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Halting and restoring species loss: incorporating the concepts of extinction debt, ecological trap and dark diversity into conservation and restoration law

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\textbf{ABSTRACT}

Although there are many conservation and restoration obligations and targets, implementation thereof has so far been insufficient to halt or slow down biodiversity loss. In this context, efforts for ecological restoration must be accelerated. In fulfilling legal obligations and policy targets on restoration, it is important for lawyers and policy makers to understand the underlying ecological concepts. In this article three concepts, that are largely unknown in legal literature, are clarified, namely extinction debt, ecological trap and dark diversity. Their implications for law and policy are analysed and recommendations are made for better integration of these concepts into restoration projects. We recommend more efforts for monitoring beyond the simple presence of certain species, a higher ambition level for restoration measures, a substantial increase in measures for connectivity and restoration measures for ‘absent’ species.

1. Introduction

In light of the deplorable state of many species and their habitats worldwide, conserving remaining nature in its current status will not be sufficient to reverse biodiversity loss. Ecological restoration is becoming recognised as essential to tackle the biodiversity crisis.\textsuperscript{1} This form of restoration seeks the ‘highest and best effort’ towards full recovery of an ecosystem.\textsuperscript{2} Restoration obligations can be found in international conventions, regional laws and national laws,\textsuperscript{3} as well as in international soft law targets.\textsuperscript{4} These obligations and targets however are far from being met, in spite of some restoration measures being taken worldwide.\textsuperscript{5} This is caused by a lack of implementation of restoration obligations, as well as a lack of ambitiousness in restoration measures taken. This lack of ambition can partly be explained by a lack of political will, lack of finances, lack of project staff and

\textsuperscript{1}See, for example, Hobbs and Harris (2001); Aronson and Alexander (2013).

\textsuperscript{2}McDonald et al (2016), p 19.

\textsuperscript{3}See Telesetsky et al (2017).

\textsuperscript{4}See, for example, Aichi Target 15, CBD (2010) COP 10 Decision X/2, Strategic Plan for Biodiversity 2011–2020.

conflicts with stakeholders. But it can also be explained by a lack of understanding of the ecological complexities that form the basis of taking restoration measures. In particular, as a consequence of the delayed effects of detrimental human activities and the ensuing ecological changes, it might (wrongly) seem that conservation and restoration obligations and targets are fulfilled, creating a false sense of security. In reality, the conservation status might be far worse off and thus more restoration measures are justified. For instance, focal species that are still present in a certain area can lead to the false impression that the conservation measures that were taken are sufficient. However, it could be that the presence of these species is not sustainable and additional restoration measures are required.

In order to better understand and implement the restoration obligations under nature conservation laws, it seems indispensable that lawyers, judges and policy makers should be aware of certain ecological concepts that are important for ecological restoration. Cooperation between lawyers and restoration ecologists is seen by Telesetsky and others as a fundamental precondition for future development and implementation of international restoration law. At a more general level, for many environmental issues, collaborative research between lawyers and ecologists is rather scarce and in many environmental laws explicit or concrete reference to scientific methods is lacking. A closer cooperation between these disciplines is essential to bolster application of nature conservation laws. According to Freyfogle, lawmakers could use ecology to refine existing laws so that they are more effective in achieving current goals. Although we advocate for a science-based law and policy, we acknowledge the importance of public participation, lay knowledge and experience based-expertise. Restoration projects will thus not only depend on their biological feasibility, but also their social acceptability and financial feasibility.

This article attempts to bridge the gap between different disciplines by explaining several ecological concepts that are relevant for ecological restoration, and providing recommendations to include these concepts in the implementation of nature conservation and restoration law. By taking into account these ecological concepts and the attendant policy recommendations, a more effective implementation of restoration obligations will be achieved.

Three ecological concepts will be discussed, namely extinction debt, ecological trap and dark diversity. Although ecologically highly relevant, they are highly neglected or even absent in regulations and in legal literature. We have opted for the discussion of these three concepts, because they all relate to the extinction of species and they contribute to our knowledge about underlying processes that can lead to species extinction. These concepts are in particular relevant to counter misconceptions about how species extinction takes place.

In this article we examine possible solutions for the better implementation of ecological restoration obligations in light of these ecological concepts. We will first examine whether

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6See also Cortina-Segarra et al (2016).
8See, for example, Epstein et al (2016); Trouwborst et al (2016).
10Freyfogle (2006).
11See, for example, on this issue Gross (2006); Higgs (2005); Richardson and Lefroy (2016).
12See Richardson and Lefroy (2016).
these concepts are explicitly mentioned in any laws. Furthermore we will focus on four aspects that are crucial for the implementation of these concepts in restoration: the need for monitoring; the ambition level of restoration measures; the need for connectivity measures; and the need to restore areas for ‘absent’ species. Although these ecological concepts should also play a role in impact assessments of projects and plans on habitats and species, we will not deal with this aspect, as this could be the focus of an entire article in itself. Another issue the article will not explore is the situation where certain environments have changed to such an extent that these changes are irreversible and that restoration to a previous historical trajectory is impossible. Instead, this article considers ecological concepts that should be taken into account when implementing restoration standards and obligations, in situations where restoration is still biologically feasible.

The geographical focus of this article is restoration of terrestrial ecosystems, though some of the concepts and their implementation are likely to also be applicable to marine environments. Although there have apparently been fewer marine extinctions so far, compared to terrestrial extinctions, many small marine populations that have an already precarious existence, such as coral reefs, face the risk of extinction because of global warming. This could constitute evidence of an extinction debt. Loss of species in marine environments appears to be increasing rapidly. Also the concept of an ecological trap seems to apply to marine species, such as manatees and sea turtles.

In regard to the research methods of this article, it combines insights from ecological science with a legal analysis. The legal analysis focuses on international and European Union (EU) nature conservation law. The international perspective is mostly limited to the Convention on Biodiversity (CBD), as one of the major global nature conservation treaties. We studied the Convention and subsequent documents including decisions by the Conference of Parties (COP) and technical reports under the CBD. Although these documents are legally non-binding, they clarify and interpret the legal obligations of the convention text and point to the political commitments taken pursuant to it. At the regional level, we assessed the EU Habitats Directive, as one of the core EU nature conservation instruments. The focus on the CBD at the international level, and the EU at the regional level, is prompted by the fact that at both levels concrete targets have been set for ecological restoration. The specific character of the EU, as a supranational organisation, with binding legislation and binding enforcement mechanisms is particularly of interest, as much more concrete guidelines and case law are available than at the international level. Next to the legally binding provisions in the Directive itself, additional information is found in guidelines and other documents from the European Commission, which although legally non-binding, are normatively persuasive. Also some cases by the European Court of Justice clarify the legally binding obligations on ecological restoration in the EU. We did not analyse other international, regional or national legal instruments on restoration. Additional insights were gained in documents from relevant non-

13See Richardson (2016).
14Briggs (2011); see also Mora and Sale (2011).
governmental organisations, such as the Society for Ecological Restoration’s (SER) global standards on restoration.

2. Ecological concepts

The ecological concepts, extinction debt, ecological trap and dark diversity need to be further clarified in order to fully grasp the legal obligations they can engender.

2.1. Extinction debt

The concept of ‘extinction debt’ refers to the often substantial time delay between the impact of environmental changes and pressures on a habitat-specialist species and the moment the species goes extinct.19 According to Kuussari and others, extinction debt is a highly relevant but so far neglected aspect of the impact of global change on biodiversity.20 Accumulating evidence suggests that such extinction debts pose a significant but often unrecognised challenge for biodiversity conservation across a wide range of taxa and ecosystems.21

Species suffering from extinction debt are sometimes called ‘the walking dead’. Extinction debts can arise because (1) individuals of a species with a long generation time may survive long after the habitat quality change; (2) populations may have become so small that stochastic catastrophic events sooner or later make them surpass their extinction threshold; and (3) metapopulations may survive long after that connectivity has decreased if colonisation-extinctions dynamics are slow.22 Especially in highly fragmented landscapes, as occurs in much of Western Europe, there are many relict-species that risk an extinction debt.23

In order to avoid ultimate extinctions and the gradual decrease of species richness of a focal habitat or area it is crucial that nature conservation laws and policies fully recognise the extinction debt concept and its causes. It is not sufficient to simply record that a focal species is still present in an area, it is also necessary to monitor its population size over time and assess the risk for extinction on the long term and its causes. Upscaling of such assessments for the whole community of specialist species of a particular habitat or area is essential to avoid biodiversity loss. In practice, we therefore recommend more attention for:

(1) restoring or maximising the habitat size after successive habitat loss;
(2) restoring the habitat quality (i.e. reduction of environmental pressures from the surroundings, appropriate management to ensure diversity in habitat structure, presence of transition zones between habitats and mosaics of different habitats (because many species depend on different habitat types or habitat structures to complete their life cycle), presence of sufficient food sources for focal species);
(3) restoring connectivity between fragmented areas to enable proper metapopulations functioning with sufficient genetic variation, also taking into account possible increased vulnerability for harmful effects of alien invasive species or predation.

22Hylander and Ehrlén (2013).
23See on this aspect, for example, Krauss et al (2010).
It is crucial that when applying the above-mentioned measures, the element of time delay in measures to tackle biodiversity loss is taken into account. The urgency to take additional measures for effects that are currently not visible is challenging as legal processes for taking nature conservation and restoration measures are usually time-consuming. By the time that environmental reporting, which is commonly a periodic requirement, shows the extinction risk, and by the time that additional conservation or restoration measures are taken, it might be too late to save the species from extinction.

2.2. Ecological trap

The ‘ecological trap’ concept refers to the presence of poor quality habitats that reduce or make it impossible for a species to successfully reproduce and build a sustainable population. Although the area can be colonised by a habitat specialist species, the area acts as a ‘sink’ for the species population and not as a ‘source’. This may affect the size and the functioning of the regional metapopulation as a whole. The concept is linked to the extinction debt concept in the sense that the presence of a trap in a landscape will gradually drive a local population to extinction. A well-known example is meadow birds breeding in agricultural fields where the nests are destroyed by the mowing activities of the farmer. When the reproduction has successively failed over several years and the parent birds have died, the local population goes extinct. Offspring of animals from neighbouring areas may colonise these unsuitable agricultural fields, in the end risking the extinction of metapopulations if the causes for reproduction failure are widespread. Another example is roadside habitat strips, which contain useful remnant vegetation but lead to high mortality of resident wildlife hit by passing motor vehicles or because of the absence of sufficient food sources. Traps may be relatively common in rapidly changing landscapes. Common approaches for population modelling may introduce faulty assumptions that mask the effects of ecological traps and lead to overly optimistic predictions about population persistence. It is important that more attention is paid to ecological traps.

The lesson for conservation laws and policies is that it is not sufficient to simply record the presence of focal species in an area. In order to be able to anticipate the presence of ecological traps, we must have knowledge of the reproductive success of the focal species or a set of specialist species from a focal habitat. It is important to notice that ecological traps may also occur in areas where ecological restoration measures have been taken but without restoring all necessary conditions for successful reproduction.

2.3. Dark diversity

The ‘dark diversity’ concept refers to the absent portion of a habitat-specific species pool for a given reference habitat in a given region. The absence may be the result of direct extinction after habitat loss, severe degradation of habitat quality or specific human

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activities. Over the long term, species suffering from extinction debt and ecological traps will lead to an increase of dark diversity for an affected area.

The concept is also valid in the case of ecological restoration of degraded habitats, where habitat-specific species are unable to recolonise the area. The latter phenomenon is also known as the ‘recovery debt’ in restoration projects. This can be caused by a lack of connectivity between restored sites and other similar sites in the neighbourhood to allow proper metapopulation functioning. The term ‘metapopulation’ refers to spatially separated populations of the same species which more or less interact with each other. Habitat patches of good quality may be permanently occupied by a species (and have the potential to act as a ‘source population’ for species dispersal), while other habitat patches are less suitable for a species and may be occupied only temporarily (and act as a ‘sink’). Connectivity, habitat quality, dispersal capacity and stochastic events (e.g. climatological fluctuations) determine metapopulation dynamics. In completely isolated habitat patches of suboptimal quality a population may suffer from an extinction debt when recolonisation of the habitat is no longer possible.

The concept of dark diversity should play a more prominent role in nature conservation laws and policies. By identifying the dark diversity and its causes of a specific habitat or site appropriate measures can be implemented to reduce dark diversity. The concept is especially relevant when species that play a key role in the proper functioning of the habitat are absent (e.g. predator species, ecosystem engineers). There is evidence that the presence of more complete species communities in a given area is crucial for ecosystem stability and resilience. Dark diversity can thus be used to complement conservation prioritisation and management decisions. The concept also allows for better assessment of the restoration potential of degraded habitats.

3. Extinction debt, ecological trap and dark diversity in international and EU law

The aforementioned concepts show that ecological knowledge and insights are very important as guidance for implementing restoration obligations. The concepts as such are largely unknown in legal literature and regulations. Neither important international conventions, such as the CBD, nor regional instruments such as the EU Habitats Directive, explicitly refer to these concepts in their primary legal texts. However, in ancillary documents to these instruments, reference to some of these concepts can occasionally be found. For instance, ‘extinction debt’ is mentioned in a recent CBD COP Decision of December 2016 on the Convention’s financial mechanism. The COP Decision lists the ‘Priority Clusters’, one of which is to mainstream biodiversity across sectors as well as landscapes and seascapes, and in particular Priority B is to ‘Manage biodiversity in landscapes and seascapes’. The expected Outcome 4 of this priority is:

Loss, fragmentation, and degradation of significant natural habitats, and associated extinction debt, is reduced, halted or reversed, and conservation status of known threatened species is

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improved and sustained, including through monitoring, spatial planning, incentives, restoration, and strategic establishment of protected areas and other measures.32

As these concepts are mostly absent in legal instruments, the question is whether they implicitly allow for their implementation. A similar question has been posed regarding climate change. Most international nature conservation laws do not explicitly mention climate change or adaptation to climate change. That doesn’t mean that these instruments are unable to adapt biodiversity to the effects of climate change. Implicitly, the measures included in the legal instruments are broad enough to extend them also to the challenges of climate change. Legal research has examined if international nature conservation and restoration law33 and the EU Habitats Directive34 can deal with the effects of climate change. Overall, the conclusion of this research is that these instruments can indeed be used to cope with climate change, or in other words, are ‘climate proof’ as Arie Trouwborst concluded in his analysis of the Habitats Directive.35 However, the absence of explicit recognition of ecological concepts in key legal instruments can reduce the political will to take action and reduce legal accountability.

Implicitly, also the precautionary principle can play an important role in the application of the ecological concepts acknowledged in this article. The precautionary principle can be invoked to avoid extinction, even when there is a lack of full scientific certainty that there is an extinction debt and that species will disappear. The precautionary principle can also be applied when species have gone locally extinct, to take restoration measures for enabling the species to return.

The precautionary principle is probably the most important environmental law principle available for use in restoration.36 In the framework of the CBD, the precautionary approach is linked to adaptive management37: this allows for responses to evolve in light of new knowledge and changed circumstances. This can include monitoring the risk of extinction debt and ecological traps and adapting the conservation and restoration measures to this new knowledge.

4. Discussion and recommendations

In order to identify whether international and EU nature conservation law are capable of dealing with the ecological concepts of extinction debt, ecological trap and dark diversity, we see the following aspects as crucial: (1) adequate monitoring; (2) high ambition level of restoration site-specific objectives and measures; (3) measures for connectivity and (4) measures for ‘absent’ species. In the following sections we discuss if law allows or obliges these four types of measures. We distinguish two phases.

A first phase relates to the situation that (focal) species are still present in a certain area, but might face (local) extinction. In this phase, adequate monitoring is crucial in order to assess if there is a risk for an extinction debt or ecological trap condition. If so, then two

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32Emphasis added.
34Trouwborst (2015).
35Trouwborst (2015).
types of measures are required to prevent extinction: (1) a sufficiently high ambition level for pro-active restoration in terms of the size and quality of the habitat; and (2) measures to improve habitat connectivity to the extent that proper metapopulation functioning is achieved in a sustainable way.

In a second phase, habitat-specific species have already become locally extinct (dark diversity). Thus, measures are required for resettlement of extinct focal species in order to restore more complete species assemblage and ecosystem integrity. This will again require a sufficient ambition level for restoration of habitat size, quality and connectivity. Re-introduction of species may also be a valid measure. If they have successfully returned, monitoring is required to assess the risk for an extinction debt or ecological trap situation.

The following table summarises the three concepts in their relation to the recommended measures. In the next section we will discuss the legal possibilities for these recommended measures.
4.1. Measures to prevent extinction debt and ecological traps

4.1.1. Monitoring

The global changes we are facing and their effects on biodiversity require unprecedented levels of research effort.\footnote{Jackson and Sax (2010).} Monitoring and data collecting is of crucial importance. However, we should be aware that data collecting as such is not enough and it will on its own not stop further biodiversity loss.\footnote{Ellison (2016).} It is equally important that monitoring is included in an adaptive management process. If monitoring shows that restoration has been inadequate, additional conservation and restoration measures should be taken.

Monitoring should focus on the early detection of the occurrence of an extinction debt or ecological trap condition for habitat-specific species. Monitoring should thus go beyond a simple ‘ticking the box’ (‘species X is present in area Y, so the legal obligations are fulfilled’) and specifically look at issues such as population dynamics and reproduction success, both in conservation and restoration areas. Special attention should go to ‘umbrella species’ as indicators for the integrity of the ecosystem and the local pool of habitat-specific species.\footnote{See on the usefulness of umbrella species, Roberge and Angelstam (2004).}

Most international and regional conservation laws include the obligation for environmental monitoring (see e.g. Article 7 of the CBD; Article 11 of the Habitats Directive). In spite of this general legal basis, there is limited assessment of extinction debt, especially on larger scales (national, regional or global). Red lists of threatened species at national or global scale might thus be too optimistic. Evidence for extinction debt at these larger spatial scales has not yet been examined for a broad range of taxa. However, many conservation policies are developed and implemented at the larger spatial scales. Assessing extinction debt at these larger scales would appear to be a crucial step.\footnote{Dullinger et al (2013), p 7342.}

There is also a need to monitor specific restoration projects. In the CBD short-term action plan on ecosystem restoration,\footnote{CBD (2016) Decision XIII/5. Ecosystem restoration: short term-action plan.} monitoring is seen as one of the key actions in the action plan.\footnote{CBD (2016) Decision XIII/5, Annex, para 11.} Ecosystem restoration plans should include a plan for monitoring project implementation and efficacy.\footnote{CBD (2016) Decision XIII/5, Annex, paras 15, 3.} Monitoring should begin during the earliest phases of restoration planning, in order to measure the ecosystem conditions against a reference model. Subsequently, monitoring is also required once a restoration project is being implemented: the action plan considers the following possible actions:

1. Assess the efficacy and effects of implementing the ecosystem restoration plan, including the success of ecosystem restoration activities.
2. Adjust plans, expectations, procedures, and monitoring through adaptive management based on monitoring results and lessons learned and promote continuity beyond the project end.\footnote{CBD (2016) Decision XIII/5, Annex, paras 16, 1–2.}
Also relevant are the recently adapted international standards for ecological restoration\textsuperscript{46} from the SER. Monitoring the responses of an ecosystem to restoration actions is essential to identify whether the actions are working or need to be modified, as well as to answer specific questions, such as to evaluate which organisms or processes are returning to the ecosystem or not.\textsuperscript{47}

At the EU level, a study commissioned by the European Commission, recommended the assessment of the extinction debt. According to the study, biodiversity in the EU is threatened by an unforeseen extent because of extinction debt in habitats. Seminatural habitats in particular have been destroyed over the last 50–100 years throughout Europe. The study indicates that an extinction debt must be expected particularly for long living species such as perennial plants. These species react slowly but will go extinct in the future if no counteractions are started immediately. Importantly, such losses would also negatively affect many associated shortliving animals in the future. The study recommended that an early assessment of extinction debt in all habitats that have been perturbed within the last decades should be performed, with urgent restoration of these habitats to prevent future species loss due to extinction debt.\textsuperscript{48}

Although monitoring of extinction debts and ecological traps is not explicitly included in the EU Habitats Directive, the monitoring obligations under the Directive provide possibilities to take this into account. The Habitats Directive requires in Article 11 a periodic assessment of the species and habitat types to see if they are at a favourable conservation status. Based on their monitoring obligations, Member States must report every six years on the implementation of the measures taken under the Habitats Directive (Article 17). This report shall include in particular information concerning the conservation status referred to in Article 6(1) as well as evaluation of the impact of those measures on the conservation status of the natural habitat types of Annex I and the species in Annex II and the main results of the surveillance of the conservation status of EU protected habitats and species. There is a reporting format\textsuperscript{49} and explanatory notes and guidelines\textsuperscript{50} for reporting. A reporting format with three classes of Conservation Status has been adopted: Favourable, Unfavourable-Inadequate and Unfavourable-Bad. ‘Unfavourable-Bad’ denotes habitats or species in serious danger of becoming extinct (at least regionally).\textsuperscript{51} The matrix on the assessment of the conservation status of a species in the ‘Unfavourable – Bad’ category states that in regard to its ‘future prospects’ (population, range and habitat availability), it faces: ‘[s]evere influence of pressures and threats to the species; very bad prospects for its future, long-term viability at risk’.\textsuperscript{52} Although this does not explicitly include ‘extinction debt’ or ‘ecological trap’, the reporting can certainly include this. In practice, monitoring under the Habitats Directive might still fail to detect extinction debt: the monitoring is limited to the habitats mentioned in Annex I and species of Annex II, IV and V of the Habitats Directive, which is only a fraction of habitats and species present in Europe.

\textsuperscript{46}McDonald et al (2016).
\textsuperscript{47}McDonald et al (2016), p 16.
\textsuperscript{48}Lundberg and Bommarco (2009).
\textsuperscript{50}Evans and Arvela (2011).
\textsuperscript{51}Evans and Arvela (2011), p 8.
\textsuperscript{52}Assessment and reporting under Article 17 of the Habitats Directive. Reporting Formats for the period 2007–12 (May 2011), 11.
Furthermore, the assessment of Annex I habitats is mainly focussed on the presence of certain plant species, but often omits to look at the habitat-specific fauna. Yet those species are often most susceptible to habitat loss and degradation, and loss of connectivity. We therefore recommend that the European Commission develop more concrete guidelines on monitoring, in which these aspects are also taken into account.

In sum, although general monitoring obligations exist in international and EU nature conservation law, they do not explicitly require that monitoring take into account the ecological concepts discussed in our article. On the other hand, the legal instruments do not exclude these concepts either. Monitoring should go beyond a perfunctory ‘ticking the box’ approach that only assesses whether certain species are present. Not taking into account extinction debts and ecological traps could well underestimate the state of conservation, as delayed effects are not adequately addressed. Also important is that monitoring should be a continuous activity and part of adaptive management, strengthening the ambition level of restoration measures if monitoring shows that current measures are inadequate. More concrete government guidelines on monitoring, taking into account the above mentioned ecological concepts, are thus necessary.

4.1.2. Ambition level of restoration goals and measures

In spite of legal obligations for restoration at the international and EU level, States are not doing enough to implement their legal obligations and targets. Although some efforts are underway and restoration projects have been set up, this has been largely insufficient to actually halt or reverse the detrimental state of biodiversity.

With the Aichi Biodiversity Targets in 2010, global restoration targets have been set, including Target 15, which calls for the restoration of at least 15 per cent of degraded ecosystems. In a midterm evaluation the Global Biodiversity Outlook Report 4 shows that restoration is under way for some depleted or degraded ecosystems. Many countries, organisations and companies have pledged to restore large areas. Despite restoration and conservation efforts, there is still a net loss of forests, suggesting no overall progress on this component of the target. The combined initiatives currently under way or planned may put States on track to restore 15 per cent of degraded ecosystems by 2020, but it is hard to assess and it is not certain that this part of the target will be met. The evaluation of the Global Biodiversity Outlook Report 4 was confirmed and strengthened in an analysis by Tittensor and others who stated that the progress on Target 15 cannot be measured as there are no indicators available for extrapolation.

At the regional level, assessments in the EU show that the efforts made so far are not enough to reverse negative trends. The State of Nature Report from the EU shows that 60 per cent of assessed EU protected species have an unfavourable conservation status. More than one-sixth (17 per cent) of species assessments have an unknown status. The status of protected habitats in the EU shows us an equally grim picture: the overwhelming majority (77 per cent) of habitats have an unfavourable conservation status. The assessment of future trends show that 4 per cent of species populations are in unfavourable condition but improving, 20 per cent are stable, 22 per cent are deteriorating and 14 per cent are

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without a known trend. A third of the habitat types are unfavourable but stable (33 per cent). However, a further 30 per cent are still deteriorating, which is a serious cause for concern. Only 4 per cent are showing any improvements so far. The report also specifically looked at the contribution of the EU protected areas to the status of species and habitats. The report concludes the overall conservation status of species and habitats listed in the Habitats Directive is not significantly associated with Natura 2000 coverage. This may be due to the fact that the necessary conservation and restoration measures have not yet been implemented for the majority of sites or have not had enough time to show concrete influence.

The scientific insights relating to concepts such as extinction debt and ecological trap necessitate additional caution. What might appear as a success of conservation measures because of the presence or return of certain species, might not take into account the delayed effects of biodiversity loss. It is important to take into account both the magnitude of degradation in the planning and implementation of restoration measures, as well as the magnitude of the improvement of the ecosystem condition expected due to restoration measures. On the one hand, ignoring the magnitude of degradation ignores the fact that highly degraded areas are likely to have higher extinction debts and would require more restoration measures. On the other hand, ignoring the magnitude of the improvement of the ecosystem condition expected due to restoration measures could allow reaching the 15 per cent restoration target with ecologically inconsequential minor measures across 15 per cent of degraded land. This would however not help to stop overall biodiversity loss.

In order to reverse negative trends, we need to both restore or maximise habitat size and restore habitat quality. Maximising habitat size can be achieved by designating additional or expanding existing protected areas. For instance, several COP decisions under international biodiversity conventions urge States to strengthen the ecological networks as a way to face the challenges of climate change. Although legal possibilities exist for expanding and maximising protected habitats, the political will to actually implement the existing laws in this regard might be missing. Researchers advocate that we need more investments including educational and financial support.

Restoring habitat quality requires adequate conservation and restoration measures. Although some international laws include restoration obligations, key concepts are not defined, the targets are vague, and laws lack credible sanctions for performance failures. One way to ensure more ambitious and precise targets is to consider conservation and restoration obligations as an outcomes-based obligation. As an example, consider the EU Habitats Directive. The general aim of the Directive, as enunciated in Article 2(1) is to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the EU Treaty applies. This is considered an outcome-based obligation. Article 2(2) is more precise on the measures to be taken to reach this aim: ‘[they] shall be designed to

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59For references to the COP decisions, see Telesetsky et al (2017), pp 275–278.
61Richardson (2016).
maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest. The measures to fulfil this obligation include both the designation and protection of an ecological network in the EU, and the strict protection of species. It appears from these obligations that more measures will be necessary where a species has an unfavourable conservation status. The concept of ‘favourable conservation status’ is thus the ambition level put forward by the Habitats Directive. According to Article 1 of the Directive, a species has a favourable conservation status when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

In the Commission guidelines on species protection, the concept is clarified: the fact that a habitat or species is not threatened (i.e. without any direct extinction risk) does not necessarily mean that it has favourable conservation status. The target of the Directive is defined in a positive way, as a ‘favourable’ situation to be reached and maintained, which needs to be defined based on the best available knowledge. Therefore, the obligation of a Member State is more than just avoiding extinction. All measures taken under the Directive must aim to reach or maintain a favourable conservation status. The guidelines also mention that: the assessment of conservation status not only includes an element of “diagnosis” based on current conditions, but also an important element of “prognosis” (foreseeable future) based on influences. In spite of the definition, and the guidance by the Commission, the concept of favourable conservation status still leaves room for interpretation and needs further clarification.

In order to reach a more ambitious level, such as favourable conservation status, conservation and restoration measures must take into account the delayed effects of extinction debts and ecological traps. This implies for instance that certain detrimental human activities should be restricted. This restriction can be within protected areas (e.g. Article 6(2) of the Habitats Directive, which obliges Member States to take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated), or can apply as horizontal measures for protected species (e.g. Article 12 of the Directive, which contains strict species protection). Defining which measures to take should be based on monitoring that considers issues such as species’ reproduction success. In the above example of an ecological trap – meadow birds breeding in agricultural fields where the nests are destroyed by the mowing activities of the farmer – this should entail restricting the mowing activities.

In a court case for the European Court of Justice, the so-called Hamster case, France was convicted by the European Court for not doing enough to protect the European hamster in the Alsace region. The Advocate General explained:

If its conservation status is good, it may be sufficient to make general provision for the prohibitions laid down in Article 12(1) and to monitor the species. An unfavourable conservation status gives rise to more far-reaching obligations for the Member States, however, because the system of protection is intended to help to restore a favourable conservation status. The protection of breeding sites and resting places of a species with a very unfavourable conservation status, as in the case of the European hamster in Alsace, therefore requires a generous delimitation of territory in order to prevent the species from disappearing, and thus the functionality of the sites from being lost. The protection measures must, so far as possible, be adjusted specifically to the circumstances giving rise to the unfavourable conservation status.67

In conclusion, although some international law contains restoration obligations, the prescribed standards are typically vague and unambitious. It is therefore important that restoration obligations are precisely framed in regard to specific outcomes to be achieved. The EU Habitats Directive comes closer to fulfilling this approach, but nonetheless the implementation of the EU legislation has so far not been able to stop environmental degradation. The challenge is thus also to establish better guidance from the European Commission and more robust compliance oversight at national and EU levels. This reform is also necessary at the international level.68 A helpful tool is proposed in the SER’s international standards for ecological restoration, in which a ‘five-star recovery system’ is promoted. A five-star recovery is a status where the ecosystem is on a self-organising trajectory to full recovery (based on an appropriate local native reference ecosystem). The five-star recovery contains the following characteristics:

- Establishment of a characteristic assemblage of biota to a point where structural and trophic complexity is likely to develop without further intervention. Appropriate cross boundary flows are enabled and commencing and high levels of resilience is likely with return of appropriate disturbance regimes. Long term management arrangements in place.69

This five-star recovery is the ‘gold standard’ to which all ecological restoration projects should aim.

### 4.1.3. Restoration of connectivity

Connectivity is recognised by expert commentators as an important measure in nature conservation and restoration.70 Connecting nature areas can consist of large habitat corridors, linear elements or ecological stepping-stones. Restoring connectivity can have various functions including to allow movement of species for genetic interchange and to help species adapt to climate change.71 Restoring ecological stepping-stones between protected areas can help to ensure that migratory species have resting and feeding locations to ensure their safe passage. A landscape/seascape mosaic can link various habitats into a viable and more functional ecosystem.72 A decrease of connectivity can lead to lower recolonisation and immigration rates, affecting the equilibrium in a metapopulation. These processes that affect metapopulation functioning will often be delayed and thus create the risk of an

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70 On the importance of connectivity see inter alia: Bennett (1998, 2003); Bennett and Mulongoy (2003); Lausche et al (2013).
extinction debt. Restoring connectivity between fragmented areas can enable proper metapopulation functioning and thus counter extinction debt and ecological traps.

Measures for promoting connectivity are already included in international law. According to an International Union for Conservation of Nature (IUCN) paper on this subject, virtually all global and regional legal instruments dealing with biodiversity, climate change, and natural resources require States to provide for adequate connectivity conservation or otherwise promote such connectivity. Although several international legal instruments mention networks of protected areas, and some also refer to corridors, few have tried to implement them. The focus in nature conservation law is mostly on the designation and protection of core protected areas, but often without specific measures for connecting these core areas. In the framework of several international and regional nature conservation conventions attention has been given to the importance of connectivity in COP decisions, including the Ramsar Convention on wetlands, the Bonn Convention on migratory species and the European Bern Convention.

The CBD’s State Parties have also focused on connectivity. The Convention obliges States to establish a ‘system of protected areas’ (Article 8, a), which has been interpreted as implying connectivity measures to link core protected areas. In 2004, under the Programme of Work on protected areas, States agreed to a goal: ‘[t]o integrate protected areas into broader land- and seascapes and sectors so as to maintain ecological structure and function’ with the aim by 2015 that ‘all protected areas and protected area systems are integrated into the wider land- and seascape … by applying the ecosystem approach and taking into account ecological connectivity’. Among the suggested activities for State Parties is action 1.2.5, which encourages States to ‘[r]ehabilitate and restore habitats and degraded ecosystems, as appropriate, as a contribution to building ecological networks, ecological corridors and/or buffer zones’. Other COP decisions also refer to connectivity and States are encouraged to increase their efforts for connectivity measures. Connectivity is also part of the Aichi Targets. But implementation at a national level remains unsatisfactory; few national biodiversity strategies and action plans (NBSAPs) explicitly address the connection or integration of protected areas into wider landscapes and seascapes.

Also, in the EU, there are legal requirements for establishing and restoring connectivity elements. Article 3 of the Habitat Directive obliges States ‘to improve the ecological

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73 See Hylander and Ehrén (2013).
75 Lausche et al (2013), p 175.
80 Recommendation no. 25 on the conservation of natural areas outside protected areas proper (1991); Recommendation no. 135 on addressing the impacts of climate change on biodiversity (2008); Recommendation no. 143 on further guidance for Parties on biodiversity and climate change (2009); Recommendation no. 180 on improving the conservation of nature outside protected areas proper (2015).
84 See also in Telesetsky et al (2017), pp 252–255.
coherence of Natura 2000 by maintaining, and where appropriate developing, features of
the landscape that are of major importance for wild fauna and flora as referred to in Article
10’. Article 10 provides that: ‘Member States shall endeavour … to encourage the manage-
ment of features of the landscape which are of major importance for wild fauna and flora’.
Articles 3 and 10, however both seem to be weak obligations when compared to other obli-
gations in the Directive, using words like ‘shall endeavour’, ‘where they consider it neces-
3ary’, ‘to encourage’. Presumably as a consequence of this rather weak formulation, the
implementation of the Habitats Directive has so far mainly been aimed at the conservation
of the status quo of habitats and species within the core areas. A more explicit legal frame-
work has been advocated in literature.85
But even without a more explicit legal framework, Articles 3 and 10, when read in com-
bination with other provisions of the Directive, are mandatory. Because many habitats and
species in the EU are already in an unfavourable conservation status due to fragmentation
and other human impacts, connectivity measures will be essential to reach a favourable
conservation status. Member States must adopt measures beyond the Natura 2000 net-
work aimed at ensuring the functional connectivity between the Natura 2000 sites.86
According to the Commission, the concept of favourable conservation status is not limited
to the Natura 2000 network or to the species protected by this network.87 It therefore fol-
lows that Member States should promote the implementation of connectivity measures
where these are required to maintain or restore a favourable conservation status, irrespec-
tive of their contribution to the coherence of the Natura 2000 network.88
In a recent case before the European Court of Justice involving Spain,89 the Court
recognised the importance of connectivity. The case dealt with an open-cast coal mining
project in the Natura 2000 site ‘Alto sil’, causing a loss of habitat for the brown bear in a
corridor area. Also, the mining operations were found capable of producing a barrier effect
likely to contribute to the fragmentation of the habitat of the capercaillie, a type of grouse,
and the isolation of certain sub-populations of that species.90 Although the case relates to
activities within a Natura 2000 site, it is likely that the Court would have arrived at a simi-
lar decision if the case would have concerned populations in non-adjacent Natura 2000
sites, connected through a corridor not lying in a Natura 2000 site.91 The case shows
that in order to safeguard the integrity of a Natura 2000 site, features of the landscape
that are essential for migration, dispersal and genetic exchange of wild species for
which the site has been designated, must be preserved and, if necessary, restored.92
The EU understands well the need for connectivity, as reflected in various initiatives,
including Target 2 of the 2011 EU Biodiversity Strategy encouraging States to develop
Green Infrastructure by 2020 capable of maintaining and enhancing ecosystems and
their services. Green Infrastructure is a strategically planned network of natural and
semi-natural areas with other environmental features designed and managed to deliver
a wide range of ecosystem services. It incorporates green spaces (or blue for aquatic

85See Verschuuren (2015); Krämer (2013).
ecosystems) and other physical features in terrestrial (including coastal) and marine areas. The work that has already been done by EU Member States to establish the Natura 2000 network provides a backbone for Green Infrastructure efforts. According to the Green Infrastructure Strategy, it is:

a reservoir of biodiversity that can be drawn upon to repopulate and revitalize degraded environments and catalyze the development of GI. This will also help reduce the fragmentation of the ecosystem, improving the connectivity between sites in the Natura 2000 network and thus achieving the objectives of Article 10 of the Habitats Directive.

The Strategy aims to promote Green Infrastructure in other policy areas and the Commission commits itself to explore opportunities for establishing financing mechanisms to support Green Infrastructure. The Commission’s Strategy was supported by a resolution from the European Parliament of 2013.

In conclusion, connectivity has been recognised in the framework of international and regional nature conservation instruments, as a way to cope with the effects of climate change and fragmentation. It often lacks implementation on the ground and increased attention for connectivity measures is in order, especially taking into account the risks of extinction debt and ecological traps.

### 4.2. Measures for absent species

‘Dark diversity’ is a new concept in conservation and restoration science. It is as such absent in law and policy. The ‘classical’ approach in nature conservation law is to designate, protect and restore areas for species and habitats that are present in a certain area. Taking restoration measures for ‘dark diversity’ is going a step further and requires adopting measures for habitat-specific species that went extinct in the (recent) past and have not yet returned to that site, despite the potential of the site.

Firstly, environmental inventories should take ‘dark diversity’ more explicitly into consideration to assess ecosystem health, measure the effectiveness of existing conservation policies and enable the development of adapted restoration policies. According to the SER’s international standards on ecological restoration, an assessment of a restoration project should consider any remaining potential for regeneration. Furthermore, it should assess the need to reinstate missing biotic and abiotic elements, if the regeneration potential has been depleted. The ecosystem baseline inventory should include the relative capacity of the biota on site or external to the site to commence and continue recovery with or without assistance. An inventory should identify both native and non-native species presumed absent and those potentially persisting as propagules or occurring within colonisation distance.

International and EU nature conservation law (implicitly) includes the possibility to designate areas that have a potential for (re)colonisation of locally extinct species. States

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94 European Commission (2013b) 7.
95 European Parliament resolution of 12 December 2013 on Green Infrastructure – Enhancing Europe’s Natural Capital (2013/2663(RSP)).
98 See, for example, the CBD Programme of Work on Protected Areas, Programme Element 1: Direct actions for planning, selecting, establishing, strengthening, and managing, protected area systems and sites (CBD (2004) COP 7 Decision VII/
are encouraged to restore suitable habitat conditions and build ecological networks to allow for species dispersal. For example, the CBD’s Programme of Work on protected areas directs States to restore habitats and degraded ecosystems, as appropriate, as a contribution to building ecological networks, ecological corridors and/or buffer zones.99 A more concrete example is again found in EU law, where Member States have the option to identify non-present species when filling in the Standard Data Form (a form that has to be drawn up for every designated Natura 2000 site):

In cases where a species for which the site was originally designated for (e.g. which was formerly present in the site) is no longer present in the site, it is strongly recommended to indicate this by entering ‘x’ in the column NP (alternative to the deletion of the information for this species from the SDF). Species which have not been present on the site since the Directive came into force as well as ‘historic occurrences’ should not be noted.100

According to the Commission Decision on the Standard Data Form, species are considered as absent in the site, for instance, if they have not been observed in the site for a long time. The time period will vary between species: absence of a few years for an easy-to-observe species probably indicates disappearance, whereas for difficult to observe species, lack of observations for many years does not necessarily indicate absence if the habitat has not adversely changed.101

However, it remains to be seen whether authorities will go as far to take restoration measures for species that are no longer present in a specific area. Relevantly, in the Hamster case102 the Advocate General elaborated on whether restoration measures were also required in areas where there are currently no hamster burrows, stating that:

measures in areas where there are no hamster burrows are not necessary. Measures of that kind are certainly sensible for the future repopulation of those habitats by the European hamster and, therefore, presumably also necessary for the restoration of a favourable conservation status for the species in Alsace generally. However, the measures required by Article 12 (1)(d) of the Habitats Directive relate only to the breeding sites and resting places of existing populations. The Commission has not asserted, and it appears unlikely, that a favourable conservation status for those specific populations would require a particular form of management of land outside the vicinity of their burrows.103

The Advocate General’s analysis is regrettable as restoration measures outside of current breeding sites or resting places could be important for relict populations and/or the establishment of healthier metapopulation functioning, and thereby avoid risk of an extinction debt. The Advocate General was not prepared to let nature conservation prevail over the literal content of Article 12(1).104 The opinion of the Advocate-General corresponds to the Commission’s guidelines on species protection,105 which state that ‘it is important to recognise that proactive habitat management measures (such as restoration of habitats/

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28. Protected areas (Articles 8 (a) to (e)); see criteria for establishing Special Areas of Conservation under the Habitats Directive (Annex III, A, c and B, b).
99CBD (2004) COP 7 Decision VII/28. Protected areas (Articles 8 (a) to (e)), para 1.2.5.
100NP stands for ‘Non Present’; SDF stands for ‘Standard Data Form’.
populations, improvement of habitats) are not an obligation under Article 12, even though they might well be under Article 6.

In another case however, Ireland was convicted by the Court for not designating an area as Special Protection Area (SPA) under the Birds Directive, even though the species, the sandwich tern, had already disappeared from the area due to predation by the American mink. In her opinion, the Advocate General stated:

However, there would be no point in classifying the area as an SPA if it could not be restored to an area most suitable for the protection of birds. In that case classification of it as an SPA would also be unnecessary. However, as the Commission submits, without contradiction, there is a genuine chance that the sandwich tern may resettle the area of Cross Lough (Killadoon). This species frequently changes its colony site and continues to use sites near the area. Therefore, if appropriate measures were taken against the mink, renewed use of the area would be possible.

The Court agreed with the Advocate General and ruled that Ireland breached its obligations under the Birds Directive for not designating the site as a protected area. According to the Court, Ireland ought, at the very least, to have adopted appropriate measures in order to avoid pollution or deterioration of the habitats in the Cross Lough area or any disturbances affecting the sandwich tern. Having failed to take such measures, Ireland had not provided proof that the area would no longer be suitable for designation even if protection measures had been taken. Moreover, according to the results of scientific research submitted by the Commission, protection measures were possible. Relying on these observations, which confirm the potential for recolonisation of areas by the sandwich tern, the Commission stated that there is a genuine chance that the sandwich tern may resettle in the area. It appears from this case that Member States don’t always have the discretion for not taking restoration measures for absent species, especially in European protected areas under the Birds and Habitats Directives.

A more active way of getting locally extinct species back to a certain area is through re-introduction of species. International law usually allows this type of measure. For example, Article 9 of the Biodiversity Convention allows the State Parties to adopt measures for the recovery and rehabilitation of threatened species and for their re-introduction into their natural habitats under appropriate conditions. Article 16 of the EU Habitats Directive allows Member States to derogate from the strict species protection for the purpose of repopulating and re-introducing these species. Further guidance on species re-introductions can be found in the IUCN’s guidelines.

In conclusion, international and EU nature conservation laws focus on the conservation and restoration of species already present in a certain site. However, this article recommends expanding existing ecological networks and creating refuge to enable species migration. In light of the understandings of dark diversity and extinction debt, it is important to incorporate these insights into conservation and restoration policies, both at the level of designating and expanding protected sites, and providing restoration measures.

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110IUCN/SSC (2013).
for ‘absent’ species. It is probably unrealistic to return all typical species in a given site, especially when connectivity and habitat size issues cannot be solved or for very rare species, species with low dispersal power or species affected by irreversible changes in local climatological conditions. Priority for resettlement should be given to species that play a key role in the proper functioning of an ecosystem (e.g. predator species and ecosystem engineers). Additionally it can be useful to select focal and/or umbrella species with different habitat requirements. Monitoring of this set of species can serve as early warning indicator to safeguard returned species from a new extinction debt or ecological trap condition. Re-introduction of extinct native species should follow the procedures as outlined by IUCN.111

5. Conclusions

Harmony between science and law can lead to better restoration on the ground. In order for the conservation and restoration laws to be adequately implemented, it is crucial that policy makers, lawyers and judges are aware of the concepts discussed in this article.

We advocate incorporating the concepts of extinction debt, ecological trap and dark diversity in the implementation of nature conservation and restoration laws and policies in order to halt the loss of biodiversity in all ecosystems worldwide. These three concepts relate to species extinctions. Because of delayed time effects of pressures on biodiversity, species that are still present in a certain area can go extinct in the future. In order to prevent extinction debt and ecological trap conditions, we emphasised the importance of dedicated monitoring beyond the simple presence/absence of habitat-specific species in a site and the need for a good understanding of metapopulation functioning in relation to habitat size, habitat quality and connectivity. In times of rapid environmental changes at global scale, especially for fragmented areas, more attention and efforts are urgently needed for an increase of habitat size and quality, and better connectivity as preventive measures to avoid further species loss. For the remaining large, less fragmented nature areas, it is absolutely essential that governments ensure no loss in size, quality and connectivity.

For species that are typical for a certain ecosystem but have already disappeared in a given site, measures that enable resettlement are recommended in order to restore the typical species assemblage and proper ecosystem functioning. After these species return, monitoring is needed in order to prevent a new cycle of extinction debt or ecological trap conditions emerging.

Rather than having new legislation at international or EU levels, we recommend taking into account these concepts at the implementation level. Aside from the fact that amending international or EU law is politically very difficult, it is probably not necessary to amend existing international and EU laws given that they do not exclude the application of these concepts. Although the concepts are not explicitly mentioned in the CBD or Habitats Directive, the existing provisions are broad enough to encompass the recommended actions that canvassed in this article. However, at the level of implementation, these concepts are not or insufficiently taken into account. We recommend that through more specific guidelines (such as a COP decision under the CBD, or European Commission

111IUCN/SSC (2013).
States can better implement their existing obligations, taking into account these ecological concepts. Further legal reforms are needed at national and local government levels, but as already explained these dimensions of governance are not within the scope of this article.

We advocate providing more attention and funding for dedicated monitoring in the implementation of conservation and restoration policies, at least for a selection of focal and/or umbrella species. For the practical implementation of restoration projects, obviously also the broader context should be taken into account, including biological feasibility and social acceptability. Public education and participation in restoration projects can provide valuable means to achieve the latter objective.112

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112Richardson (2017).


