"Rewilding ensures natural processes and wild species play a much more prominent role in the land and seascapes, meaning that after initial support, nature is allowed to take care of itself. Rewilding helps landscapes become wilder, whilst also providing opportunities for modern society to reconnect with such wilder places for the benefit of all life."*

6. Principles for Rewilding

To focus the wide range, both in scope and geographic application, of particular forms of ecological restoration projects that have been described as "rewilding", in 2021 the journal *Conservation Biology* published a paper, written by 33 coauthors from around the world, and empowered by a directive from the International Union for the Conservation of Nature, entitled, "Guiding Principles for Rewilding" [53]. This aimed to produce a unifying description and a set of 10 guiding principles derived from a detailed survey of rewilding pioneers and organisations. More than 150 rewilding experts and practitioners were consulted at a series of international workshops to arrive at a set of principles for undertaking rewilding safely, and to propose means by which policymakers and funding agencies might assess the effectiveness of particular projects and prioritise support for them [54].

As a "unifying definition" of rewilding aimed to reflect a global scale inventory of underlying goals and practices, the group arrived at the following:

> *"Rewilding is the process of rebuilding, following major human disturbance, a natural ecosystem by restoring natural processes and the complete or near complete food web at all trophic levels as a self-sustaining and resilient ecosystem with biota that would have been present had the disturbance not occurred. This will involve a paradigm shift in the relationship between humans and nature. The ultimate goal of rewilding is the restoration of functioning native ecosystems containing the full range of species at all trophic levels while reducing human control and pressures. Rewilded ecosystems should—where possible—be self-sustaining. That is, they require no or minimal management (i.e., natura naturans [nature doing what nature does]), and it is recognized that ecosystems are dynamic."* [53].

While it has grown in popularity, misuse of the rewilding concept risks alienating communities, harming existing biodiversity and undermining confidence in a methodology that offers enormous potential for ecological restoration. To avoid any such misunderstandings, the 10 principles for rewilding have been defined [53,54] as follows:

6.1. The 10 Rewilding Principles

1. Rewilding uses wildlife to **restore tropic interactions** (*i.e.*, food webs and chains).
2. Rewilding employs landscape-scale planning that considers core areas, **connectivity**, and co-existence (*i.e.*, that outcomes are to the mutual benefit of people and nature).
3. Rewilding focuses on the **recovery of ecological processes**, interactions, and conditions based on reference (*i.e.*, similar healthy) ecosystems.
4. Rewilding recognises that **ecosystems are dynamic** and constantly changing.
5. Rewilding should anticipate the effects of **climate change** and act as a tool to **mitigate** its impacts.
6. Rewilding requires **local engagement** and (community) support.
7. Rewilding is informed by science, **traditional ecological knowledge** (TEK), and other local (indigenous) knowledge.
8. Rewilding is **adaptive** and dependent on monitoring and feedback.
9. Rewilding recognises the **intrinsic value** of all species and ecosystems.
10. Rewilding is a **paradigm shift** in the coexistence of humans and nature.

Achieving consensus regarding the real practice of rewilding is impeded by a lack of definite guidelines, and broad-scale studies on how rewilding is done are limited. To address this, in 2024, the lead author of the above study co-authored a paper which, to some extent, builds on their previous work by presenting a set of operating tools aimed to inform how IUCN rewilding guidelines will be met, in definite practical applications, to improve accord and collaboration among the rewilding community [55].

As a simpler and more pragmatic guide, Rewilding Britain has proposed "Five Principles of Rewilding" [56]:

6.1.1. Support People and Nature Together

Rewilding is about all of us finding ways to work and live within healthy, flourishing ecosystems. Rewilding can enrich lives and help us reconnect with wild nature while providing a sustainable future for local and wider communities.

6.1.2. Let Nature Lead

From the free movement of rivers to natural grazing, habitat succession and predation, rewilding seeks to reinstate natural processes. This includes reintroducing missing species where appropriate, particularly keystone species. It is not geared to reach any human-defined optimal point or end state. It goes where nature takes it.

6.1.3. Create Resilient Local Economies

Rewilding creates opportunities for resilient new nature-based economies. It's about finding livelihood opportunities that thrive alongside and enrich nature.

6.1.4. Work at Nature's Scale

Rewilding is restoring ecosystems with enough space to allow nature to drive the changes and shape the living systems on which we depend. Scale may come from single landholdings or through joining up nature to thrive from mountain top to doorstep, from source to sea.

6.1.5. Secure Benefits for the Long-Term

Rewilding leaves a positive legacy for future generations. Securing rewilding areas' continued, long-term benefits is key to a healthy, prosperous future.

This is accompanied by a "12-step plan for rewilding" [57], while Rewilding Europe have offered their own, "Guidelines for Drafting the National Restoration Plan", aimed to present rewilding as a smart, practical, immediate, and cost-effective approach to restoring nature at scale across Europe [58].

7. Trophic Rewilding

Trophic rewilding uses species (re)introductions to restore trophic interactions and complexity, to promote resilient, biodiverse, self-regulating and self-sustaining ecosystems. Typically, this involves top-down and associated trophic cascades where a top consumer/predator controls the primary consumer population [59,60]. Hence, if successful, this would reverse defaunation by re-introducing missing wildlife and halt biodiversity declines. Ecosystem engineers are "organisms that demonstrably modify the structure of their habitats" [61], and, in rewilding, may include beaver, elephants, bison, elk, cattle (as analogues for the now extinct aurochs) and pigs (as equivalents for wild boar). They may also be keystone species, which are those with a disproportionately large environmental effect compared to their abundance, for example beavers. The presence of keystone species (e.g., predators, pollinators, and herbivores) can help to build biodiversity and food webs, while ecosystem engineers can aid in the physical development of landscapes (e.g., river meanders and wetlands), and by creating or maintaining habitats that benefit other species. As they perform their own particular ecological functions, large mammals can also effect changes in biogeochemical pathways in ecosystems [59,60].

Apex predators may be required in some rewilding projects to prevent browsing and grazing animals from over-breeding (and hence over-feeding), and exceeding the ecological carrying capacity of the rewilding area. Nonetheless, while predators are important agents in ecosystems, it is not always clear whether their control of prey populations is from direct predation or a less direct mechanism, for example, Behaviourally Motivated Trophic Cascades [62], also termed the "Ecology of Fear" [63]. For example, it is generally believed that the reintroduction of wolves in Yellowstone caused changes in elk grazing patterns, which allowed aspen forests and other vegetation to regenerate. However, this has recently been called into question [64].

The (re)introduction of animals is often done on a case by case basis [65]. So, while large landscapes (e.g., in Eastern Turkey) can have wolves, bears, lynx, *etc.* introduced [66], this is probably not viable for smaller, urban regions [67]. In the UK, the Dangerous Wild Animals Act 1976 restricts the reintroduction of certain animals, including bison, wild boar and lynx, while the Wildlife and Countryside Act 1981 sets out the licensing, consultation and assessment requirements for native species which may be legally reintroduced [68]. Various aspects of Trophic

Rewilding have been surveyed in articles collected in a special issue of Philosophical Transactions of the Royal Society B [69].

Human-Wildlife Conflict

As already noted, the fear exists that, once introduced, dangerous animals might make their way into towns and cities [1], and the reintroduction of brown bears to Italy's Trentino province, through the EU-funded Life Ursus project, has led to growing tensions between humans and wildlife. Initially, the scheme was applauded, but now that there are more than 100 bears, conflicts with humans have increased in number, including the fatal attack on Andrea Papi in 2023, which is the first modern death from a wild bear in Italy [70]. While calls for stricter controls have been elicited, including the culling of dangerous bears, others argue that such conflicts are a result of poor management, inadequate public education, and a lack of preventive measures such as bear-proof bins [70]. Farmers have also opposed plans to reintroduce the lynx in the United Kingdom because of fears that this will lead to an increase in sheep predation. However, others maintain that lynx preferentially prey on foxes, which attack sheep, so introducing them may prove beneficial [71].

It is sometimes debated whether humans are the top apex predator [72], although, a study of the human trophic level (HTL) may be noted, which concluded that, in the context of the global food web, the answer is no, and that humans are similar to anchovies or pigs [73]. Nonetheless, for example, on the Knepp Estate, a 3500-acre rewilding project, it is humans that kill cattle, pigs, *etc.*, partly from its business activities but mainly to keep numbers in check, so in a rewilding area without bears, wolves, lynx, *etc.*, humans may function as a surrogate apex predator [74].

The ecological benefits of trophic rewilding have been evaluated empirically by means of a 9-year exclosure experiment [75], which concludes that trade-offs exist between rewilding strategies, in regard to biodiversity and ecosystem function. Thus, woody plant diversity and total carbon storage were reduced by 73% and 23%, respectively, compared to passive rewilding plots that excluded mammalian herbivores. In contrast, plant diversity and carbon storage were improved compared to land where agriculture had continued, e.g., artificial pastures associated with intensive livestock production. The diversity and biomass of ground-dwelling arthropods were enhanced by 21% and 167%, respectively, relative to passive rewilding, partly because more structurally complex vegetation was created by trophic rewilding. Overall, it is concluded that tropic rewilding is not a panacea for conserving biodiversity and ecosystem functions, and how it should be used in restoration depends on those particular conservation outcomes that a society places value upon [75].

Svenning et al. have stressed that, from what is currently known, the evidence is that trophic cascades may be successfully restored via species reintroductions and ecological replacements. Nonetheless, the influence of megafauna is subject to various factors that are, as yet, not well understood. It is proposed that applied programmes be implemented to assess the role of trophic complexity, interplay with landscape settings, land use, and climate change, as well as determining scope for rewilding globally, and means to maximize benefits and mitigate human–wildlife conflicts [59].

The complexity of tropic rewilding is highlighted elsewhere, from which it is concluded that a range of social and ecological context dependencies can cause outcomes in a rewilded carbon cycle to vary, and lead to ethical considerations for successful implementation. Those technologies that are currently available for predicting and monitoring progress toward both biodiversity and climate mitigation goals have also been surveyed [76].

8. Rewilding to Ameliorate the Climate Emergency and Biodiversity Crisis

The world is experiencing a climate emergency and biodiversity crisis [11,77], among which is the catastrophic decline in insect numbers, which is of particular concern [78,79]. However, rewilding strategies offer the potential to both ameliorate and provide resilience to climate change, supporting biodiversity in the process [80], as a result of carbon capture and storage, changes to the Earth's albedo, natural flood management, reduction of wildfire risk, and facilitating species to move to new, climate safe habitats, thus creating biodiverse and climate resilient ecosystems. Some of these aspects are considered below. Through its diversification of the range of outcomes provided, rewilding may offer a supporting approach to natural climate solutions, ensuring the delivery of other nature-based benefits to biodiversity conservation and society [81].

8.1. Herbivores and Carbon

When herbivores consume vegetation, carbon is assimilated within their biomass and released by respiration, digestion and defecation [82]; hence, the rewilding of *large* herbivores is the most significant in terms of biogeochemical cycling and the development of ecosystem structure [83]. For example, in a tropical forest in Guyana it was found that, when numbers of mammalian species were increased from 5 to 35, tree and soil carbon storage rose by a factor of four to five, respectively, as compared with an increase of 3.5 to four times by increasing the number of tree species from 10 to 70 [84]. Large herbivores can influence climate change in a number of ways, both direct and indirect [85]. For example, reindeer (*Rangifer tarandus*) and muskoxen (*Ovibos moschatus*) are the only large herbivores in the Arctic, where temperatures are increasing, and so thermophilic plant species are invading the tundra. The reindeer and muskoxen are able to maintain the composition of vegetation there, even in a warmer climate [86], and also prevent the expansion of woody plants as temperatures rise, thus maintaining a greater albedo [87] and consequent cooling effect. While uncertainties remain, it seems probable that the introduction of increased numbers and diversity of large herbivores may mitigate some of the consequences of warming in the Arctic [85]. Thus, we may note “Pleistocene Park”, a future-oriented rewilding project set in Arctic Siberia to slow the melting of permafrost, by introducing large herbivores into the area [88].

The loss of fauna from tropical rainforests leads to a reduction in the dispersal of tree species with megafaunal fruits, which have a higher wood density and contribute strongly to carbon storage in tropical forests [89]. Accordingly, the introduction of large herbivores could enhance the forest’s carbon storage potential [85]. By replacing ruminant livestock with non-ruminant wildlife on rangelands, a significant reduction in greenhouse gas emissions could be achieved [85]. It has been proposed by Cromsigt et al. [85] that populations of large (>100 kg) non-ruminant herbivores should be the focus of tropic rewilding as a climate mitigation approach.

8.2. Natural Climate Solutions and Rewilding

A comprehensive analysis was made of twenty natural climate solutions (NCS), involving conservation, restoration, and/or improved land management actions that might be adopted to increase carbon sequestration and/or to curb emissions of greenhouse gases globally, across forests, wetlands, grasslands, and agricultural lands. It was deduced that one-third of the climate mitigation needed up to 2030 as required to keep global heating below 2 °C could be provided by such NCS methods [90]. More recently, Schmizt et al. have argued that NCS typically underrate the importance of animals in controlling the carbon cycle, and present evidence that by protecting and restoring key wild animals and their functional ecosystem roles, natural ecosystem carbon sinks can be “supercharged”. The paper shows that an additional 0.6 Gt CO_2 per year could be sequestered by restoring populations of just 3 species: baleen whales, bison and African forest elephants. Furthermore, the authors emphasise the critical role of marine and other key species in the global carbon cycle, which could absorb another 5.8 Gt CO_2 per year [91].

In their Rewilding and Climate Breakdown report [92], Rewilding Britain has estimated that by restoring and protecting native woodlands, peatlands, heaths and species-rich grasslands over 30% of the UK landscape (7 million hectares), 53 million tonnes of carbon dioxide could be sequestered per year, which is over 12% of current UK emissions. Similarly, Rewilding Europe have estimated that by rewilding over 10% of European land, 10% of European emissions could be captured and stored, and that this could be done at a “cost per sequestered tonne of carbon” of around 25–50 euros, which is far cheaper than most other carbon sequestration methods [93]. In its 7th Carbon Budget, the UK Climate Change Committee have offered several land-based mitigation options: improved management of existing forests and woodland generation, perennial energy crops, restoration of degraded peatlands, sustainable agriculture on organic soil, along with an expansion of agroforestry and hedgerows. Under the Balanced Pathway, these measures are predicted to bring about emissions savings for the UK of around 8 Mt CO_2e in 2040, rapidly increasing to around 25 MtCO_2e in 2050 [94].

Due to deforestation, Mo et al. have estimated that the total carbon stored in global forests is 328 billion tonnes below their optimum, natural capacity. However, they conclude that, without encroaching on urban or agricultural lands, forests could capture a total of around 226 billion tonnes of carbon: 61% of this (139 Gt C) by protecting existing forests (“proforestation”), so that they can recover to maturity, and the remaining 39% (87 Gt C) through reconnecting fragmented forest landscapes using restoration and sustainable ecosystem management [95]. The integration of rewilding with forest management has been emphasised to improve trophic complexity, natural disturbances, and species dispersal, thus enhancing biodiversity, resilient carbon storage, and social-ecological resilience [96].

Tropical rainforests appear to be particularly susceptible to, and hard hit by, the effects of climate change, and the Brazilian Amazon is found to have emitted a net 3.6 Gt CO_2 (equivalent) over the past 20 years. Based on satellite monitoring data, it is concluded that the best chance for preserving the Amazon, and its ability to buffer against climate change, lies in placing formally protected areas and lands in the care of indigenous peoples [97]. Elsewhere, it has been proposed that, to preserve global biodiversity and rewild key habitats, science and Indigenous knowledge must work in partnership, while also being restitutive and rights based. Such traditional and Indigenous knowledge has successfully preserved and restored biodiversity across the globe, although its validity compared with Western science is far less well recognised [98].

8.3. Wetlands

Worldwide, the remaining area near natural peatland (over 3 million km^2) sequesters 0.37 gigatonnes of CO_2 a year. Peat soils contain more than 600 gigatonnes of carbon, representing up to 44% of all soil carbon, and exceed the carbon stored in all other vegetation types, including the world's forests [99]. However, when drained for agriculture, peatlands transform from a carbon sink to a carbon source, releasing carbon stored over centuries into the atmosphere. Emissions from drained peatlands are estimated at 1.9 Gt of CO_2e annually, equivalent to 5% of global anthropogenic greenhouse gas emissions, and hence their preservation and restoration are critical to ameliorate climate change and biodiversity loss. Indeed, it has been estimated that by ending the conversion and degradation of forests, wetlands and peatlands (restoring them instead), some 9 Gt CO_2 per year could be sequestered by 2050 [100].

In terms of actual means to begin addressing this, we may note the Global Peatlands Initiative [101], which was inaugurated at the 2016 UNFCCC COP in Marrakech, Morocco, aiming to preserve peatlands "as the world's largest terrestrial organic carbon stock and to prevent it from being emitted into the atmosphere". Rewilding Britain has outlined the broader issue of restoring wetlands, in their many different forms [102], and Rewilding Earth have provided a concise guide to accomplishing this [103].

To mark World Wetlands Day (2 February 2025), the Global Rewilding Alliance, along with ten partner organisations, launched a report, "Taking Animals into Account", which, based on 11 case studies, demonstrates the vital role played by wild animals in keeping the world's wetlands functional and resilient**.** Evidence is presented that the reintroduction and protection of key wild animal species could be a "game changer" in regard to addressing climate change, biodiversity loss, invasive species control, and water security challenges [104].

Harvey and Henshaw have examined rewilding in the context of the hydrological changes it might deliver, through reducing land management, natural vegetation regeneration, species (re)introductions, and changes to river networks. This involves major changes to above- and below-ground vegetation structure (and hence interception, evapotranspiration, infiltration, and hydraulic roughness), soil hydrological properties, and the biophysical structure of river channels [105]. Harvey et al. have investigated this further, in terms of using rewilding to mitigate hydrological extremes, e.g., floods and droughts, and offer aims for future research: capture effects on both high and low flow extremes for a given type of change; to analyze both magnitude and timing characteristics of flow extremes; and examine temporal trajectories (before and after data), ideally using a full before-after-control-impact design [106].

Rewilding Europe has showcased a number of projects involving the rewilding of rivers across Europe and the areas around them. By creating healthy, free-flowing rivers that are well-connected with the surrounding landscapes, a wide range of habitats for wildlife species are developed, including enlarged grazing areas, and allowing the river to perform its natural function as a buffer. Such "waterscapes" help to purify water and lessen flooding downstream during periods of heavy rainfall; they are also more resilient to the effects of climate change [107].

Rights of Nature (RoN) refers to a legal framework which aims to promote and assert natural rights and move towards a system where nature is valued and protected for its own sake and not for the value it provides to humans. Kings College London has offered the following, fuller definition: "RoN prioritises the intrinsic rights of nature and the undeniable inter-connection between the human and natural world. RoN rejects a "human-centric" (or anthropocentric) approach in which law treats nature as property and conceptualises the world in terms of property rights. Instead, the RoN movement aims to promote and assert natural rights and move towards a system where nature is valued and protected for its own sake, not for the value it provides to humans. In other legal systems, such as those of indigenous persons, the RoN approach is used to protect natural entities such as rivers and forests, and around the globe, new laws and constitutions which recognise RoN are gradually being introduced. Alongside this shift, RoN lawyers and activists are also re-imagining existing laws through a RoN lens." To assist with the latter efforts, the college has produced a "legal toolkit" for the protection of rivers in England and Wales [108].

8.4. Wildfires

Although the frequency and intensity of fires have multifold effects on climate, their net effect remains uncertain [85]. Nonetheless, fires are significant sources of greenhouse gas emissions, and their smoke can alter the Earth's albedo (ability to reflect sunlight into outer space). Wildfires may be increasing in areas more prone to droughts due to climate change [109], the incidence of which can be reduced using trophic rewilding. Since they consume large amounts of potential fuel, large grazers are the most effective. Grazing and browsing are thought to reduce the risk of wildfires: for example, the loss of wildebeest from the Serengeti led to an increase in grass, due to lack of grazing, which led to more frequent and intense fires, and caused the grassland to convert from a carbon sink to a carbon source. When the wildebeest population was restored through disease management practices, the Serengeti became a carbon sink once more [91].

A new study shows that holistic landscape management, with rewilding playing a key role, may be effective in preventing large wildfires (>1 km^2) in Mediterranean regions [110]. Along with other parts of the world, the UK has seen record outbreaks of wildfires in recent years. However, there is increasing evidence that healthier, more diverse ecosystems—including those with a variety of vegetation, wetland habitats, key species of wildlife, and healthy water-retaining soils—are more resilient against extreme weather events, including wildfires [111].

9. Rewilding Landscapes at Scale

It has been argued [112] that, "*The pursuit of wilderness has been abandoned in favor of wildness, vindicated by the so-called 'rewilding philosophy'. Rewilding does not pursue wilderness, no longer possible in the hybrid Anthropocene, but aims to restore the spontaneous order of the wildness*". Thus, as we have seen, humans are essential agents in the rewilded landscape.

Winning the Earthshot Prize in 2024, the Altyn Dala Conservation Initiative is working to restore Kazakhstan's steppe ecosystem. It has successfully brought the endangered Saiga antelope back from the brink of extinction. It is one of the largest rewilding projects in the world, covering an area of over 75 million hectares, roughly the size of Turkey [113]. An inverse relationship has been demonstrated between the degree of management intensity and size of the rewilding landscape, described as becoming "bigger, better, more joined up" as the landscape scale increases [6].

A conceptual framework—Spatial Planning of Rewilding Effort (Spore)—has been devised for the spatial optimisation of ecological function. This can improve the ecological outcome of rewilding by maximizing overlap between where the function is provided and where it is needed. It is proposed that Spore can be used to identify priority areas and produce relevant maps, thus actively engaging stakeholders in a collaborative effort to construct effective rewilding projects [114]. Dedicated to the late and esteemed Professor Dame Georgina Mace, and published by The Royal Society of London, is a policy document aimed to assess the best management of multifunctional landscapes, by means of an overarching decision-making framework within which potentially competing commitments can be reconciled against one another [115].

Elsewhere, Perino et al. have offered a framework intended to guide researchers and managers in choosing rewilding actions. It applies to various rewilding approaches, ranging from passive to trophic rewilding, and aims to promote beneficial interactions between society and nature [5]. In this paper, the authors further propose that Rewilding can be broken down into 3 dimensions ("The 3 D's of Rewilding"), all of which build back stability: Diversity, Disturbance, and Dispersal.

The expansion of European protected areas through rewilding is addressed by Araujo and Alagador, who conclude that around 117 million hectares is suitable for rewilding, 70% of which is in cooler climates. They show that opportunities for passive rewilding are predominant in Scandinavia, Scotland, and Iberia, with active rewilding prospects being widely distributed across Europe. This is an important distinction and a reminder that rewilding is not *synonymous* with the reintroduction of wolves or other large carnivores. Similarly, the paper differentiates between rewilding and "land abandonment", which offers more limited advantages [116], while Wang et al., show that rewilding abandoned farmland has greater benefits than afforestation [117].

Rewilding Europe also note [118] that "*Rewilding can be the best option for land-use in cases of farmland abandonment in Europe and all over the world when the social structure of farming communities has been eroded and low-intensity farming is no longer socially or economically viable.*" du Toit and his coworkers have emphasised the differences between rewilding and restoring an ecologically degraded landscape [42] , along with policy implications of rewilding [119], while Ockendon et al. have presented the results of a process attempting to identify

100 questions which, if answered, would make a substantial difference to terrestrial and marine landscape restoration in Europe [120].

The Nature Restoration Regulation is an unprecedented EU law which came into force on 18 August 2024. This requires Member States jointly to restore at least 20% of the EU's land and sea areas by 2030. In addition, all ecosystems in need of restoration must be restored by 2050. The law sets specific, legally binding targets and obligations for nature restoration in terrestrial, marine, freshwater, and urban ecosystems [121], and Rewilding Europe has produced a practical guide to support policy makers and other stakeholders involved in drafting and developing the National Restoration Plans ("NRPs"), under this regulation [58].

The Iberian Highlands Rewilding Landscape has marked a major milestone, adding 850,000 hectares of land to help upscale rewilding efforts across Europe**.** It is Rewilding Europe's tenth landscape [122], with others identified here [123]. The Global Rewilding Alliance and OpenForests have officially launched a map of rewilding projects around the world: organizations have contributed stories, photos and videos for projects in 70 countries covering 1 million square kilometers (386,000 square miles), and the alliance's leaders say more will be added over time [124].

Assessing Rewilding Progress

Torres et al. have devised a novel approach for monitoring progress in rewilding, based on its particular ecological attributes. This is based on a bi-dimensional framework for assessing the recovery of processes and their natural dynamics through: (i) decreasing human forcing on ecological processes, and (ii) increasing ecological integrity of ecosystems, intended to broaden the scope of rewilding projects, facilitate sound decision-making, and connect the science and practice of rewilding [125]. Other workers have devised a "Site Rewilding Potential Score", which can identify and quantify areas with rewilding potential at a national scale [126].

The need for an evidence-led approach has been stressed to obtain better spatial planning for future rewilding. This would lead to a map of "appropriate" rewilding areas, based on landscape scale characteristics, national species and habitat priorities, and predicted future landscape changes. Importantly, these 'target' areas would also be sensitive to local social, economic and agricultural contexts [127]. A pioneering method for evaluating rewilding progress has been applied across seven of Rewilding Europe's operational areas. Positive impacts have been revealed at the site-level, but challenges to upscaling have also been identified [128].

10. Rewilding and Food Security

In a report by the WWF [129], it is posited that rewilding advocates have often not engaged appropriately with farmers and are perceived as "elite" outsiders who do not comprehend rural communities or environments. Media coverage has further driven this division, with the result that rewilding and farming are frequently regarded as conflicting with one another. The WWF has proposed that, rather than being seen as a simplistic binary choice between farming and rewilding, the latter should be considered as part of a broad spectrum of approaches to help nature recover. This spectrum incorporates different kinds of "nature-friendly" farming and more "traditional" conservation techniques, with rewilding-type approaches sitting more towards one end of the range. Thus, aspects of cost-effectiveness, landscape fragmentation and stakeholder opposition are all part of the integrated discussion [129].

Some commentators fear that leaving land to regenerate for nature will compromise food production in the UK and relocate our environmental footprint to other countries. Sustainable food production in the UK needs properly functioning nature—healthy soils, clean and plentiful water, and thriving insect populations, all of which are the foundation of successful farming. In 2021, the UK Government's Food Security Report [130] determined climate change and ecological breakdown to be the major challenges to food security. The report concludes that a more effective overall use of land is needed, including diets based more on plants and less on meat, along with reducing food waste [131].

Similarly, the Dimbleby Report ("National Food Strategy") concludes that [132], "*If we were to... increase productivity by 30% and reduce meat eating by 35%, we could produce the same amount of food from 40% less land. Both these scenarios free up enough land not just to achieve our climate goals but also to make space for nature, both in wilder areas and on our farms, without compromising our levels of food self-sufficiency*".

While record temperatures have been experienced during the past few years, it is predicted by the UK Met Office that, as compared to the UK's climate in 1990, by 2070, winters will be between 1 and 4.5 °C warmer, and up to 30% wetter. Summers will be between 1 and 6 °C warmer, and up to 60% drier, depending on the region, with hot summer days being between 4 and 7 °C warmer. This is likely to have significant effects on health and food production, and some crops may not fare well under hotter and dryer conditions, while excessive rainfall/flooding of fields is a further issue [133].

From an analysis of the impacts of climate change-driven abiotic stresses on crop productivity, Razzaq et al. have concluded that the overall loss in crop production may exceed US$170 billion year^{-1}, and seriously endanger global food security. It is argued that wild progenitors of modern crops had a greater stress tolerance, and that our overall paradigm of crop breeding needs to be changed, with a broader use of wild relatives as a major tool in improving resilience to climate change [134]. In a separate study, Hawkesford has emphasised the use of *de novo* domestication of under-utilized crops, wild relatives of crops, and ancestral germplasm, as a means to develop (climate change-) resistant and high-yielding new crops and varieties [135].

The implications of rewilding for agriculture are examined in a broader context by Fraanje and Garnett. They conclude that, where a large-scale implementation of rewilding occurs, the development of rural landscapes would be influenced significantly, but how exactly nature, agriculture and rural populations would be affected differs according to the particular major rewilding strategy employed in a given region [136].

Corson et al. propose that agricultural rewilding may provide a multifunctional approach for enabling livestock systems to respond to societal demands more effectively. They conclude that this potential to conserve and restore biodiversity should be explored, along with the benefits delivered to farmers by different kinds of agricultural rewilding and agroecology [137]. Gordon et al. have identified potential benefits of including domestic and semi-domestic livestock species in the rewilding portfolio. However, this calls for a re-conceptualisation of the characteristics of rewilding and/or rewilded landscapes, and also that some of the policy and regulation constraints imposed on feral/free-living livestock will need to be lifted [138].

In opposition to the view that crop production losses are inevitable when land is turned over to rewilding, Pywell et al. have shown that habitat creation in lower yielding areas increased yields in cropped areas of the fields, an effect that became more pronounced over a period of 6 years. It was also found that numbers of birds and insects increased during the process [139]. The introduction of flower strips and the seminatural habitat surrounding farms was found to increase the numbers of *Diaeretiella rapae*, and hence may provide a natural management strategy for the control of *Brevicoryne brassicae* densities in brassica crops [140].

Two practical guides are available, "How to rewild a field" [141], which stresses that due to human caused distortions of the landscape, just leaving the field to Nature will create a large broadleaf dominated area, rather than the desired natural mix of shrub, grass and woodland; it also mentions the "3 D's of Rewilding". The second document addresses the larger-scale challenge, "How to rewild a farm" [142].

Project Drawdown includes rewilding in the context of NCS aspects [143], but this is really a call to overhaul the global food system. They note that "the rewilding of agricultural lands could be a big win for climate and nature. But it first requires shrinking the overall footprint of the food system by cutting food waste, shifting away from wasteful diets, and phasing out crop-based biofuels".

11. Urban Rewilding

Rewilding can also be incorporated into urban environments, where the interconnectivity of smaller spaces over a larger overall city landscape is important, rather than merely isolated pockets of green space, whatever intrinsic value the latter may have. This may include creating habitat corridors with green roofs and walls, improving and extending green spaces, street tree planting, and biophilic design, thus delivering benefits not only to wildlife but also to people, with improvements to their physical and mental health [144]. It is expected that, by 2050, approximately 70% of the 10 billion expected human global inhabitants are likely to occupy urban areas [145]. This increase (by 20%) in urban populations will be accompanied by changes in land-cover, with a rapid enlargement of urban footprints and associated with a growth in agricultural land requirements [146].

Since the most extensive biodiversity losses are occurring in and around cityscapes [147,148], these are where actions might be most effectively taken. Initiatives for urban rewilding most likely involve more than the recovery of particular species and community engagement, and may further aim to restore complete historic assemblages of species that have been lost, as is often true with efforts to restore vegetation in city environments.

Notwithstanding the challenges of reintroducing fauna into cities, urban rewilding does offer a unique and, as yet, little explored opportunity to bring the natural environment to city dwellers [149]. It is thought that biodiversity decline on the global scale is caused by an increasing disconnection between humans and nature, which on the present course, is likely to increase. However, for meaningful community engagement to be part of any urban rewilding effort, the relevant urban green spaces must be safe and accessible, encouraging regular visitation and engagement, as well as being ecologically rich [149]. Implementing urban rewilding will most likely involve local authority engagement, and means for overcoming potential challenges and maximising opportunities for landscape-scale management have been considered [150].

As noted on the "How to Rewild" website, which offers a cornucopia of practical information, "Rewilding urban areas isn't something you do on a site by site basis—it needs to be holistic; taking into account habitats in the wider landscape." [151]. ZSL has published a comprehensive report, "Rewilding our Cities", which concludes that large-scale nature recovery in urban areas could buffer city dwellers against the worsening impacts of climate change (for example, flooding and heatwaves), while also helping to restore biodiversity. The report emphasises that private gardens; green spaces, belonging to councils, businesses and religious groups; and public spaces such as parks, urban waterways, estuaries and wetlands; as well as less obvious areas such as railways, are key locations where rewilding could be implemented at a large enough scale to make a significant difference [152].

On a more individual and community scale, it has been proposed that "gardens could be joined up to create wildlife corridors, because the biggest problem that many species face is habitat fragmentation. Gardens are generally very small, but if you get together with your neighbours and the people all along your street, then you could really make a contribution." [153]. Lehmann has given evidence for the opportunities and benefits of regreening and rewilding cities to strengthen their resilience against climate change, biodiversity loss, and major resource depletion [154]. Russo et al. have identified that rewilding can have substantial positive social-ecological impacts in urban areas. Thus, as adapted within urban contexts, new solutions may be found for societal challenges such as sustainability and food security. Aspects of concepts, pros and cons, scale, applicability, and particular examples are surveyed [155].

12. Rewilding in a Changing World

Svenning has proposed that rewilding should be central to the massive restoration efforts necessary to overcome the global biodiversity crisis and enlarge the capacity of the biosphere to mitigate climate change. Critical factors in achieving this include large areas being set aside for nature, the restoration of functional megafauna and other natural factors to promote biodiversity, synergy with major societal dynamics, and judicious socio-ecological implementation [80]. Thus, rewilding, as adapted systemically, can provide (part of) the solution(s) needed to resolve the systemic problem of the "climate and nature crisis", also described as being "one indivisible global health emergency." [156]. Svenning et al. have further considered introducing megafuana, which may promote vegetation heterogeneity, seed dispersal, nutrient cycling and biotic microhabitats. These are essential drivers of biodiversity and ecosystem function and, under increasingly novel ecological conditions, are likely to become increasingly important for maintaining a biodiverse biosphere [60]. The broad topic of "Rewilding and restoring nature in a changing world" has been given prominence in papers published in a special issue of PLoS ONE [157].

Neugarten et al. have determined that, by conserving around half of the global land area, 90% of the ten current contributions to humans from Nature could be achieved, along with minimum representation targets for 26,709 terrestrial vertebrate species. This aligns with recent commitments under the Global Biodiversity Framework to conserve at least 30% of global lands and waters, and proposals to conserve half of the Earth. However, since over one-third of those regions needed to provide Nature's contributions to humans and other species are also suitable for agriculture, renewable energy, oil and gas production, mining, or urban expansion, future collisions may occur between conservation, climate mitigation and development goals, especially as populations grow [158].

As a result of human impacts on the environment, unprecedented combinations of organisms are appearing, and while such novel ecosystems would often be thought of as "bad", from a restoration or conservation viewpoint, there are instances where they can provide benefits such as habitat for plants and animals that are threatened by habitat loss elsewhere. It is possible, then, that such novel ecosystems will need to be reconciled with traditional concepts of restoration/conservation [159]. It has been proposed that assisted colonisation on a massive scale will likely be necessary, not particularly to conserve threatened species, but to maintain functional forest ecosystems in the United Kingdom. The authors advance that conservationists must shift from largely attempting to prevent species extinctions to maintaining functioning ecosystems to facilitate the emergence of robust novel ecosystems, given the biotic changes that are now inevitable in a hotter world [160].

The importance of ecological complexity and emergent properties at multiple scales has been highlighted, particularly of individual ecosystems and across landscapes, regarding future restoration efforts. It is proposed that certain current restoration methods might be incorporated within a complexity approach, while also encompassing more novel concepts such as rewilding [161].

Gardner and Bullock have proposed that, in the climate emergency, conservation must become “Survival Ecology” [162]. Species and ecosystems are beginning to be subject to unprecedented conditions, which will likely undermine their continuing to exist in historical ranges; nonetheless, conservation remains largely directed towards returning species and ecosystems to a historical state, but where the deleterious impacts of humans are ameliorated. This approach reorients conservation efforts toward a future where humans and other species can coexist within a dynamic planetary system, acknowledging inevitable change, and actively shaping the world’s forward trajectory rather than solely focusing on preserving a static past. They further advance that, since conservation science and advocacy have been insufficient to bring about change on the scale necessary, survival ecologists should also embrace non-violent civil disobedience [162].

13. Marine Rewilding

The importance of the world’s oceans can hardly be overstated, covering as they do more than two-thirds of the Earth’s surface and representing about 95% of the planet’s biosphere [163]. They also help to stabilise the climate, by absorbing roughly 30% of anthropogenic (CO_2) emissions [164] and around 90% of the excess heat reined in by greenhouse gases [163]. The oceans are also an important source of animal protein for billions of people [163], and of associated livelihoods in “the blue economy” [163], along with providing critical wildlife habitat. While more species are assessed to exist on land than in the oceans, this is. Still, one measure of biodiversity, and in contrast, phylogenetic diversity, is reckoned to be higher in the oceans than on land [165].

Marine and coastal habitats are diverse, ranging from those neighbouring terrestrial environments, for example, estuaries, mangrove forests, coral reefs and seagrass beds; to those in the open ocean, including hydrothermal vents, seamounts and soft sediments on the ocean floor [166].

The oceans are a major stabilising element of the climate system [163], but are under threat from heating and acidification. Moreover, new evidence suggests that, with continued warming and CO_2 emissions, the ocean’s capacity to absorb increasing amounts of CO_2 could first stall and then actually reverse [167]. Further threats are from over-fishing (and unsustainable practices such as bottom trawling), coastal habitat destruction (especially of coral reefs and mangroves) and pollution, for example from river run-off, contaminated with industrial and agricultural waste [163].

Nonetheless, while terrestrial rewilding has gathered considerable traction and momentum, its marine counterpart is still at a comparatively nascent development stage, although similar overall principles may well apply in both cases [168]. From a systematic review of the literature, a broad definition of marine rewilding is proposed (given that a growing number of ocean initiatives accord with its general ethos) along with a set of operating principles that can be applied to given regions or cultures, aiming to promote marine rewilding within more established conservation policy and practice [168]. Cornerier has further examined the concept of marine rewilding with reference to a collection of major marine rewilding initiatives (MRIs) around the world. She emphasises the limitations of technical and scientific tools, the need to bring such rewilding projects into the social and political arenas, and concludes that the implementation of MRIs may spark environmental controversies around the multiple uses of the sea [169]. Rewilding Britain has given some practical coverage to marine rewilding and its importance, with five representative projects described [170].

The protection of 30% of the world’s oceans will be a common goal for all those countries party to the “Kunming-Montreal Global Biodiversity Framework” adopted during the 15th meeting of the Conference of the Parties of the Convention on Biodiversity (CBD) in December 2022, over the next decade. Accordingly, a plan to reach the “30 by 30” targets is proposed, based on the distribution of over 150 types of marine species, habitats, ecosystems, and abiotic elements, and the marine protection priority levels of coastal, near-shore, open ocean, and deep ocean trench areas [171]. To overcome some of the financial barriers for some countries in signing up to the 30×30 agreement, an approach is proposed, based on the context of marine habitats contained by nations’ exclusive economic zones (EEZs), to reduce the costs to all nations [172].

The most comprehensive assessment has been made, to date, to determine those ocean areas that, if strongly protected, would most contribute to a more abundant supply of healthy seafood and provide a cheap, natural solution to address climate change, in addition to protecting “embattled” species and habitats. It is further concluded that targeting these areas would protect almost 80% of marine species, add over 8 million tonnes of fish to global catches, and prevent the release of more than one billion tonnes of CO_2 by protecting the seafloor from the widespread yet highly destructive fishing practice of bottom trawling [173]. However, from another study, it is concluded that, to bridge the gap between the current 8% of the global ocean that has some Degree of protection (only 3% being highly protected) and the 30% needed, will require the establishment of another 190,000 small marine protected areas (MPAs) (in coastal regions, alone), and an additional 300 large MPAs (in remote, offshore areas), by the end of 2030 [174].

14. Rewilding and Human Ecological Overshoot (Aspects of the Broader Canvas)

As we have seen, rewilding can help Nature to regenerate and act to mitigate biodiversity loss and climate change. However, these are but symptoms of the wider underlying issue of human ecological overshoot, as noted by Ripple et al. [175].

The tendency to focus on carbon emissions, with renewable energy as its antidote, misses much of the broader canvas of threats impinging on nature and society. It has accordingly been termed "Carbon Tunnel Vision" [176]. Undoubtedly, to rapidly ameliorate increasing atmospheric CO_2 (plus other greenhouse gases) concentrations is essential and critical [175], since they are causing ocean acidification, elevating air and ocean temperatures, melting of ice sheets, glaciers, and sea ice, rising sea-levels, and are interrelated with biodiversity loss [11].

In addition [175], we see collapsing fisheries and coral reefs, deforestation and habitat loss, the draining of fossil aquifers, rivers and lakes, soil erosion, desertification, massive species displacement and extermination, insect die-off, resource depletion, pollution of air, land and water—e.g., by microplastics and "forever chemicals"—all being driven by an unsustainable consumption of 100 billion tonnes of "natural resources" each year, thought to reach up to 184 billion tonnes in 2050 [177]. Hence, even if we could switch our energy from fossil fuels to "net-zero" emissions, current consumption by human enterprises would continue to exceed and degrade the Earth's biocapacity. Rees has proposed that, on our present course, a "population correction is inevitable" [178]. None of those listed above is a single, isolated problem, but components of a complex web of societal and biophysical processes, defined by a set of planetary boundaries, 6 out of 9 now exceeded [179]. Hence, globally, the overarching collective solution is to reduce current hyperconsumption, for which a set of actions and timescales has been proposed [77].

The Global Footprint Network [180] concludes that human enterprises use 1.78 "Earths" worth of resources (2024 data). In other words, we are liquidating "natural capital" 78% faster than the Earth can renew it—treating it as "income", the dangers of which E.F.Schumacher warned about in his iconic book, "Small is Beautiful", published in 1973 [181]. Hence, it is necessary to reduce global consumption by around 44%, although the reductions needed would vary considerably around the world, being greatest in the wealthiest nations (up to 80%). Merz et al. have identified that the root of human ecological overshoot lies in a behavioural crisis, driven mainly by advertising. However, those same mechanisms may also provide means for healing the malady [12].

Although it is not a "cure" for the condition, the potential of rewilding (as part of an NCS approach) to restore and regenerate ecosystems can play a significant role in addressing ecological overshoot in the following ways:

- Restoring Ecosystem Services: Rewilding can bring back key species, repair damaged ecosystems, and restore natural processes that provide essential services like clean air and water, flood and fire prevention, soil health, pollination and carbon sequestration.
- Increasing Biodiversity: By reintroducing native species and allowing natural processes to shape ecosystems, rewilding can increase biodiversity and resilience, leading to more stable and productive ecosystems. Healthy, diverse ecosystems are more resilient to climate change and human disturbance, and provide long-term ecological stability.
- Reducing Reliance on Human Management: Rewilding allows Nature to take care of itself, reducing the need for human interventions and resource extraction, which can strain ecosystems. Rewilding helps to reestablish natural predator-prey relationships and nutrient cycling, reducing the need for human intervention (e.g., pesticides, irrigation).
- Enhancing Carbon Sequestration: Rewilding projects, particularly those involving proforestation/reforestation, peatland, grassland and wetland restoration, which act as significant carbon sinks, can help mitigate climate change.
- Promoting Sustainability: Rewilding can foster a more sustainable relationship between humans and Nature by demonstrating the value of healthy ecosystems and the importance of responsible resource management.
- Addressing the Behavioural Crisis: Rewilding can also play a role in addressing the behavioural crisis [12] that drives overshoot by fostering a greater appreciation for nature and promoting more sustainable consumption patterns. It has also been proposed that rewilding can enable humans to expand our consciousness [182], and better comprehend the limits to growth [183].

Rewilding as Part of a Larger Solution

To help get below ecological overshoot, rewilding (and other NCS) must be part of an integrated approach that includes the following strategies:

- Energy transition—Cut fossil fuel use (and emissions) by moving more to renewables and reducing (minimising) total energy demand.
- Degrowth/post-growth economics—Redefine progress and prosperity.
- Circular economy—Reduce waste and resource extraction.
- Behavioural/cultural change—Shift values from consumption to stewardship.
- Relocalisation—Change from global dependency to local resilience.
- Population—Amend the culture of pronatalism to bring human numbers back within planetary limits.
- Policy—Land use, subsidies, and regulations must support regeneration over exploitation.

15. Conclusions

The term "rewilding" often elicits strong emotions, especially as presented in the media. Thus, anger is provoked that farmers will be forced to waste precious cropland, letting it return to the wild, or from fear that dangerous animals will be released into the urban environment. With equal fervour, others, taking an approving view, comprise the growing movement of guerrilla rewilders, secretly breeding butterflies, birds and beavers, and illegally releasing them (e.g., "beaver bombing") across the countryside.

In truth, rewilding is a complex and widely encompassing proposition, which can be considered as a strategy within the natural climate solutions (NCS) [nature based solutions (NBS)] approach, aimed to restore and enhance wetlands, grasslands, forests, agricultural lands, seascapes *etc.* While exact definitions may vary, a key feature is that (after some initial support) it minimises the level of human intervention/management in a given region, *instead encouraging natural processes to take the lead and self-manage*, in the restoration, shaping and enhancement of natural ecosystems and of critical ecosystem functions. The resilience of such ecosystems should also be considered, especially in regard to how the impacts of a changing climate may prevail upon them.

Rewilding is informed by science, traditional ecological knowledge (TEK), and other local (indigenous) knowledge. It is a long-term process with dynamic changes occurring over time, and rather than focussing on reaching a fixed endpoint, provides a continuous journey of letting nature's processes unfold. This can lead to increased biodiversity, amelioration of and resistance to climate change, and the provision of ecosystem services, benefitting both nature and people, including economic opportunities for local and indigenous communities, along with improved overall health and well-being.

Despite its manifold and clear benefits, rewilding (along with other NCS) is not a panacea for all our troubles, many of which are rooted in the systemic issue of human ecological overshoot, and it is this that must be addressed to begin fixing the current global polycrisis [184].

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