Office for Environmental Protection

Drivers and pressures affecting terrestrial and freshwater biodiversity in Northern Ireland

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Presented to the Northern Ireland Assembly

by

The Office for Environmental Protection

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The Office for Environmental Protection is a non-departmental public body, created in November 2021 under the Environment Act 2021. Our mission is to protect and improve the environment by holding government and other public authorities to account. Our work covers England and Northern Ireland. We also cover reserved matters across the UK.

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This report is accompanied by the following documents available on our website:

- A spreadsheet of pressures impacting priority species and habitats.
- Our summary of responses received to our call for evidence.
- Literature reviews conducted by consultants, academics and experts.
- Research we have commissioned on:
    - Biodiversity Indicators for Northern Ireland.
    - Waste management and illegal disposal in Northern Ireland: A baseline evidence assessment for the OEP.

We are publishing related reports on the state of the natural environment in Northern Ireland which will be available on our website:

- A review of implementation of the Water Framework Directive Regulations and River Basin Management Planning in Northern Ireland.
- A report on protected sites in Northern Ireland.

Foreword

Foreword

Nature sustains the Northern Ireland economy and the health, wealth and wellbeing of its people. Protecting the natural environment is therefore fundamental to achieving economic and social goals. Nevertheless, over the lifetime of many, more and more has been demanded of the environment. It is now clear that more pressure has been applied than Northern Ireland's land and water can bear.

In this, our first, broad-ranging report on the natural environment of Northern Ireland, we have systematically assessed the drivers and pressures impacting upon nature, and identified the relevant challenges associated with multiple sectors of the economy. To know how best to act, government must first know well enough how things are, and why they are as they are. We hope that this assessment provides government with the comprehensive and timely assessment it needs to plan for the future, as Northern Ireland's first Environmental Improvement Plan is agreed.

It can come as no surprise that we find pollution from farming, in the form of excess fertilisers and animal wastes, and land use change for farming are the main pressures contributing to Northern Ireland's significant biodiversity loss.

Economic drivers, such as those manifest in the 'Going for Growth' initiative, have led to growth and intensification in the agri-food industry. This has come at great cost to the natural environment. There is a need for better accounting for the cost of environmental degradation, so that this may be weighed more fully against models for growth.

The responsibility for nature's decline does not rest solely with agri-food businesses, despite their predominance in Northern Ireland. Activities such as sewage management, waste management, resource extraction, urban development and chemical pollution have all contributed, and are contributing, to an ongoing loss of biodiversity.

While global environmental crises might appear distant from the daily lives of many, Lough Neagh's chronic deterioration brings into sharp focus the local consequences of long-term neglect of the natural environment. Unsustainable practices in the Lough and its catchment, exacerbated by global environmental change, have led to increased risks to human and animal health, tourism, fisheries and even to supplies of precious drinking water. All of which are over and above the evident harms to the Lough's diverse habitats and species.

But Lough Neagh's dreadful predicament also makes clear how many of the solutions are also to be found locally. Some solutions, such as improvements in sewage treatment, are relatively simple but costly. Others, such as changes in farming practices, are undoubtedly more challenging, given the importance that society places upon agri-food businesses.

Lough Neagh is a clear illustration of the problems affecting all of Northern Ireland's environment. Together they pose a very conspicuous challenge to government. Lough Neagh also provides a visible test of the solutions and of government's actions and intent as it must now rise to that challenge.

While government faces difficulties in ensuring environmental protection alongside dealing with other pressing issues, the long-term environmental, social and economic costs of inaction should weigh more heavily in decision-making. This is especially true for Northern Ireland, where environment, economy and people are so tightly bound.

Climate change will undoubtedly exacerbate many of the environmental challenges ahead. However, the Environment Act 2021 and the Climate Change Act (Northern Ireland) 2022 together create obligations and present opportunities for government simultaneously to address nature's decline, reduce carbon emissions, and adapt to climate change by adopting nature-based solutions.

Conservation works, and it pays back on investments. Strenuous effort creates the opportunity for iconic species, such as curlew, corncrake and red squirrels, to return and expand their populations. Threatened species and habitats can be allowed to thrive, alongside benefits for people. On the Garron Plateau in the Antrim Hills, restoration of precious peatland habitats brings multiple benefits to society, through protection of drinking water sources and by addressing climate change.

Government must act not only to reverse a lifetime of environmental degradation and to restore the diversity of Northern Ireland's habitats and species, but also to ensure a sustainable agri-food industry and wider economy. This is key to avoiding the heavy toll on the prosperity and well-being of future generations, were action to be deferred once again.

Prompt and decisive action is now essential. In May 2024, soon after its return, the Northern Ireland Assembly declared an ecological and biodiversity crisis. With a new Environmental Improvement Plan to guide improvement work for a generation, there is an opportunity now to renew Northern Ireland's relationship with its natural environment. It is an opportunity that is too costly to squander.

Dame Glenys Stacey
Chair, Office for Environmental Protection

Executive summary and recommendations

Executive summary and recommendations

Nationally and internationally important species and habitats are in severe decline in Northern Ireland. Action to address this loss of biodiversity, together with ongoing declines in air and water quality, requires understanding of the causes of deterioration in the natural environment.

In this report, we examine the root causes of biodiversity loss, by assessing the drivers and pressures that have negative impacts on nature. Our report provides a synthesis of otherwise fragmented evidence relating to the causes of deterioration in terrestrial and freshwater environments. Coastal and marine environments will feature in later work.

Our purpose at this stage is to define the problem and identify its causes, with a view to helping government and others prioritise and drive action towards solutions that will protect and improve the natural environment.

Our findings

The two principal pressures causing biodiversity loss are land use change and pollution.

More than three quarters of Northern Ireland's land area is used for agriculture. Over recent decades, seminatural habitats, such as peatlands, have been destroyed and become more fragmented, as land use has changed with agricultural expansion.

Farming practices have also become more intensive, enabling more to be produced from the same area of land. This intensification has required greater inputs of nutrients, in the form of fertilisers and animal feeds, and of pesticides, primarily in the form of herbicides, to increase productivity.

The joint environmental harms of land use change and pollution are therefore closely linked with agricultural intensification.

The primary form of pollution affecting terrestrial and freshwater habitats is excess nutrients from agriculture, in the form of fertilisers and animal wastes, and excess nutrients that come from sewage. Combining its effects in water and on land, nutrient pollution from farming likely has a greater impact on biodiversity than that from sewage, though both require urgent intervention to reduce their impacts.

Taking together the elements of land use change and pollution that stem from farming, we find that agriculture is the activity that contributes most to biodiversity loss. The well-evidenced and direct link between agricultural practices and environmental deterioration, means that Northern Ireland's agri-food industry is unsustainable in its current form.

Land use has also changed with development in both urban and rural areas, related to expansion of housing, industry, tourism, transport infrastructure and energy production. Studies assessing the impacts of development are limited in scope and tend to focus on specific locations, habitats and species. There is also a lack of assessments of the cumulative impacts of multiple developments.

Chemical pollution from diverse sources, including industry, waste management, contaminated land and sewage, is a ubiquitous problem. However, there has been no comprehensive assessment of the large-scale impacts of chemical pollution on biodiversity.

The only available national assessment of the presence of chemicals in the environment stems from the Water Framework Directive and shows that all water bodies fail to achieve Directive targets because of ubiquitous, persistent, bioaccumulative and toxic chemicals.

Relative to its area and population, Northern Ireland consumes a disproportionately large amount of natural resources. Energy consumption, resource extraction, food production and waste generation can be summed into the per person 'material footprint'. A 2022 Department for Economy analysis found that the material footprint is 16.6 tonnes per person, nearly three times greater than that needed to live sustainably. Ecological footprint is closely related to material footprint but incorporates impacts on the environment and biodiversity. Current evidence is that Northern Ireland's material and ecological footprints are unsustainable.

The risks posed by invasive species are well understood, as are the actions to prevent their introduction. With climate change increasing these risks, there is a need for enhanced vigilance and actions to prevent further introductions and spread. The lack of a current assessment of the wider potential impacts of climate change on biodiversity in Northern Ireland is an impediment to understanding future states.

A general challenge in addressing biodiversity loss is uncertainty around multiple interacting pressures, and how to manage any cumulative impacts on biodiversity. For example, it remains largely unknown how chemical and nutrient pollutants interact, together with physical modifications of water bodies, to affect aquatic biodiversity. Nevertheless, for the greatest pressures identified in this report, the evidence of their detrimental impacts is strong and consistent, and prompt intervention is both necessary and feasible.

While evidence is still developing for other pressures, uncertainty about their relative importance, or combined impacts, should not be construed as a barrier to taking positive steps to address the pressures that are well understood, and where evidence is unequivocal. Moreover, adaptive management approaches can enable interventions in the face of uncertainty and, where uncertainty persists, the precautionary principle should be applied, as proposed in the draft Environmental Principles Policy Statement.

Recommendations

As a new part of Northern Ireland's system of environmental governance, the Office for Environmental Protection must assess and report on progress in improving the natural environment, enabling government and public authorities to be held to account. Our assessments provide recommendations on how progress might be improved.

We recommend the prioritisation of action in a number of key areas, to address the major causes of environmental deterioration, and to halt and reverse biodiversity loss:

1. **Reduce pollution by nutrients from farming and sewage**. Northern Ireland has an unsustainable nutrient surplus. Government should prioritise addressing nutrient pollution arising primarily from the agri-food industry, and from sewage treatment.

2. **Change land use to restore habitats**. Most seminatural habitats have been destroyed or become fragmented by land use change. A focus on restoration and nature-positive land use change is essential to provide space for nature and increase biodiversity in rural and urban areas.

3. **Reduce the material and ecological footprint**. The extraction, consumption and disposal of raw materials are causing widespread damage to biodiversity within Northern Ireland and beyond. Action should be taken to reduce the impact of society on the environment to achieve a sustainable footprint.

4. **Act urgently and effectively**. Not only should action be taken to address these priority areas, but evidence is clear that unless action is taken immediately, problems will be exacerbated and solutions will become harder. In urgently addressing these three priority areas, we recommend that government should:

    a. Adopt an adaptive management approach that will provide an iterative process of implementation, monitoring and learning, thereby enabling action now and the informed adjustment of actions later.

    b. Ensure there is coherence between approaches that address multiple pressures across sectors so that benefits are realised and trade-offs and unintended consequences are managed effectively.

    c. Develop clear implementation plans and targets to ensure coherence across government and to ensure resources are coordinated and actions are aligned to deliver improvements in biodiversity.

    d. Address the knowledge gaps identified in this report related to interactions among multiple pressures, chemicals, species abundance, climate change, urban and rural development, and the cumulative impacts of activities such as resource extraction, recreation and waste management.

    e. Develop a monitoring, evaluation and learning framework that focuses on outcome-based targets, such as increases in species abundance and reductions in ecological footprint. This framework should account for the pressures outlined in this report and set a baseline for evaluation of progress with the Environmental Improvement Plan.

Chapter One: Introduction

1. Chapter One: Introduction

Overview

Biodiversity is declining at an unprecedented rate. This decline is intertwined with the global climate crisis and urgent action is required to address both. This urgency is reflected in the Northern Ireland (NI) Assembly's declaration in May 2024 of an ecological and biodiversity crisis.[1]

While it is clear that biodiversity is in crisis in NI, evidence linking pressures affecting the environment to the decline in biodiversity is often either lacking or is scattered across multiple sources. Recent work by government includes an in depth analysis of the pressures on a limited number of priority species.[2] Our aim in this report is to provide an evidence-based assessment of the impacts of pressures on terrestrial and freshwater biodiversity in NI. Natural cycles in air, soil, water and landscapes shape biodiversity and, in turn, the decline of biodiversity disrupts these cycles. Our report includes the impact of pressures on these processes. We lay out our assessment of the key pressures on biodiversity with the aim of helping in the identification of solutions and prioritisation of actions. This assessment will also enable us to make evidence-based decisions that will guide delivery of our own functions, as set out in the Environment Act 2021.[3] Specifically, our conclusions will feed into our scrutiny of government's progress in achieving the goals and objectives of the Environmental Improvement Plan (EIP) for NI.

1.1 The state of biodiversity: globally and nationally

Biodiversity is declining at an unprecedented rate and urgent action is required.[4] Global assessments place species loss and ecosystem collapse among the fastest growing global risks in the coming decade.[5] Combined with the risk of failing to mitigate and adapt to climate change, the next decade will likely see further environmental and related social crises.

The state of biodiversity is assessed through a wide range of indicators. At the global scale, indicators including the Living Planet Index, the International Union for Conservation of Nature (IUCN) Red List,[6] and the Biodiversity Intactness Index illustrate the long-term and accelerating decline of biodiversity. The Living Planet Index, which tracks trends in populations of vertebrates, indicates a 69% decline in less than 50 years.[7] Similarly, 45% of flowering plant species are potentially threatened with extinction globally.[8]

The United Kingdom (UK) as a whole has lost around 50% of its nature.[9] The Biodiversity Intactness Index, which provides a measurement of the changes in biodiversity using abundance data for plants, fungi and animals, places the UK at the bottom of the G7 countries for the amount of nature it has left.[10] There have been declines in the abundance of UK terrestrial and freshwater species (on average 19% since 1970),[10] including mammals and birds. Also in the UK, 80% of butterfly species have decreased in abundance or distribution or both since 1970[11] and there have been notable decreases for moths,[12] other invertebrates[10] and native plants.[13,14] Other national assessments demonstrate that 16% and 12% of species in Great Britain (GB) and NI respectively are now threatened with extinction.[10]

Northern Ireland is also experiencing severe declines in its species (Box 1). Whilst there is a very limited set of indicators for biodiversity in NI, those that are available show declining trends. For example, there has been on average a 54% decline since 1970 in the distributions of bryophyte species (mosses and liverworts),[15] and farmland bird species have declined in abundance by 35% since 1996.[16] Around a quarter of birds found on the island of Ireland are now at risk of extinction,[17] and many native plant species found on land and in freshwater have declined in abundance and distribution.[14] Conversely, the distributions of certain invertebrates have increased by 24% since 1990,[15] though this figure needs further consideration due to changes to monitoring programmes and the positive impacts of climate change on some species to the detriment of others.

Northern Ireland is host to a range of nationally and internationally important habitats, many of which are in poor condition (Box 1). Within protected sites, 77% of features associated with bogs, 86% of heathland features, and 37% of grassland features are not in favourable condition.[16] Peatland habitats, which are so important for mitigating the effects of climate change, cover 12% of land area[18] though most are degraded.[18–20] The 2007 findings of the Countryside Survey demonstrated significant losses in a range of seminatural habitats between 1998 and 2007. These include the loss of 5,700 ha of fen, marsh and swamp, the loss of 3,300 ha of bog, and most notably the loss of 32,800 ha of neutral grassland.[21] There have been increases in broadleaf, mixed and yew woodland of 18,200 ha. Urban and built-up areas increased by 17,300 ha.[21] The Countryside Survey is currently being repeated and results will be available in 2026.[22]

Biodiversity indicators for the Republic of Ireland (RoI) show equally worrying declines. The Environmental Protection Agency in the RoI reports that most important habitats, including peatland and woodland, are in unfavourable condition.[23] Red List assessments for species found on the island of Ireland demonstrate that 14% of species are at risk of extinction.[23]

Box 1. Counting the cost. Quantifying the decline in Northern Ireland's biodiversity.

Species

- 14% average decline in the distributions of 891 species of flowering plants from 1970-2020.[15]
- 54% average decline in the distributions of 576 species of bryophytes (mosses and liverworts) from 1970-2020.[15]
- 17% average decline in the abundances of 14 species of butterflies between 2006-2019 and 10% decline in distribution from 1993-2019.[11,15]
- 35% average decline in the abundances of 17 species of farmland birds from 1996-2022.[16]
- 10% average decline in the abundances of 64 species of breeding birds from 1996-2021.[15]
- 30% average decline in the abundances of 36 species of wintering waterbirds from 1988-2021.[15]
- 12% of the 2,508 species in NI assessed using the IUCN Regional Red List criteria are threatened with extinction on the island of Ireland.[15]

Habitats

Peatlands

- Most peatlands are degraded, according to the NI Peatland Strategy 2022-2040.[18]
- For protected sites containing bog features only 23% of these are in favourable condition.[16]
- In the late 1980s, only 15% of blanket peat was intact and half of the loss was due to peat cutting.[24]

Woodlands

- 13% of ancient woodlands have been lost since the 1960s and now make up 0.04% of land area in NI.[15]
- For protected sites containing woodland features only 6% of these features are in favourable condition.[16]

Freshwaters

- 100% of waterbodies fail the standards required by the Water Framework Directive.[25]
- For protected sites containing freshwater features only 29% of these features are in favourable condition.[16]

Hedgerows

- 4% of hedgerows in NI were lost between 1986 and 1998, and decreased by a further 4% between 1998 and 2007.[24]

Protected sites

- 68% of the features in terrestrial and freshwater protected sites are classified as in unfavourable condition.[16]

Between 1998 and 2007,[21] NI has experienced:

- 12% loss of neutral grasslands.
- 22% loss of acid grasslands.
- 14% loss of dense bracken.
- 2% loss of bogs.
- 11% loss of wetlands (fen, marsh and swamp).
- 1% loss of lakes and ponds (standing open water).
- 30% increase in urban/built up areas.

1.2 Policy context

The United Nations Convention on Biological Diversity (CBD) provides the global framework for action to conserve, use sustainably, and share equitably the benefits of biodiversity. The Kunming-Montreal Declaration, also referred to as the post-2020 Global Biodiversity Framework (GBF), is a blueprint for coordinating the development of national strategies and action plans. The GBF sets 23 targets to be met by 2030 and four goals to be achieved by 2050.[26] These address key drivers and pressures, including the sustainable use of biodiversity, pollution and invasive species.

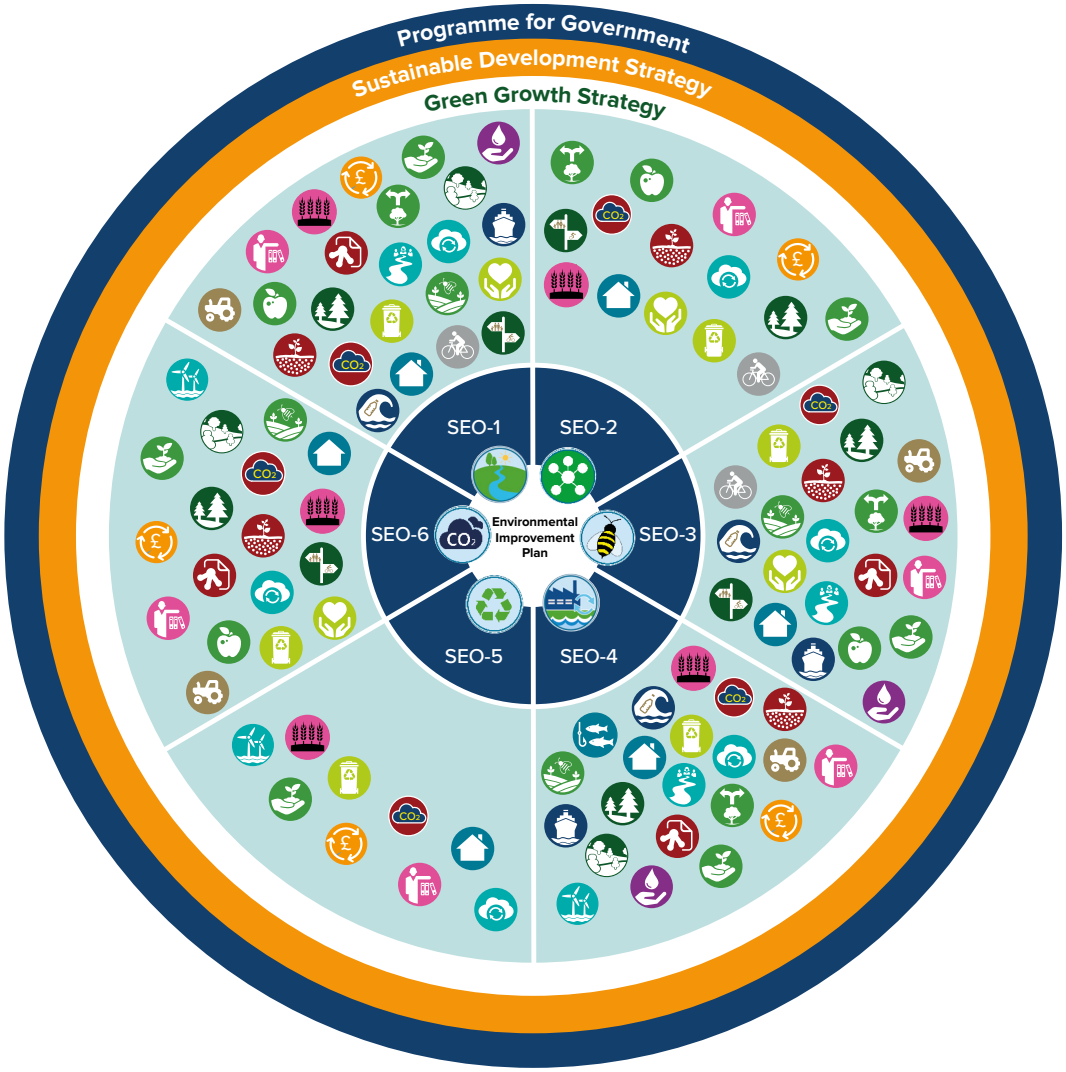
Signatories to the CBD, including the UK, must now transpose the GBF into national proposals. In the UK, the environment is a devolved matter, and the Department of Agriculture, Environment and Rural Affairs (DAERA) is responsible for developing strategies and associated action plans for NI. Devolution of responsibilities in this context provides for approaches to conservation to be tailored to the natural environments of the four nations. Where joint action between the four nations is required, it is outlined within the UK Biodiversity Framework 2024,[27] supplemented by the UK's National Biodiversity Strategy and Action Plan for 2030, when the latter is published.[27] Assessments of UK progress on previous CBD targets, however, reflect a widespread failure to deliver on commitments.[28,29]

The Nature Recovery Strategy is a key action under Strategic Environmental Outcome 3 of the EIP: '*Thriving resilient and connected nature and wildlife*'.[30] The EIP is central to delivering a cohesive response to protect and enhance biodiversity across NI, linking the goals and targets of the GBF with those in the EIP and the legally binding target for biodiversity in the Climate Action Plan, when this is specified. Furthermore, the focus on nature-based solutions within the Climate Action Plan provides further opportunities for synergies with the forthcoming Nature Recovery Strategy and EIP.

Throughout the EIP there are cross-references to initiatives and strategies such as the Peatland Strategy, Future Agricultural Policy, Ammonia Strategy, Circular Economy Strategy, Outdoor Recreation Strategy, and Green/Natural Space Strategy that will need to be delivered to reverse the decline in biodiversity. Figure 1 illustrates how each strategy/initiative linked with the EIP cuts across multiple Strategic Environment Outcomes.

The challenges of implementing an effective response to the decline of biodiversity are evident in considering the outcomes of the previous Biodiversity Strategy (2015-2020). DAERA's assessment of this strategy determined that 32 of 57 actions were fully delivered, 22 were partly achieved and three were not achieved.[31] An assessment by the Royal Society for the Protection of Birds (RSPB), however, suggested that just 13 out of 57 actions were fully delivered, 25 partly delivered, and 20 were not achieved.[32] Irrespective of the number of actions fulfilled, delivery of the strategy was insufficient to protect and conserve biodiversity, as evidenced by the ongoing decline and current state of the natural environment.[15,16]

Figure 1. Interconnections between strategies and plans and the delivery of the Strategic Environmental Outcomes in the proposed Environmental Improvement Plan.



Strategic Environmental Outcomes (SEO)

- SEO-1: Excellent Air, Water, Land and Neighbourhood Quality
- SEO-2: Healthy and Accessible Environment and Landscapes Everyone Can Connect with and Enjoy
- SEO-3: Thriving, Resilient and Connected Nature and Wildlife
- SEO-4: Sustainable Production and Consumption on Land and at Sea
- SEO-5: Zero Waste and Highly Developed Circular Economy
- SEO-6: Net Zero GHG Emissions and Improved Climate Resilience and Adaptability

Policies/Strategies

- Energy Strategy
- Water Strategy 'Sustainable Water'
- Nature Recovery Strategy
- Circular Economy Strategic Framework
- Strategic Planning Policy Statement
- Future Agricultural Policy Framework
- Sustainable Agricultural Land Management Strategy
- Nutrient Action Plan
- Ammonia Strategy
- Future Landscape Strategy
- Forestry Strategy
- River Basin Management Plans
- Clean Air Strategy
- Peatland Strategy
- UK Marine Strategy
- Climate Action Plan
- Waste Management Strategy
- Farming for Nature
- Public Health Strategy: Making Lives Better
- Housing Supply Strategy
- New Outdoor Recreation Strategy
- Marine Litter Strategy
- Greenways Strategy
- Joint Fisheries Statement
- Climate Adaptations

1.3 Aims, scope, and structure of this report

The aim of this report is to provide a synthesis and overall assessment of the available evidence for the causes of decline in NI's terrestrial and freshwater biodiversity. This assessment will enable government and others to make evidence-based decisions and will guide the actions required to reverse this decline. To do so requires a clear understanding of the state of the natural environment, the trends and the causes of change.

The Office for Environmental Protection (OEP) has been established with the purpose of protecting and improving the natural environment by holding government and other public authorities to account. This report will therefore also feed into our scrutiny of government's progress with this duty and, in particular, towards achieving the targets and commitments outlined in the EIP.

In NI, evidence linking the causes of change to the decline of the natural environment is often lacking and/or dispersed across multiple sources. This is particularly true for biodiversity (Box 2).[33]

Our assessment focuses on terrestrial and freshwater species and habitats. Where appropriate, we have considered terrestrial coastal species and habitats. Marine biodiversity is not addressed in this report and is the subject of other work programmes, for example our recent assessment of the drivers and pressures affecting the achievement of Good Environmental Status in UK marine waters.[34]

We outline our approach in Chapter 2 and a full description of our methodology is included in Annex Two, with underpinning datasets and commissioned work available on our website. In Chapter 3, we present evidence of the range and consequences of pressures affecting biodiversity, including those that are cross border. In Chapter 4, we identify priorities and set out actions that government should consider to halt and then reverse the decline in biodiversity.

Box 2. A focus on biodiversity: the sum of species, habitats and ecosystems.

Biological diversity, or biodiversity, is the *diversity within-species, between-species and of ecosystems*.[4] This is the diversity of the living natural environment across terrestrial, freshwater and marine systems. The abundance and distribution of biodiversity is impacted by the abiotic constituents of the natural environment (for example, water, air and soil) and their quality. Natural processes in air, soil, water and landscapes shape biodiversity, and in turn the decline of biodiversity disrupts these processes and undermines the health and functioning of ecosystems.

The CBD defines an ecosystem as 'a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit'.[35] The emphasis is therefore on the interactions between living organisms and their physical environment, which function together as a unit. In so doing ecosystems provide a range of services, such as carbon sequestration, soil formation, nutrient cycling and water purification. Ecosystems in NI include peatlands, woodlands and wetlands.

The significance of ecosystems is reflected in the requirement for action to be taken on an ecosystem-based approach to address global commitments, including the CBD GBF.[26] As a signatory to the CBD, the UK, including NI, must take an ecosystem approach to monitoring and evaluation when submitting national reports. This in turn requires that monitoring and reporting frameworks are improved in NI and the wider UK.

Due to limitations in the monitoring and reporting of biodiversity at the level of ecosystems in NI, this report remains largely focused on the pressures affecting species and habitats. This provides a practical approach to understanding the state of, and pressures affecting, the natural environment. However, it does not fully account for the complex interactions between species, habitats and the physical environment. Whilst an ecosystem approach in which these interactions are explored would be beneficial, this is not yet possible in NI.

Chapter Two: Evidence and assessment

2. Chapter Two: Evidence and assessment

2.1 Evidence assessment – our approach

What are drivers and pressures?

Our assessment aligns with the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) definition and classification of drivers and pressures.[36] Drivers are the underlying causes of change that indirectly affect biodiversity and ecosystem processes,[36,37] and can be economic, demographic, governance-related, technological and cultural, among others. Pressures are more direct and are the consequences of indirect drivers. Pressures unequivocally influence biodiversity and ecosystem processes and include natural processes, anthropogenic activities and the consequences of them.[36,37] The IPBES identifies five pressures: land use change, pollution, natural resource use and exploitation, climate change, and invasive species.

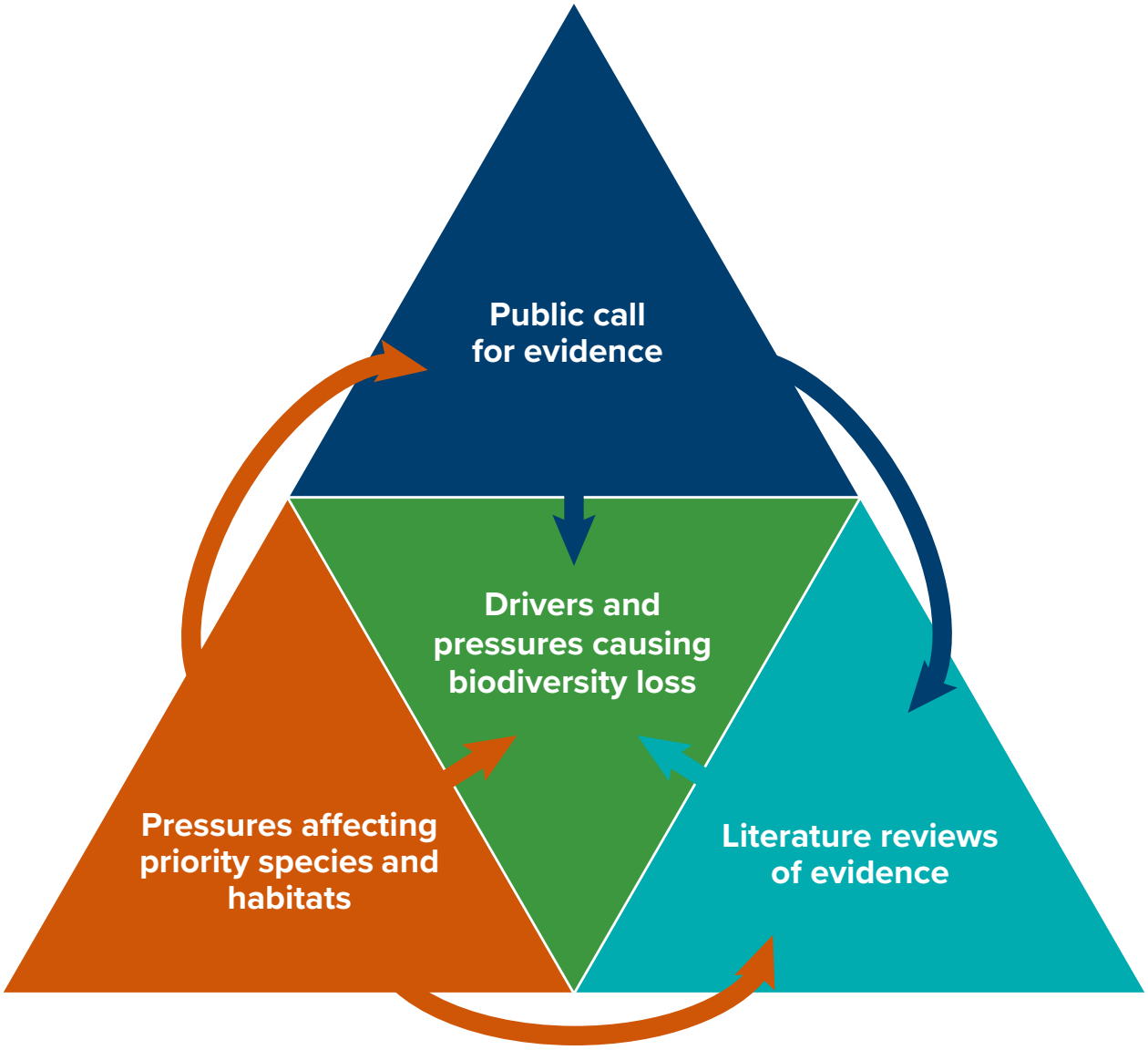
2.1.1 Our use of evidence

In identifying the drivers and pressures affecting biodiversity in NI, we draw on a range of publicly available evidence sources, expert opinion and analytical methods (Figure 2). Our assessment methodology, including the peer review of our report undertaken by members of our College of Experts, is summarised below and detailed in Annex Two.

The evidence base relating to biodiversity in NI is plentiful, strong and consistent in some areas, specific and localised in others, and in some areas evidence is lacking.[33] Our use of multiple, publicly available evidence sources enabled us to synthesise this evidence and develop a broad and sound foundation upon which to base our assessment. We prioritised evidence provided by government, mainly DAERA and NIEA, and other official sources, peer-reviewed literature, and reports produced by scientific organisations and public authorities. Our evidence collection relied on expertise in NI but drew also on that in the wider UK and in the RoI.

We first undertook a frequency assessment of the pressures affecting priority species and habitats. We then undertook a public call for evidence, which was open to all organisations and individuals to submit evidence on the drivers and pressures affecting biodiversity in NI. The call was open from the 7 September to 3 November 2023.[38] Detailed assessment of the evidence from these two analyses is available on our website.[39,40]

Figure 2. Schematic of the methodology used in the assessment of drivers and pressures affecting terrestrial and freshwater biodiversity in Northern Ireland.



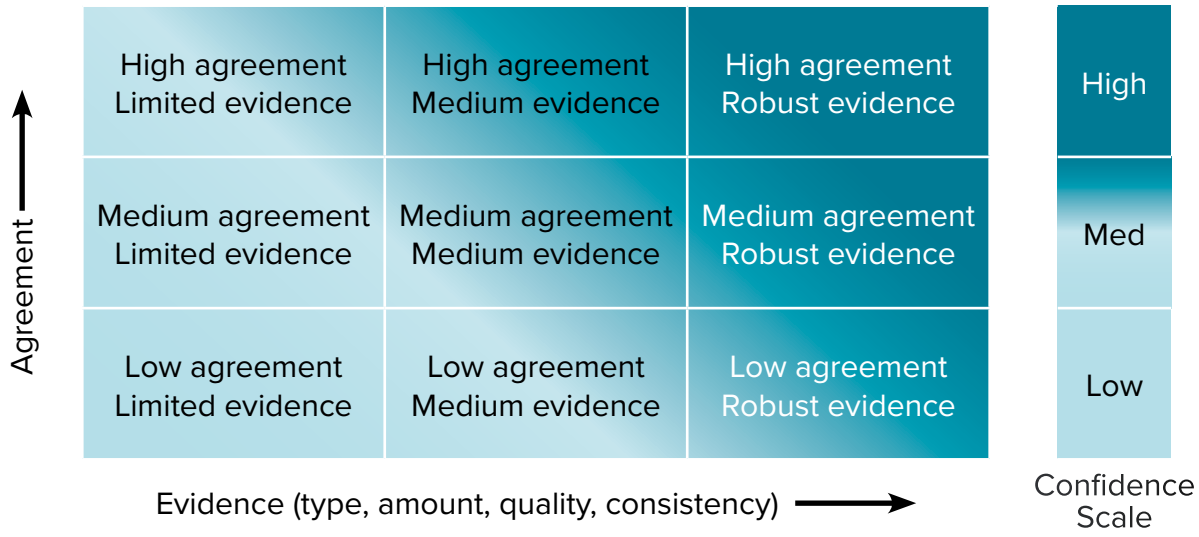
Based on the frequency analysis and the call for evidence, we commissioned six pieces of external research, the reports from which are available on our website. [33,41–45] These were literature reviews on the most frequently cited pressures derived from our analysis: urban and rural development, lowland and upland agriculture, hydromorphology and eutrophication. In addition, we commissioned an overarching review of the literature covering the five categories of pressures presented by the IPBES, and a review of data, monitoring and metrics for species in NI. We conducted our own desk-based reviews of evidence related to the pressures not included in the commissioned literature reviews. This research considered the effects on biodiversity of climate change, natural resource use and exploitation, invasive species, and other pressures, such as chemicals. We reviewed a range of academic, government and other official evidence sources. This also used other, related work that we had commissioned previously, including a review of the monitoring and reporting framework for waste management and illegal dumping.[45]

2.1.2 Our approach to evaluating confidence in the evidence

While the evidence is good in some areas, there inevitably remain gaps and uncertainty in the available evidence on the drivers and pressures affecting biodiversity in NI. Uncertainty is caused by incomplete knowledge of the natural environment, and difficulties in making accurate predictions due to variation between species, habitats, ecosystems and regions. Typically, confidence is greatest and uncertainty is least, when there is robust evidence together with agreement among multiple, independent sources.

We have assessed the confidence that should be placed in evidence by drawing on the Intergovernmental Panel on Climate Change (IPCC) guidance on managing uncertainty in evidence.[46] This provided a common approach for evaluating and communicating degrees of certainty in our findings. Table 1 illustrates the framework used by the IPCC for expressing confidence in evidence, based on the type, amount, quality and consistency of the evidence, and the level of agreement among sources of evidence. Confidence becomes greater as ratings move from the bottom left corner to the top-right corner, towards a robust body of evidence and high levels of agreement. We apply this framework throughout this report and summarise this within the key findings for each pressure.

Figure 3. Intergovernmental Panel on Climate Change framework for communicating confidence and uncertainty in evidence. The figure shows the relationship between the robustness of evidence (type, amount, quality and consistency) and agreement among sources of evidence, and how they contribute to overall confidence. As ratings move towards the top-right corner, confidence increases, as indicated by progressively darker shading. (Source: IPCC 2010)



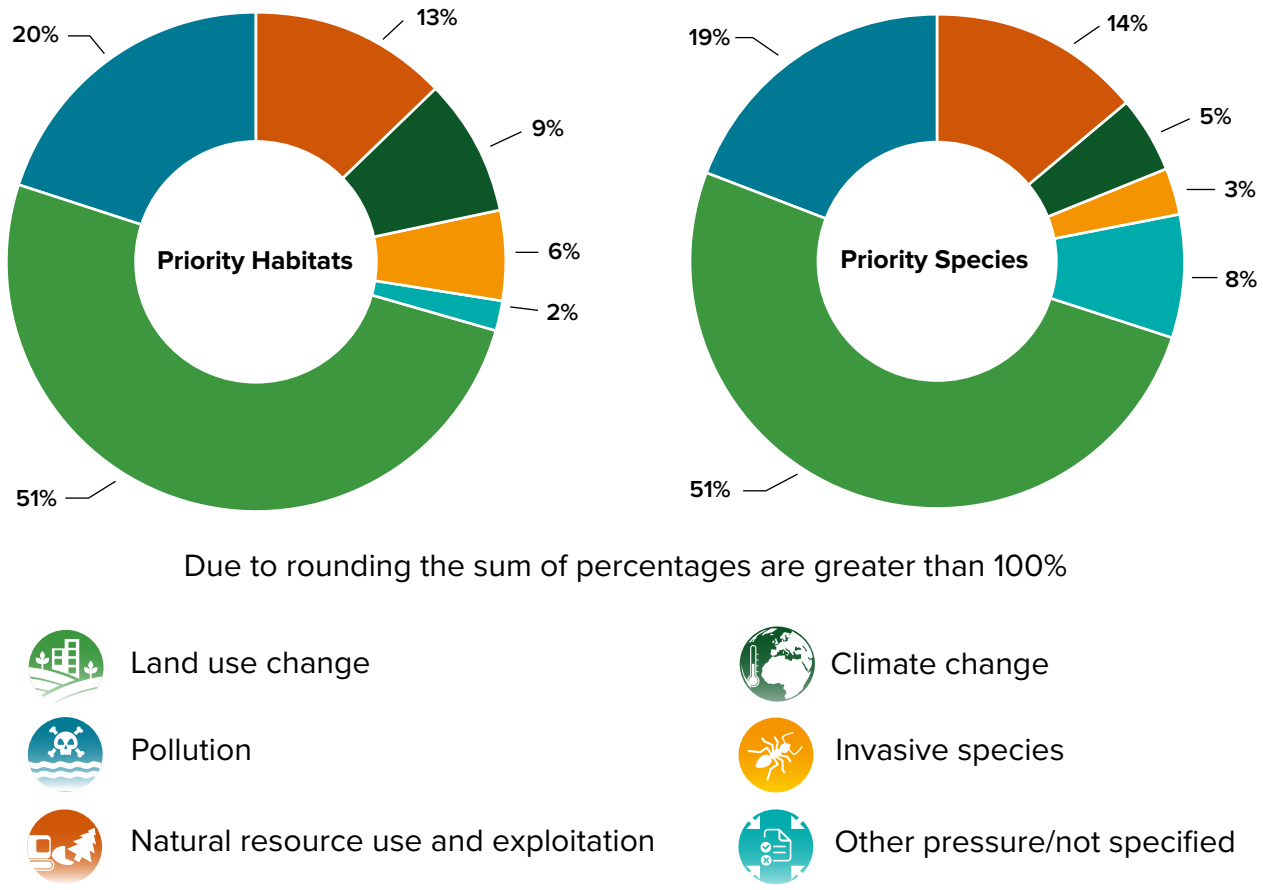
2.1.3 Our assessment of pressures affecting priority species and habitats

Where the evidence allowed, we disaggregated the five IPBES pressures into sub-pressures. This was possible for land use change, pollution, and resource use and exploitation. 30 sub-pressures were identified and our descriptions of these are set out in Annex Three. The evidence we assessed for the frequency analysis did not allow for the climate change and invasive species pressures to be disaggregated. Throughout the report when we refer to sub-pressures, we mean the 30 sub-pressures listed under the land use change, pollution and resource use and exploitation categories, plus climate change,

invasive species and other pressure/not specified. When we refer to 'pressures' we are specifically referring to the five IPBES pressures.

Land use change was the most frequently cited pressure (51% of cited sub-pressures) for both priority species and habitats (Figure 4). Pollution was the next most frequently cited for species (19%) and habitats (20%), followed by natural resource use and exploitation (14% for species and 13% for habitats). For both species and habitats, climate change and invasive species were the least frequently cited pressures. 8% of the cited sub-pressures impacting priority species and 2% of those impacting priority habitats could not be categorised within the five main pressures.

Figure 4. Frequency analysis of reported pressures on (a) priority habitats and (b) priority species in Northern Ireland. The pressures identified were categorised using the Intergovernmental Panel on Biodiversity and Ecosystem Services classification.



The category of 'other pressure/not specified' reflects instances where the sub-pressure could not be attributed to one of the five IPBES pressures. This included, for example, wildfire (not caused through deliberate management practices), species persecution, population dynamics, and predation. As an example, for species persecution 20 species, including raptors and mammals, were identified to be impacted by intentional disturbance or killing, including illegal killing. Beyond the direct consequences for affected individuals, species persecution can alter behaviours, ecological relationships and ecosystem functioning. The reasons for killing, both legitimate and illegal, can include land use change, routine management as part of natural resource use and exploitation, or illegal killing may be a crime of opportunity.[47,48] Due to a lack of direct evidence for many, but not all, species, the conservation impact of this sub-pressure is characterised by uncertainty.[47,48]

The ‘other pressure/not specified’ category also included instances where pressures were not identified in the evidence base. For 104 priority species, the pressures impacting them are either partly, or entirely, unknown. For example, pale eggar moth is extremely rare and localised across the island of Ireland. Around 50% of the Irish population is likely to live at three localities in County Fermanagh. Little is known of its local ecological requirements or threats to its numbers in the context of NI and so we could not account for the specific, local pressures affecting this species.[49] Such gaps in understanding represent a significant challenge in developing conservation actions for some priority species and habitats.

Our assessment of 478 terrestrial and freshwater species and 34 habitats drew upon publicly available evidence sources from DAERA, NIEA, and National Museums NI through www.habitas.org[50] and the NI priority habitats guides.[51]

Table 1. Relative frequency of sub-pressures affecting a) priority species and b) priority habitats in Northern Ireland.

PRIORITY SPECIES				
IPBES pressure category	**Pressure**	**Frequency**	**% contribution to pressure**	**% of total**
Land use change 	Habitat loss & fragmentation – unspecified	106	16%	8%
	Habitat loss & fragmentation – agriculture	91	14%	7%
	Livestock grazing	78	12%	6%
	Agricultural intensification	71	11%	6%
	Habitat loss & fragmentation – development	50	8%	4%
	Afforestation	45	7%	3%
	Hydromorphological change	42	6%	3%
	Military use	39	6%	3%
	Land drainage	37	6%	3%
	Agricultural nutrients	31	5%	2%
	Burning as management	24	4%	2%
	Habitat management – inappropriate	16	2%	1%
	Woodland management – inappropriate	15	2%	1%
	Arable to pasture	15	2%	1%
		660	**100%**	
Pollution 	Nutrients	81	34%	6%
	Water pollution – chemicals	44	18%	3%
	Pesticides	44	18%	3%
	Pollution – unspecified	38	16%	3%
	Water pollution – oil	10	4%	1%
	Water pollution – silt	11	5%	1%
	Waste or litter	8	3%	1%
	Air pollution	4	2%	<1%
	Noise or light pollution	1	<1%	<1%
		241	**100%**	
Natural resource use and exploitation 	Recreation, tourism, sporting activities	67	37%	5%
	Disturbance of species and habitats	33	18%	3%
	Accidental death of species	30	16%	2%
	Erosion or infilling	21	12%	2%
	Commercial fishing	14	8%	1%
	Peat extraction & turf cutting	10	5%	1%
	Aggregate extraction	7	4%	1%
		182	**100%**	
Climate change 	Climate change	**60**	**100%**	5%
Invasive species 	Invasive species	**43**	**100%**	3%
Other pressure/ not specified 	Other, unknown, not specified	**104**	**100%**	8%
		1,290		

Due to rounding the sum of percentages are greater than 100%.

PRIORITY HABITATS				
IPBES pressure category	**Pressure**	**Frequency**	**% contribution to pressure**	**% of total**
Land use change 	Livestock grazing	23	18%	9%
	Agricultural intensification	17	13%	7%
	Habitat loss & fragmentation – development	16	13%	6%
	Woodland management – inappropriate	14	11%	6%
	Habitat management – inappropriate	13	10%	5%
	Hydromorphological change	10	8%	4%
	Arable to pasture	9	7%	4%
	Habitat loss & fragmentation – unspecified	8	6%	3%
	Land drainage	8	6%	3%
	Burning as management	6	5%	2%
	Afforestation	2	2%	1%
	Habitat loss & fragmentation – agriculture	1	1%	<1%
	Military use	1	1%	<1%
	Agricultural nutrients	0	0%	0%
		128	**100%**	
Pollution 	Nutrients	23	46%	9%
	Air pollution	10	20%	4%
	Waste or litter	6	12%	2%
	Water pollution – chemicals	5	10%	2%
	Pollution – unspecified	3	6%	1%
	Pesticides	2	4%	1%
	Water pollution – silt	1	2%	<1%
	Water pollution – oil	0	0%	0%
	Noise or light pollution	0	0%	0%
		50	**100%**	
Natural resource use and exploitation 	Recreation, tourism, sporting activities	17	50%	7%
	Aggregate extraction	8	24%	3%
	Disturbance of species and habitats	3	9%	1%
	Erosion or infilling	3	9%	1%
	Peat extraction & turf cutting	3	9%	1%
	Accidental death of species	0	0%	0%
	Commercial fishing	0	0%	0%
		34	**100%**	
Climate change 	Climate change	**22**	**100%**	9%
Invasive species 	Invasive species	**14**	**100%**	6%
Other pressure/ not specified 	Other, unknown, not specified	**4**	**100%**	2%
		252		

Due to rounding the sum of percentages are greater than 100%.

Pressures affecting biodiversity: Northern Ireland in a global and regional context

Our assessment of the pressures on priority species and habitats has identified land use change and pollution as the primary pressures on biodiversity, followed by natural resource use and exploitation, climate change and invasive species. In the following section we consider how these findings compare with those of other studies carried out at regional and global scales.

Jaureguiberry et al. (2022)[52] analysed the global significance of pressures affecting biodiversity by evaluating their relative importance across different biomes and biogeographic regions. Their study showed that land use change is the dominant pressure affecting recent biodiversity loss in terrestrial and freshwater ecosystems worldwide. Direct exploitation and pollution were identified as the second and third biggest pressures in terrestrial and freshwater ecosystems, respectively. Climate change and invasive species were shown to have significantly lower importance, when compared to the leading pressures.

When focusing on Europe and Central Asia, land/sea use change, and direct exploitation were the first and second most significant pressures on biodiversity, with climate change following.[52] However, the data did not disaggregate terrestrial and freshwater from marine ecosystems at this regional scale.

The UK State of Nature Report 2023[10] concluded that agricultural intensification and climate change are the major pressures on biodiversity across the UK. For NI, the report identified the conversion and loss of natural and seminatural land due to development, urbanisation or intensive management as leading pressures, along with pollution.

The Environmental Protection Agency's 2020[23] integrated assessment of the natural environment in the RoI identified land use change, pollution, and resource use and exploitation as key pressures on habitats and species, and acknowledged the important roles of climate change and invasive species. It pinpointed agriculture as the greatest pressure on habitats, followed by residential, commercial, industrial and recreational infrastructure, and invasive species. For species, the extraction of resources and biological material was identified as the most impactful pressure, followed by agriculture and transport-related pressures.

The fourth National Biodiversity Action Plan for the RoI[53] identified ten key pressures on biodiversity. These pressures align with the IPBES pressures: land use change (overgrazing and undergrazing, development, land drainage, land abandonment, urban wastewater, and river barriers), pollution (water and air pollution), invasive species (alien and problematic species), and resource use and exploitation (recreation).

The NI Biodiversity Strategy 2015-2020[54] identified agricultural intensification, pollution, the spread of invasive species, overgrazing and undergrazing, urban development and associated infrastructure, and climate change as the main pressures on biodiversity. However, it did not attempt to quantify their relative importance.

Overall, across these multiple reports, land use change, driven largely by agricultural practices, followed by pollution and natural resource exploitation consistently emerge as the most significant pressures on biodiversity. The growing threats of invasive species and climate change are also acknowledged throughout.

Scales of change in biodiversity

Quantitative change in biodiversity and its distribution occurs over multiple spatial and temporal scales and does not always directly indicate the significance of impact.

Pressures exerted at only a local scale can have proportionately significant impacts on rare or specialised species that have restricted distributions. For example, holly fern[55] and marsh clubmoss[56] are designated as priority species and have each been recorded at only single locations in NI. Damage or loss of these species in the relatively small areas in which they occur, could therefore lead to their extinction from NI.

Conversely, with agriculture covering 77% of the landscape,[57] the pressures arising from agricultural practices have a significant impact on biodiversity at a large scale. Similarly, climate change is a global scale pressure causing widespread impacts on biodiversity across all biomes,[58] while air pollution occurs over a large area but (aside from impacts caused by ammonia) is considered to be having a relatively small impact on biodiversity in NI.

The timescale over which biodiversity has declined is also important. Biodiversity has been altered by human activities over thousands of years. NI was once covered in woodland, but today woodland accounts for just 9% of land cover (Box 3).[59]

Box 3. The loss and future of woodland ecosystems in Northern Ireland.

Woodlands are important ecosystems supporting a range of plants, fungi, animals, and their complex interactions. They also provide an important range of ecosystem services, such as timber, soil protection, recreation and climate change mitigation.[60]

NI was once dominated by woodland but now has just 9% woodland cover.[59] This compares to 10% cover in England, 15% in Wales, 19% in Scotland[59] and 12% in the RoI.[61] These are all much less than the global average of 31%[62] woodland cover and the EU average of 37%.[60]

The patterns of change in woodland cover in NI are complex and we await the results of the current NI Countryside Survey[22] to assess the most recent gains and losses. Between 1998 and 2007 broadleaf woodland increased by almost 30%, often at the cost of other seminatural habitats. Coniferous woodlands, comprised of non-native tree species that tend to have lower biodiversity value (Box 5)[60,63] decreased between 1998 and 2007, due to changes in policy.[21,24] However, plantations created in the past will continue to impact biodiversity.

Native woodland in NI is not generally in good condition, and areas of ancient woodland are small and fragmented. In addition to historical losses over centuries past, 13% of NI's ancient and long established woodland has been lost since the 1960s.[15] Within woodland protected sites, just 6% of 80 features are in favourable condition.[16] In parallel, there have been decreases in woodland bird species in NI,[15] and across the UK.[64]

Afforestation will be key actions for delivering NI's climate commitments.[65] To achieve the 2050 net zero target and the interim targets set out in the Climate Change Act (Northern Ireland) 2022,[66] the Climate Change Committee indicated that afforestation will need to 'ramp up' significantly.[65] As a nature-based solution to climate change, the expansion of woodland habitat can also benefit biodiversity and deliver socio-economic benefits, such as flood alleviation.[60,67,68] However, afforestation in the wrong areas, such as on deep peat[18] (Box 5), or in open habitats that support breeding waders, can negatively affect biodiversity. There is a need to assess strategically the synergies and trade-offs of delivering afforestation to achieve climate and biodiversity commitments.

While the loss of biodiversity over centuries has been stark, in recent decades the decline has continued apace. For example, there has been a significant decline in Atlantic salmon populations across the North Atlantic since the 1980s.[69] Along with other pressures, such as water quality, siltation, exploitation and changes to water flow regimes, this has consequences for populations of freshwater pearl mussel, the larval stage of which is dependent on salmonids.[70] Surveys conducted in the 1990s found pearl mussels in 20 sites, mainly in the west of NI.[71] There are now thought to be just three significant populations and scattered smaller populations remaining.[70] Despite conservation efforts, including investment in research and breeding programmes, both salmon and pearl mussels continue to decline.

While such vivid examples of decline create a bleak picture of failure, conservation efforts can be effective in halting or reversing losses over relatively short periods of time. A recent global study on the impact of conservation projects over the past 100 years demonstrated

that decline was reversed or halted in three-quarters of cases.[72] The majority of these conservation efforts had been implemented since the 1970s.

Local examples demonstrate the positive impact of conservation efforts over recent decades. Corncrake, once widespread across NI, faced local extinction as regular breeders in the 1990s. Habitat creation on Rathlin Island led to the return of the corncrake in 2014, with the population slowly increasing since then.[73] Similarly, since 1987, there has been an 80% decrease in the population of curlew,[32] however, conservation efforts since the early 2000s, have resulted in the local breeding populations of curlew increasing in the Antrim Hills and around Lough Erne.[74] The recovery of one species or habitat often benefits the wider ecosystem. For example, increases in the abundance and distribution of pine marten, since it gained legal protection in 1985,[75] have had positive impacts on another priority species, the red squirrel, by virtue of martens controlling non-native, invasive grey squirrels, which compete with native red squirrels.[76]

Whilst the fortunes of corncrake, curlew and pine marten show that species conservation efforts can achieve successes over relatively short time periods, the wider recovery of biodiversity requires time. For example, depending on the scale of degradation, peatland restoration can take decades or centuries to be fully effective.[77] Even with such gradual recovery, positive actions can start to deliver benefits in the short term. The recent rewetting of previously drained peatland on the Garron Plateau is already demonstrating positive environmental, social and economic benefits, including improving raw water quality.[20]

Chapter Three: Our assessment of the evidence

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3.1 Land use change

Land use change involves the conversion and intensification of seminatural landscapes into areas for agriculture, urban development and industrial use, leading to habitat destruction, fragmentation and degradation. The conversion of forests, wetlands and grasslands into farmland, towns or infrastructure causes the displacement or loss of native species. The fragmentation of habitats makes it difficult for species to migrate, reproduce and access food and territories, leading to population declines and reduced genetic diversity.

3.1.1 Key findings

Land use change	
Confidence	Key findings
High	Land use change, and the resulting habitat loss and fragmentation, is the biggest cause of the decline in biodiversity in NI.
High	The majority of land use change in recent decades is attributable to the expansion and intensification of agriculture in NI.
Medium	Urban and rural development has resulted in habitat loss and fragmentation.
High	Hydrological modifications to rivers and their catchments, to support land use intensification and development, has caused significant loss and fragmentation of terrestrial and freshwater habitats.
High	The overall rate of habitat loss and fragmentation due to land use change appears to have slowed, but historical changes continue to impact biodiversity.

3.1.2 Strength of evidence

There is robust evidence and high agreement (high confidence) across government, non-government and academic sources that land use change is the primary cause of biodiversity decline in NI. The NI Countryside Survey from 1991-2007[21] and the UK National Ecosystem Assessment (UK NEA)[24] provide a solid evidence base on the extent of land use change in NI. We await the 2026 publication of the results of the current Countryside Survey[22] to establish whether and how habitat has changed in the last 20 years.

There is robust evidence and high agreement (high confidence) that agriculture is the main cause of habitat loss and fragmentation. Furthermore, there is medium evidence and high agreement (high confidence) that agricultural land use change is one of the main causes of

biodiversity decline in NI. Key evidence comes from the NI Countryside Survey,[21] farmland bird monitoring[15] and a substantial body of research on the impacts of agriculture.

There is limited empirical evidence but high agreement among stakeholders and experts (medium confidence) to support the extent of the impacts of urban and rural development on biodiversity. Existing evidence is localised and largely specific to certain habitats, species or to particular developments. There is limited evidence on the cumulative impact of multiple developments over time on biodiversity in NI.[44] There is medium evidence regarding the impacts of hydrological modifications of land and water bodies on biodiversity and high agreement (high confidence) that such modifications have had impacts.[42]

3.1.3 Our assessment

Land use change accounts for just over half of all cited sub-pressures affecting priority species and habitats in NI and is the leading pressure affecting biodiversity in NI (Figure 4). The causes of land use change include management and conversion of land for agriculture, urban and rural development, and afforestation (Table 1).

Our assessment of land use change pressures is focused on agriculture, urban and rural development, and hydrological modifications. This approach is guided by weight of the evidence we have assessed but is supported by wider research and submissions to our call for evidence.[21] For example, the NI Countryside Survey,[21] which recorded land use changes to 2007, identifies agriculture and urban and rural development as leading causes.

Agriculture is the dominant land use in NI; the landscape now consists of 77% agricultural land.[57] The spatial extent of agricultural land in NI continues to increase, albeit at a slower rate than in the past. In the UK, just over 70% of land is said to be used for agriculture, in the RoI the figure is 62%, but across Europe is 39%.[57] The extent of urban and built up areas in NI has increased, reaching just over 5% in 2007.[21] The UK NEA uses an alternative metric, where just over 3% of NI was urban in 2002, compared to 2% in Scotland, 4% in Wales and 11% in England.[78] As a result of these trends, nature is being squeezed into smaller and more fragmented areas.

Land use change in NI continues today, albeit at a slower rate.[15,21,57] Ongoing agricultural expansion and intensification, along with urban and rural development for housing, infrastructure, industry and energy production are placing significant pressures on biodiversity. Past land use changes continue to affect biodiversity today. For example, changes to habitat connectivity in past centuries affect present day species movements and ecosystem functioning.

Agriculture

Agriculture and food processing are important to the economy and society of NI. The agri-food industry is described as the largest manufacturing industry, producing food for five times the population.[79] Agriculture is also socially and culturally important, with farms generally being small, family-run enterprises, accounting for just over 2% of employment,[57] while the entire agri-food sector accounts for just under 5% of total employment.[79]

The growth of agri-food has been prioritised by government. Expansion and intensification of this sector, however, has come with environmental costs. This includes, for example, the

loss and fragmentation of seminatural habitats through their conversion to more productive, improved grasslands.

The negative environmental impact of past and current agricultural practices are widely acknowledged. For example, the Independent Strategic Review of the NI Agri-Food Sector in 2022 stated: 'The environment has paid the price for what, on one level, is the impressive success of NI agri-food in growing its livestock sector over the last 40 years'.[79] A similar observation was made in DAERA's 2021 Consultation on Future Agricultural Policy Proposals for NI, which stated: 'changing farm practices over many decades, has resulted in habitat and biodiversity losses across our farmed landscape'.[80]

Agriculture can, however, deliver positive environmental outcomes and is among very few mechanisms for achieving this at scale, through nature-friendly farming practices. Conserving and restoring biodiversity in agricultural landscapes is also central to Target 10 of the GBF.[81]

Our analysis reveals that agricultural practices are a dominant land use change pressure. Habitat loss and fragmentation, livestock grazing, agricultural intensification, agricultural nutrients and the conversion of arable land to pasture together account for nearly 40% of land use change sub-pressures affecting priority species and habitats (Table 1). Grazing alone accounts for 12% of the land use pressures affecting priority species and 18% on priority habitats (Table 1).

These findings align with the submissions to our call for evidence. Intensive agriculture was identified across responses as the dominant land use change pressure. Specific pressures included increasing livestock numbers, nutrient enrichment, grazing regimes, inappropriate habitat management and the conversion of natural and seminatural habitats. Observations that the agriculture sector is exceeding the carrying capacity of the natural environment were reflected in evidence of the need for, and the role of the sector in adopting, nature friendly farming practices.

Expansion and intensification of agriculture

Since the 1980s, there has been a shift to more economically productive forms of land use. Agriculture now dominates the landscape, increasing from just over 73% to 77% of land area between 2012 and 2022.[57,82] During this time just over 50,000 ha was converted to agricultural land. We await the results of the current NI Countryside Survey to understand the land use change associated with this increase in agricultural land. Previous land use change has resulted in the landscape becoming more uniform, with fewer and more fragmented pockets of seminatural habitats upon which biodiversity relies.

The key change reported from the late 1980s is the increase in improved grassland.[21] Improved grassland is a term used to describe land sown with rye-grasses and clover[21,24] making them less diverse than seminatural grasslands. Improved grasslands are often treated with organic and manufactured fertilisers, and with other agrochemicals such as pesticides, primarily herbicides. They have often been drained to enable intensive management. We assess and describe the impacts of fertilisers (nutrient enrichment) and land drainage later in this chapter.

Between 1986 and 1998, improved grassland increased by 33% (141,000 ha),[83] which is equivalent to around 10% of the total land area of NI. In the subsequent period 1998 to 2007, it increased by a further 3% (18,000 ha).[21,24] This increase has been brought about by

the conversion of seminatural habitats, neutral grassland and arable and horticultural land to improved grassland used for grazing livestock and silage production.[24] While improved grasslands are beneficial for livestock production, they have a lower diversity of plant species.[24] Improved grasslands are homogeneous and lack variation in ecological niches, meaning the variety of conditions and community interactions that many species require. As an example, the Irish hare (a priority species with high cultural value) has been negatively impacted by agricultural intensification, including grassland conversion (Box 4).

Box 4. The Irish hare.

The Irish hare is a distinctive subspecies of the mountain hare and is the only native lagomorph on the island of Ireland. This species holds significant ecological and cultural importance, leading, in part, to its protection under The Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995.[84] Irish hares thrive in grasslands. In addition to feeding on grasses, their diet is adaptable and can include sedges, thyme, bilberry, and young tree shoots, depending on the available habitat. This dietary flexibility helps hares to survive in a range of habitats.

Historically, the Irish hare was widespread and common throughout the island of Ireland. There was a large decline in the 50 years leading up to the 1960s.[24] The overall trajectory of Irish hare populations is downward, suggesting that ongoing threats could lead to further declines. Several key factors are driving this trend. Agricultural intensification and the associated homogenisation[85] of the farmed landscape has posed significant challenges to its population.[85] As a grassland species, the conversion of natural, unimproved or semi-improved grasslands to improved grassland is not necessarily inherently negative, rather it is the intensive management associated with silage production that is damaging. Practices such as grass rolling and repeated mechanical harvesting of silage during the hare's breeding season[85] are thought to be particularly detrimental, as they threaten the survival of leverets (young hares). Agricultural intensification therefore not only leads to loss of valuable habitat variability, but also directly impacts hare populations through harmful associated management practices.

The native Irish hare also faces significant competition from the invasive brown hare, which has been expanding its range on the island of Ireland. The brown hare tends to outcompete the Irish hare for habitat and food resources and exhibits greater resilience to climate change, further threatening the native species.

Conservation efforts for the Irish hare are addressing both management of habitats and of invasive species. The current population of the Irish hare is considered stable but it still faces threats from habitat loss, agricultural practices and climate change.

The change in land use to improved grasslands has enabled a significant increase in the number of livestock in NI. During the post war years there were around one million cattle, this number increased from the late 1960s.[86] In the 1980s, there was an average of 1.5 million cattle, which continued to increase to a peak of just under 1.8 million in 1998.[87] Latest figures indicate there were 1.7 million cattle in 2022, which is a small increase on 2021, but is stable when compared to the previous five years.[57] Stocking densities of cattle are thought to be much greater in NI than the rest of the UK.[10]

In addition to cattle, there are currently two million sheep, three quarters of a million pigs and a poultry flock of just under 21 million.[57] In particular, the number of pigs has increased year on year since 2018, while the number of sheep has remained stable, and that of poultry appears to be decreasing.[57]

To support the increase in livestock numbers, there has been an increasing reliance on agrochemical inputs. As a pollution pressure, we specifically assess the impact of agrochemical inputs in section 3.2.3. In this section, we consider the trends in use as an indicator of the intensification of agriculture in NI.

The use of nitrogen fertilisers increased from an average of 87 kg nitrogen/ha (N/ha) in 1980 to 148 kg N/ha in 1994 and has since gradually decreased, returning to levels similar to the early 1980s. In the 1980s and 1990s, the use of phosphorus fertilisers fluctuated between 10 and 15 kg phosphorus/ha (P/ha), before declining in the early 2000s to current use levels of approximately 4 kg P/ha.

Direct fertiliser inputs to grasslands, however, are not the only significant source of nutrients. The artificial feeds fed to livestock also contain phosphorus. Livestock have been fed increasing quantities of artificial feed since the 1980s and this represents a striking change in phosphorus inputs to farming. In 1980, 8,260 tonnes of phosphorus were fed to

livestock in artificial feed and this had increased to 14,855 tonnes of phosphorus in 2022. Phosphorus in animal feed now accounts for approximately 80% of the phosphorus surplus in agriculture.[88]

Pesticides, including herbicides, have become central to modern farming and to protection of plant yields and food security. Pesticides are intrinsically harmful to living organisms and have been shown to impact biodiversity generally, and insects in particular.[89,90] Data on pesticide use in NI is collected by the agricultural sector.[91] In NI, most of the pesticides used are herbicides, accounting for 89% of the treated area and 98% of the total weight of pesticides used. The most recent report for 2021 shows the area receiving pesticide treatment increased by 6% and the total weight of pesticides applied had increased by 22% relative to 2017. Most of this increase relates to grasslands. The decrease in pesticide use seen during the 2000s has reversed.[92] This is despite legislation relating to pesticide use and subsequent regulation.[93] Across Europe, studies have shown reductions in insect abundance and diversity due to agrochemicals (pesticides and fertilisers). For example, exposure to low concentrations of agrochemicals has direct and indirect impact on plants in field margins and insects.[94] Agrochemicals may also have an indirect impact on birds reliant upon insects as a food source[89] although further research is needed.[95]

The transition to more intensively managed land for agriculture has occurred in parallel to other changes to the farmed landscape. One such change is the removal of hedgerows, which are an important habitat for farmland birds and for bats and other mammals.[24] Since the 1950s, field boundaries have been removed to increase field sizes. Data indicate that 4% of hedgerows in NI were lost between 1986 and 1998, and decreased by a further 4% between 1998 and 2007.[24] The area of bogs and other wetlands (fens, marsh, and swamp) has also decreased across NI since the 1980s.[24]

Other changes include an increase in built up areas and an increase in woodlands on a range of habitats.[24] An increase in woodland can be positive. This increase is partially attributable, however, to a lack of management resulting in ecological succession to woodland.[24] Here the biodiversity value of the original seminatural habitat is replaced by that of woodlands. Whilst the transition to woodland is quantified in the UK NEA,[24] the amount that is attributable to lack of management and succession is not clear.

Changes and loss of such habitat types is reflected in trends of biodiversity, such as the decline of bird species associated with farmland, woodland and wetlands.[16] In the following sections, we use the examples of farmland birds, breeding waders, and upland habitats to demonstrate the scale of the impact that agricultural land use change has had on biodiversity in NI.

We have selected farmland birds and breeding waders as the abundance and distribution of birds are indicators of the state of biodiversity. Due to their position at, or near to, the top of food chains, birds are relatively sensitive to environmental change. In addition to the established data sets and understanding of bird biology and life histories, bird species found in farmland, woodland, uplands, waterways and wetlands indicate the condition of ecosystems.[15] Monitoring data have shown that farmland birds have experienced a significant decline in recent years.[15,16]

We have selected upland habitats as they support a wide range of flora and fauna, some of which are restricted to these areas. The uplands of NI, such as the Antrim Plateau, include areas of blanket bogs, wet heath, dry heath and alpine heath.[41] Blanket bogs and upland heathland are both priority habitats, with the former being globally rare.[77] The restoration

of these habitats is not only vital for reversing the decline in biodiversity but also in contributing to climate mitigation and adaptation.

Impact of agriculture on farmland and breeding wader communities

Change in land use is a principal pressure affecting bird communities, such as those found on farmlands (Figure 5).[43] Agricultural expansion and intensification, including the move to improved grassland, has had a significant impact on farmland birds. According to the 2023 State of Nature report for NI, there has been an average decrease of 43% in the abundances of farmland birds between 1996 and 2021.[15] This decline is also manifest in England (59%) and Wales (29%), though there has been an increase of 13% in Scotland.[10] As the indicator started after agricultural intensification had commenced in NI, it is highly likely the indicator underrepresents the total impact of agricultural land use change.[15]

Intensive agriculture affects farmland birds through the loss of habitat, and loss of food sources such as insects and winter stubble. Farmed landscapes have become increasingly homogeneous with intensification, including by conversion to improved grasslands reducing the ecological diversity that bird communities, and other species, require.[43] Other activities, including land drainage, application of nutrients and increased frequency of grass cutting for silage, are causing habitat loss and fragmentation, and reducing feeding opportunities.[10]

13 of the 17 farmland bird species in NI are in decline (Figure 5). Eight of the farmland bird species are also priority species and all but one have declined, some by over 50%.[16] Yellowhammers, for example, are a seed-eating farmland species that has been negatively impacted by the conversion of low intensity arable farmland to improved grasslands. Yellowhammers are also impacted by inappropriate hedgerow management.[96]

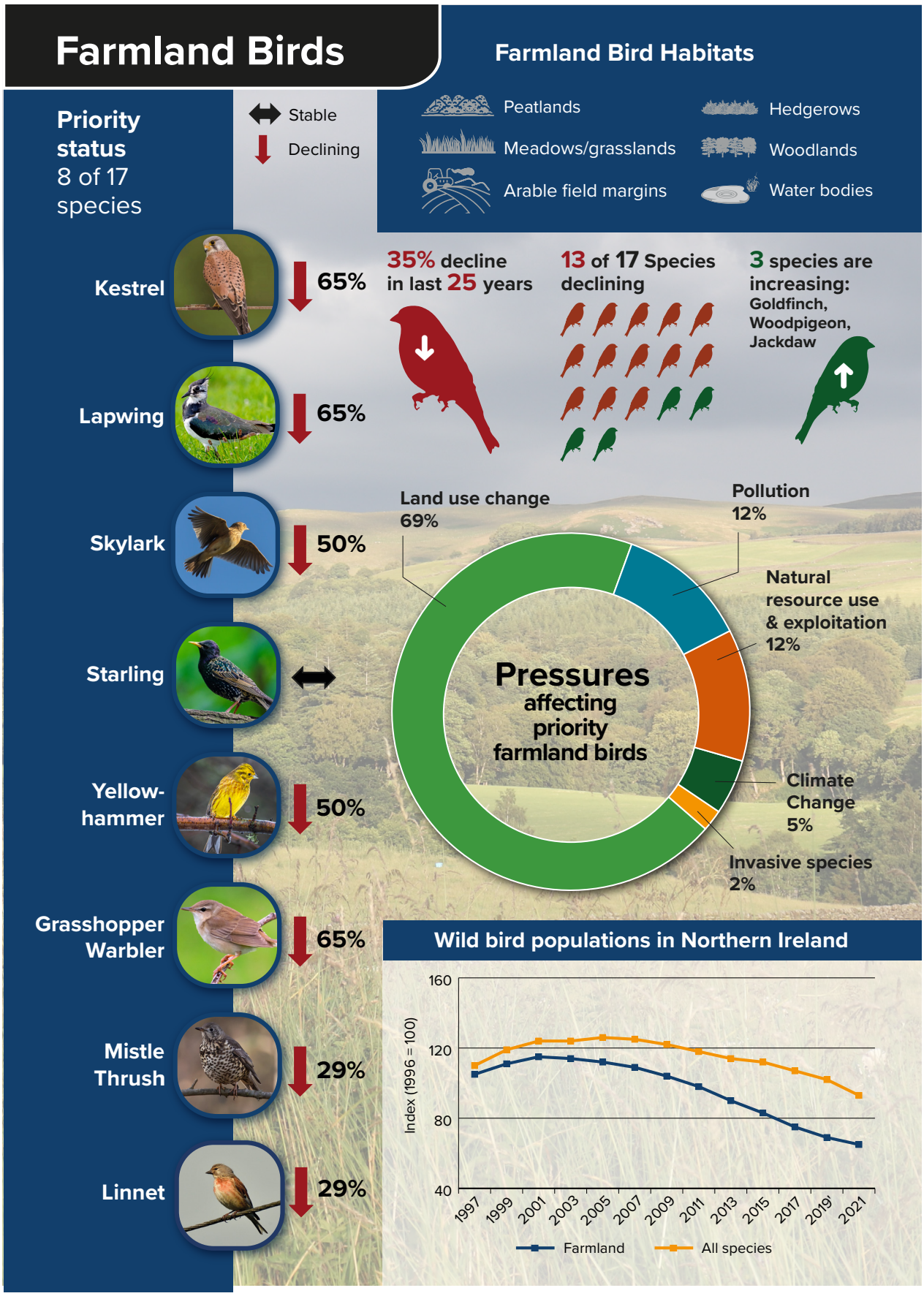
A number of generalist bird species have benefited from recent changes in farming practices.[16,43] For example, increases in sheep grazing and the expansion of improved grassland have increased the availability of carrion and soil invertebrates leading to an increase of 179% in hooded crow populations between 1995 and 2022.[43]

Breeding waders have been negatively impacted by agricultural expansion and intensification.[43] The term breeding waders describes birds that are largely associated with wetland or shallow waters, although many utilise drier habitats, including farmland or moorland, during the breeding season. Breeding waders found in NI include lapwing, curlew, and redshank, all of which are priority species. These are all reliant on priority habitats, including seminatural grassland and peatlands.[43]

Once common and widespread, populations of breeding waders in NI have experienced significant declines.[43] The effects of climate change, including changing weather patterns, are understood to be negatively impacting waders throughout Western Europe.[43] However, the period of decline corresponds most closely to the period of agricultural expansion and intensification. Recent estimates suggest that, between 1987 and 2013, internationally important breeding populations of lapwing, curlew and snipe in NI declined by 84%, 89% and 80%, respectively.[43] While conservation action in the Antrim Plateau is benefitting curlew, they, along with snipe, are now largely limited to Counties Fermanagh and Tyrone.[43] Assessments of lowland wet grasslands demonstrate that redshank populations had decreased by 76% by 2018-2019 relative to 1985-1987.[43,97] Of a sample of lowland damp grassland sites in NI, 64% had no breeding waders present in 2018-2019.[43,97]

The loss of nesting and foraging habitat, and increase in nest predation by foxes and corvids are harming the breeding success of waders in NI.[43] These pressures are brought about by, for example, inappropriate afforestation of peatland providing increased predator habitat, expansion of homogeneous habitats, chemical fertilisation, and increased cutting and use of machinery. Whilst the increasing intensity of land use is harming waders, so too can the opposite process, in the form of abandonment of land, resulting in scrub and tree encroachment of open landscapes. We know from the NI Countryside Survey and UK NEA that abandonment and succession is apparent in certain locations but the extent is not known. Studies from Eastern and Central Europe have linked abandonment to declines in wader populations.[43]

Figure 5. Summary of population changes and pressures impacting farmland birds in Northern Ireland. Data are adapted from (1) our frequency analysis of the pressures on priority species (2) DAERA Environmental Statistics report 2024 (3) Breeding Birds Survey 2022.



Pressures on upland habitats

Upland habitats are not in good condition in NI.[41] Assessments of blanket bog within protected sites, for example, demonstrate that it is largely in unfavourable condition.[41,98] A significant proportion of blanket bog and other upland habitats, however, lie outside the protected site network. These are likely to have less management in place and be in unfavourable condition, a conclusion reflected in the NI Peatland Strategy 2022-2040.[18] The current poor state of upland habitats is as a result of the multiple pressures from agricultural expansion and intensification. These include drainage, afforestation (Box 5), burning and, increasingly, deposition of ammonia from lowland agricultural sources.[41]

Box 5. Afforestation of upland habitats.

Afforestation with non-native trees was carried out and managed by public bodies to increase timber production. As food production had been prioritised, forestry predominantly occurred on poor quality land.[41] During the 20th century, over 55,000 ha of coniferous forest were planted, often in the uplands.[41] From the late 1990s, afforestation on habitats recognised as having high biodiversity value ceased, with Forest Service guidance being that intact blanket bogs and certain degraded blanket bogs should not be afforested.[99]

Most of the historic afforestation in the 20th century was on peatlands, which involved them being ploughed and fertilised, in addition to being drained. Once established, coniferous forests have less biodiversity value than broadleaved forests, as they lack heterogeneity[60] and often have less value than the previous habitat. However, woodlands can support biodiversity with appropriate management. Conifer plantations also affect biodiversity in adjacent upland areas and have wider impacts, including on water quality, rates of evapotranspiration and release of greenhouse gases.[41] Coniferous forests also harbour predators[41] with negative impacts on ground-nesting birds, in particular. Whilst this and other forest edge effects can have negative impacts, edges created by afforestation can benefit certain species through the structural diversity that edges provide.

Impact of grazing on upland biodiversity

Grazing is a non-uniform process where livestock alter the vegetation cover through selective defoliation, trampling and deposition of excreta. A diverse vegetation structure supports biodiversity by creating opportunities for species of plants, insects, birds, reptiles and mammals. Grazing strategies and other land management decisions can influence biodiversity, both positively and negatively.[41]

Grazing practices are of particular importance in the uplands of NI where the majority of habitats are peatlands. Biodiversity in these areas is closely related to the condition of vegetation which is influenced by seasonal grazing practices.[41]

Livestock, particularly sheep, are selective grazers, choosing the most nutritious plants available, which vary seasonally.[41] Heather provides the most nutritious feed in early spring, but once grass growth begins, animals prefer grazing on grasses. Poor vegetation condition can result from livestock densities that do not match the growth patterns of vegetation or from excessive grazing of certain plant communities.[41]

Heather cover has been shown to reduce with increased grazing and as such significant increases in livestock numbers led to widespread habitat deterioration. These changes affected the structure and botanical composition of vegetation.[41] In this way, inappropriate management adversely affects upland plant and animal communities. Overgrazing, caused by a significant increase in livestock numbers, has been blamed for habitat modification and consequent changes in biodiversity.[41] Historic levels of overgrazing, driven by European agricultural policy, has been particularly damaging in NI.[41] After joining the European Economic Community in 1973, sheep numbers rose dramatically from 1 million in the late 1970s to a peak of just under 3 million in 1998.[86] This increase was driven by headage payment regimes and Less Favoured Area support.[41] From the late 2000s, sheep numbers declined to around 2 million and have remained relatively stable since.[86]

Undergrazing may also be damaging to upland habitats in certain situations.[24,41] In some areas, upland habitats are dependent upon livestock selectively grazing vegetation, preventing succession from distinctive upland vegetation to scrub and then woodland. Other practices, such as burning, can also prevent succession, but have inherent risks and can also have negative impacts on habitats and species.[41] Evidence of the cumulative impact of undergrazing in Northern Ireland is, however, inconclusive.

To support the expansion of upland agriculture, peatland drainage has been a common practice. Such practices are aimed at lowering the water table to dry out heathlands and so replace moss and heath communities with grass and extend the period for which land can support livestock grazing. Drainage has also occurred to support the afforestation of uplands (Box 5 and Box 7). Decades of extensive drainage in the uplands have led to peatland degradation, characterised by fluctuating water table depths that dry peat layers, exposing them to conditions that favour soil carbon losses.[41]

Evidence to show how inappropriate levels of grazing have affected biodiversity of upland habitats is based upon studies on a small number of sites in NI, but which are consistent with the results of similar studies across GB.[41] For instance, overgrazing caused significant heather habitat loss on Glenwherry Hill Farm Centre in NI.[41,100] Early winter grazing by cattle also caused damage,[41] whereas summer grazing by sheep and cattle was found not to be detrimental and possibly beneficial, slowing down succession.

Studies have shown that habitat mosaics, which are spatially and temporally heterogeneous support a wider range of birds and other species than uniform vegetation.[41] For example, hen harriers are largely confined to the hills and uplands across the island of Ireland and require forage areas, such as grazed blanket bog or upland heathland, in favourable condition as well as nesting areas with large blocks of taller under grazed heather.[41] However, declines in hen harrier populations are not just due to the intensification of agriculture in upland areas. Other pressures include illegal killing, afforestation, peat extraction, increased public access and wind farms.

Studies have also found that upland grasslands managed under agri-environment schemes have higher terrestrial invertebrate abundance and greater family-level richness compared to those managed conventionally. This improvement is attributed to these schemes maintaining more diverse plant swards with a higher coverage of native plant species, which provide habitat for invertebrates.[41]

Past agri-environment schemes have sought to apply universal management prescriptions across diverse soil and vegetation communities. These schemes have not been successful in delivering effective action to maintain or restore biodiversity.[41] A site specific approach to grazing is required that takes into account the species and habitats present as well as farming practices and livestock type.[41]

Urban and rural development

After pressures relating to agriculture, the second most frequently cited land use change sub-pressure was habitat loss and fragmentation associated with development. Responses to our call for evidence also placed development as the second most significant land use change pressure. The 2023 State of Nature Report for NI also highlighted development as a significant pressure.[15]

Land use change caused by urban and rural development creates a range of pressures on biodiversity. The loss of natural or seminatural habitats to development and urbanisation is of principal importance.[15] This occurs across a range of sectors including housing, energy, transportation and agriculture, and at a rage of scales from single houses to industrial developments. Other pressures caused by urban and rural development, such as pollution and resource use are considered in sections 3.2 and 3.3 respectively.

The NI Countryside Survey found that in 2007, over 5% of land was urban or built up, following a 30% increase between 1998 and 2007. Prior to this, between 1986 and 1998 there had been a 16% increase.[21] These increases in urban and built up areas were largely at the expense of greenfield sites, including improved grasslands and neutral grasslands, which is likely to have an impact on biodiversity.[21] Whilst the area of land lost to urban and rural development has been relatively small compared to agriculture, it has resulted in the loss of important habitats. Such loss is illustrated by the Bog Meadow in Belfast (Box 6).

Box 6. Bog Meadow, Belfast.

Since 1901, Belfast has more than doubled in area, from 67km^2 [101] to the current 132km^2. This expansion has resulted in the loss of a significant quantity of seminatural habitat from the land around Belfast. The current Bog Meadow is the remnant of a much greater area of habitat, with only 19 ha of wetland currently remaining in Belfast. Historically, Bog Meadows were part of the floodplain of the Blackstaff River, covering about 160 ha, which has been lost or fragmented due to developments, such as the M1 motorway in the 1960s. The current site contains some of the original variety of habitats once present, including lowland meadows, reedbeds, wet woodlands and hedgerows and is home to a number of locally rare species of vegetation and invertebrates.

A report on the Bog Meadow in Belfast demonstrated that the cost of maintaining the natural capital assets of the Bog Meadow site was £19,400 per year while the benefits to society were £842,000 per year.[102] The benefits provided by this site include water quality and water flow regulation services, and cultural services including recreation, educational and aesthetic values.

While there are official data relating to the number of developments and the associated environmental assessments in NI, there is limited direct evidence in the form of peer reviewed literature and official reports of any impacts on biodiversity.[44] For example, in 2022/23, over 60% of planning applications in NI related to housing, with 30% of these being for new rural single dwellings[103] often on greenfield sites,[44] this being land which has not previously been developed, often including seminatural habitats. This reflects demographic drivers, including a growing population.[44] Whilst housing is therefore a key development pressure, the extent of direct and indirect impacts on biodiversity remains largely unknown,[44] though the expected impacts include habitat loss and fragmentation, and light and nutrient pollution.[44]

Other significant development pressures in rural areas are associated with the growth of the agri-food sector, which can be inferred from agricultural statistics.[44] In addition to the increase in livestock, there has also been an increase in large scale and intensive farming

developments including poultry holdings. In addition to the infrastructure impacts, there are indirect pressures such as nutrient enrichment (section 3.2.3).[44]

Other greenfield developments that can negatively affect biodiversity include infrastructure for renewable energy, resource extraction (such as quarrying), transport and industry.[44] Whilst helping to mitigate climate change, wind turbines have been identified as a potential risk to biodiversity if located inappropriately. The construction and operation of wind turbines in upland areas has been shown to impact populations of birds and bats.[44] Damage to upland and adjoining habitats by infrastructure development, including renewable energy, is demonstrated by the 2020 Meenbog peat slide, where the construction of a wind farm was associated with a 65,000m^3 peat slide.[104,105] Peat and debris entered the Sruhangarve stream impacting the Mourne Beg and Derg Rivers, which flow into the River Foyle and then Lough Foyle. The peat slide resulted in a significant loss of macroinvertebrates and fish, including Atlantic salmon, and impacted the wider ecosystem.[105–108]

Habitat fragmentation is a significant problem in the case of infrastructure developments such as roads. NI has a road network that is twice the length per person than that of GB, and it has increased by 4% (1,034km) since 2003, compared to a 0.4% increase in GB.[44] While individual stretches of road will have some impact on biodiversity in terms of direct habitat loss, habitat fragmentation will have a cumulative impact across the landscape.

The current lack of data regarding the impact of urban and rural development on biodiversity in NI is an important gap in understanding. This is especially problematic if effective mitigation measures such as 'biodiversity net gain' are to be built into the planning and development process. Where official data are available, it is often not being fully utilized to understand the impact of development.[44] This gap in understanding is compounded by the number of permitted developments that do not require planning permission but which are also likely to affect biodiversity.[44]

While the spatial extent of urban or built-up areas (5%) is significantly less than that of agriculture (77%), the indirect impacts of urban development are substantial. Indirect impacts include solid, liquid and gaseous waste, pollution of air and water and from noise and light, and material consumption, such as energy or food.[109] As an example, the wastewater system in NI is under significant pressure, including from the expansion of urban developments, and patterns of single house development.[110]

Urbanisation has also been shown to disrupt the natural water cycle. Impervious surfaces rapidly move rainwater to receiving waters, altering flow regimes in waterbodies, which impacts freshwater species dependent upon habitats with particular flow regimes.[42] Other such indirect pressures include the offsite impacts of ammonia emissions from livestock housing.[41]

These indirect pressures are addressed further in later sections on Pollution and Natural resource use and exploitation.

Hydrological modifications of land and rivers

Hydrological modifications include changes to how rivers and streams flow though the landscape, and changes to the wider river catchments. Such modifications include straightening, widening, deepening or dredging channels, removing riparian vegetation, arterial and land drainage, and introduction of physical barriers within river systems. For our

analysis, we consider these activities (hydromorphological change and land drainage) as related pressures, accounting for 12% of land use change sub-pressures on priority species and 14% on priority habitats (Table 1). Evidence submitted to our call for evidence support this understanding of hydromorphological modifications as an important land use pressure affecting both freshwater and terrestrial biodiversity in NI. These modifications can also impact receiving marine ecosystems.

Hydrological modification and land drainage across NI has enabled a wide range of land use changes. This includes the conversion of land to improved grassland, expansion of urban and rural developments, afforestation of peatlands, infrastructure development and flood protection. However, drainage of habitats such as peatlands, including blanket bogs, lowland raised bogs and fens, has caused extensive harm to biodiversity (Box 7).[42] Equally, modification of river hydrology has been shown to increase sedimentation, cause habitat loss, and disrupt ecosystem connectivity, which harms species movement.[42] For example, sedimentation in rivers has been a significant additional pressure on freshwater pearl mussel populations.[70] We consider the impact of arterial and land drainage, and physical barriers further below.

Box 7. Drainage of peatland ecosystems.

Peatland ecosystems include blanket bogs, lowland raised bogs and fens, and are crucial ecosystems covering over 3% of the global land surface.[111] In NI, peatlands make up about 12% of the land,[18] and peat soils account for 18-25% of land area.[18,19,112] Peatlands provide ecosystem services, including water storage and flood protection. Peatlands also play a significant role in climate change mitigation through carbon sequestration.

Drainage is a principal cause of the poor condition of peatlands, as set out in the NI Peatland Strategy 2022-2040. Assessments suggest that just 8% of lowland bogs and 15% of upland bogs in NI were intact in 2007.[24] In addition to the extraction of peat for fuel and horticulture (section 3.3.3), drainage, in which the water table is lowered to allow for intensive livestock grazing and forestry, has significantly damaged peatlands. Drainage results in the erosion and loss of characteristic peat-forming vegetation, such as sphagnum mosses. The consequence of this loss cascades throughout peatland ecosystems, including in the loss of priority species such as the marsh fritillary butterfly.[113] Drainage also affects biodiversity beyond the boundaries of the peatland, through alterations to hydrology and river flow across catchments.

Arterial and land drainage

Across the island of Ireland there is a long history of arterial and land drainage[42] in both lowlands and uplands.[41] This is in response to inefficient natural drainage, coupled with relatively high rainfall and the consequent frequent flooding of rivers.[42] It is estimated that 50% of land in the RoI has been subject to some form of drainage.[42] For NI, records of drainage are sparse, however it was estimated in 1988 that since 1947 arterial drainage had occurred on 6,000km of rivers and at higher densities than in the rest of the UK and RoI.[42]

Arterial drainage involves the artificial widening, deepening and straightening of main rivers and streams to increase their effectiveness in draining water from catchments. Land drainage involves the construction of field drains to remove excess water. The rapid drainage of water facilitated by arterial and land drains increases sediment transport from land to rivers and from bank erosion.[114] Many arterial drains involved significant hard engineering to deepen, widen and straighten channels and so had enormous impacts by destroying instream habitat and impacting vegetation, animals and sediment processes.[42]

Riparian zones (the boundaries between water bodies and the adjoining land) are also impacted, for example, by the removal of habitats during widening activities.[42] Arterial drainage often requires ongoing maintenance, including dredging, which is known to cause habitat loss and fragmentation. There are, however, limited records of where and the extent to which freshwater systems in NI have been subject to these modifications.[42]

The evidence reviewed for this report highlights the importance of the small stream network, including headwaters, as critical to riverine biodiversity (Box 8). The small stream network is underrepresented in monitoring programmes such as those required by the Water Environment (Water Framework Directive) Regulations (NI) 2017. While the impact of pressures in headwaters is recognized in academic literature, this is not monitored and not recognised in policy.[42] The cumulative impact of pressures in headwaters are however observed downstream in monitoring programmes.

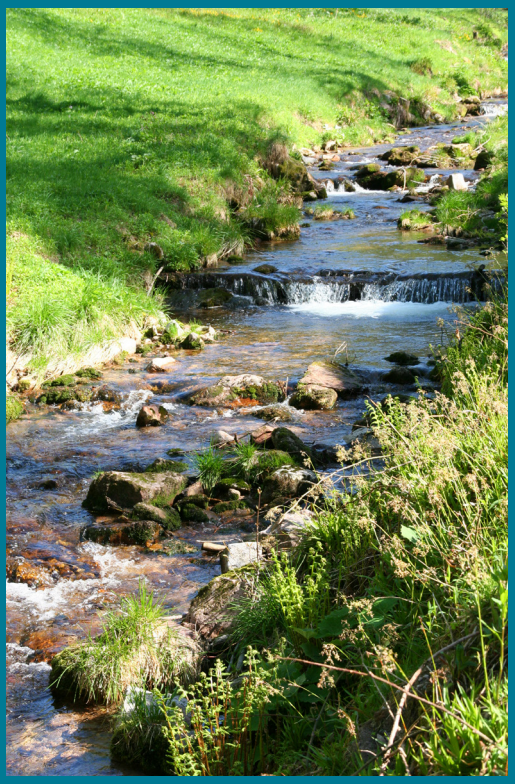
Physical barriers

Artificial barriers in rivers, such as such as culverts, locks, weirs, bridge aprons, fords and dams are frequent and widespread across the island of Ireland. Across Europe, there are over 600,000 recorded barriers, though researchers have estimated the actual number to be over one million.[118] Barriers disrupt river continuity, impeding water movement and the natural siltation process, with direct impacts on biodiversity. Impacts can vary, depending on the type and location of the barrier. For example, complete barriers fragment rivers, preventing migration, reducing breeding success and increasing local extinction risk.[42] Declines in fish populations are widely attributed to barriers, in particular for migratory species such as Atlantic salmon and river lamprey.[42]

River lamprey is a priority species in NI[119] and the rest of the UK.[120] It is found in rivers throughout NI, during its larval and spawning phases, however there is a lack of data on distribution and population size.[119] A key threat is lack of habitat connectivity: physical barriers in rivers restrict the ability of river lamprey to migrate upstream in the autumn to mate and spawn in the following spring when water is the correct temperature.[119] Breeding is reliant upon spawning nests being built in the river substrate (gravel and sediment). If the river flow and sedimentation regime is not good, due to hydrological modifications such as barriers or channelisation, this will impact breeding success. Other pressures on the river lamprey include poor water quality and incidental captures in fisheries.[119,121]

Modifications to rivers and streams such as barriers do not occur in isolation. They add to other pressures such as nutrient pollution, other pollution events and climate change, all resulting in biodiversity loss. These pressures extend along the length of rivers, to estuaries and the sea.

Box 8. Headwaters.



Headwaters[115] are the foundation for naturally functioning rivers and play an essential role in providing natural flood management, trapping sediments, retaining and processing nutrients, and maintaining biodiversity, all of which then extends into downstream reaches, lakes and estuaries.[42]

Along with natural and constructed ditches, drainage channels and first order streams, headwaters (collectively known as the small stream network) constitute a major part of the overall river network across the UK and the RoI.[42,115]

The nature of headwaters makes them intrinsically vulnerable to anthropogenic and global pressures (including land use change, climate change and invasive species)[42,116] that contribute to their chemical and physical degradation.[42] In particular, the high level of connectivity[117] of headwaters to the surrounding landscape makes them particularly sensitive to land use pressures. Altering connectivity changes the water-mediated transfer of matter, energy and nutrients.

3.2 Pollution

Pollution occurs in a variety of forms that have a detrimental effect on biodiversity. Chemical pollutants, such as pesticides, heavy metals and endocrine disruptors can cause acute and chronic health issues in wildlife, including mortality, reduced reproductive success and developmental problems. Nutrient pollution causes eutrophication in water bodies, leading to algal blooms that deplete oxygen levels and impact aquatic organisms. Air pollution also affects ecosystems by altering soil chemistry and water quality, for example, through acid rain and the deposition of pollutants.

3.2.1 Key Findings

Pollution	
Confidence	Key findings
High	Impacts of nutrient pollution are widespread and pervasive across freshwater and terrestrial ecosystems in NI.
High	Agriculture is the dominant source of nutrient pollution in NI.
High	Wastewater is making a significant contribution to nutrient pollution in waterways.
High	While historical practices have contributed significantly to the impacts of nutrients on biodiversity, current inputs into the environment are environmentally unsustainable.
High	Chemical pollution is a threat to biodiversity. However, the extent of chemical impacts on terrestrial and freshwater biodiversity in NI remains largely unknown.
Medium	Light and noise pollution from rural and urban development have impacts on biodiversity but the extent of this impact in NI is unknown.
Medium	Limitations to the monitoring and reporting framework for waste mean the pressure of waste and litter on biodiversity is likely underestimated.

3.2.2 Strength of evidence

There is a robust evidence base across government, non-government and academic sources and a high level of agreement (high confidence) that nutrients represent the greatest pollution pressure in NI and exert a significant and widespread impact on terrestrial and freshwater biodiversity. There is robust evidence and a high level of agreement (high confidence) of the contribution from agriculture to pollution by nitrogen in terrestrial habitats and nitrogen and phosphorus in freshwaters.

Despite uncertainty in relation to accurate source apportionment for wastewater, there is robust evidence and a high level of agreement (high confidence) that wastewater is making a significant contribution to nutrient pollution of freshwaters. Uncertainty exists regarding the overall input of nutrients from wastewater treatment systems, due to factors such as a significant number of wastewater treatment plants operating beyond capacity, insufficient monitoring of combined sewer overflows, and limited data on the management and inputs from small wastewater treatment plants and septic tanks.

There is a medium evidence base and a medium level of agreement (medium confidence) that excess nutrients in soil negatively impact above and below ground biodiversity, but the extent and magnitude of this impact is yet to be determined in NI.

There is medium evidence and a high level of agreement (high confidence) that chemical pollution is impacting biodiversity globally. The evidence base for many chemicals is robust, but still emerging for other chemical and mixtures. There is a limited evidence base and a lack of widespread assessment (low confidence) of the risks posed to biodiversity in NI by chemical pollution. The evidence that is available is localized, species-specific, or habitat specific.

Box 9. What are nutrients?

Nutrients are essential for plant and animal growth, making them crucial for food production. However, excess nutrients can be detrimental to the environment. Nitrogen (in the form of nitrate and ammonia) and phosphorus are the two main nutrients of concern, entering the environment in chemical fertilisers and in animal manure in agriculture, and in effluent from wastewater treatment plants. In terrestrial environments, excess nutrients can cause soil degradation, change in species assemblages, and biodiversity loss. In freshwaters, nutrients lead to eutrophication, promoting algal blooms that deplete oxygen levels, harm aquatic life, and degrade water quality.

3.2.3 Our assessment

All forms of pollution together accounted for 19% and 20% of the cited sub-pressures affecting priority species and habitats, respectively (Figure 4). For priority species, nutrient enrichment (Box 9) accounted for over a third of cited sub-pressures within the pollution category, while for priority habitats it accounted for nearly half (Table 1). Where ammonia and/or nitrogen deposition was cited, we included this as nutrient enrichment sub-pressure, rather than as air pollution. For priority species, pollution of water by chemicals accounted for 18% of cited pressures, and wider pollution caused by pesticides also accounted for 18% (Table 1). For priority habitats, these accounted for fewer, at 10% and 4% respectively.

Excluding ammonia/nitrogen deposition, 20% of pollution pressures on priority habitats related to air pollution, including sources such as combustion engines (Table 1). There were several instances where air pollution was generically referred to within documents on priority species and habitats with no specific pollution source or type identified.

The evidence received through the call for evidence placed pollution as the second most frequently cited pressure. Specific pollution sources and types included atmospheric, water, chemical, light and waste. Responses reflected that whilst some progress has been made in reducing atmospheric pollution,[16] ammonia and nitrogen deposition (largely from agricultural

sources) is a significant pressure on species and habitats.[11,12,15,122,123] Water pollution caused by agricultural practices and wastewater treatment was also identified as a significant pressure in responses to our call for evidence.[38] Submissions highlighted the deleterious effects of waste, light and noise pollution, however evidence of any such impacts on biodiversity across NI is currently insufficient.

Nutrient enrichment

Species and habitats are adversely affected once nutrients levels exceed a certain threshold. The evidence we have reviewed demonstrates nutrient enrichment of freshwater and terrestrial environment in NI is unsustainable if the ongoing decline in biodiversity is to be halted and then reversed.[41,42,124] The current crisis in Lough Neagh highlights the urgency of addressing this issue (Figure 7).

Despite the introduction of legislation over the past three decades,[i] insufficient progress has been made in reducing inputs of nutrients to the environment. For example, DAERA's statistics demonstrate that ammonia emissions from agriculture increased from 2011-2021.[16] Soluble reactive phosphorous concentrations in rivers also increased from 2011-2022, followed by a decrease in 2023.[16] It is too early to determine if this decline will continue.

It is unlikely that these data provide a comprehensive picture of nutrient enrichment in terrestrial and freshwater habitats, as the small stream network, lakes below 50 ha, terrestrial habitats outside of the protected sites network, and soil ecosystems, are not covered by monitoring programmes.

Impact of nutrients on terrestrial habitats

The main form of nutrient impacting terrestrial habitats is ammonia, which, in NI, predominantly arises from livestock farming. Ammonia adversely affects terrestrial habitats primarily through direct exposure of sensitive plant species to atmospheric ammonia, and nitrogen deposition in nitrogen-poor habitats.[41,125] This pollution manifests through the bleaching and discoloration of foliage, while also heightening susceptibility to drought, disease, pests and frost.[41] Furthermore, the increased availability of nitrogen in these habitats leads to the displacement of species, such as liverworts, mosses, and heathers, by nitrogen-loving species, like grasses and nettles.[41]

100% of Special Areas of Conservation (SACs), 100% of Special Protection Areas (SPAs), and 99.7% of Areas of Special Scientific Interest, are exposed to ammonia concentrations exceeding 1 µg/m^3, which represents the long-term annual average critical level for lichens, mosses and the ecosystems they support.[126] Moreover, approximately a quarter of these sites exhibit ammonia concentrations surpassing 3 µg/m^3. At the same time, ammonia emissions continue to increase year on year, from a low of just over 26kt in 2010 to 32kt in 2021.[16] While evidence of the impact of ammonia on protected habitats is clear,[126] the effects of such pollution on NI's wider natural environment are largely unknown and warrant further investigation.

Globally, it is estimated that soils contain >50% of the world's biodiversity.[127] It is estimated that each year in NI, 6,000 tonnes of excess phosphorus are added to agricultural soils, as

i The Nutrient Action Programme Regulations (Northern Ireland) 2019, The Conservation (Natural Habitats, etc) Regulations (Northern Ireland) 1995, Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2017, Urban Waste Water Treatment Regulations (Northern Ireland) 2007, and Water (Northern Ireland) Order 1999

chemical fertiliser and as animal manure.[128] This has resulted in an estimated 40% of soils having phosphorus concentrations above what is required for agricultural crop growth. Across the island of Ireland, soil biodiversity is receiving greater attention,[131] but the impact of widespread nutrient enrichment of soil on biodiversity in NI remains largely unknown. The ongoing Soil Nutrient Health Scheme will provide an invaluable baseline against which to monitor change in soil nutrients, including soil carbon, over time.[132] In addition, it will provide a better understanding of how fungal and bacterial communities are impacted on by management practices.

Nutrient enrichment of soils impacts on above and below ground biodiversity, and typically favours fast-growing, nutrient-demanding species. This is likely to impact on species-rich grasslands, leading to a decline in their diversity. High nutrient levels can also lead to changes in the composition and diversity of soil fauna and microbial communities. For example, it has been demonstrated that application of chemical fertiliser, pig and cattle manures have differential impacts on earthworm populations in NI grassland.[133] While the key driver of these differences was organic matter, the impact of nutrients on plant growth impacted on the biomass of some earthworm species.

Impact of nutrients on freshwater habitats

The detrimental effects of phosphorus on freshwaters in NI have been highlighted by the occurrence of the toxic algal bloom in Lough Neagh (section 3.6),[134] and bringing attention to widespread nutrient enrichment in lakes across the region, including Lough Erne and Lough Melvin.[124] While toxic algal blooms serve as the most visible effect of nutrients, impacts extend throughout the ecosystem. Nutrients also increase growth of larger plants in the edges of lakes, with consequences for the ecological community in shallower waters. Nutrient enrichment often favours a few dominant species of more pollution-tolerant fish species, such as non-native roach, which may increase, while more sensitive fish species, such as Arctic charr, decline. The decomposition of large algal blooms consumes oxygen, leading to low oxygen levels, which then impact on invertebrate and fish communities.

Similarly, in riverine systems, the evidence of impact of nutrient enrichment is unequivocal.[42] It causes an increased growth of aquatic plants and filamentous algae, particularly in lowland river systems. In response to increased nutrient pressure, macroinvertebrate communities shift from having many species with few individuals to few tolerant species with many individuals. These changes to the habitat and food web have impacted biodiversity and fish species such as Atlantic salmon.[42] A significant portion of river waterbodies in NI fail to achieve good status due to phosphorus. In 2015, soluble reactive phosphorous was responsible for 20% of river water bodies that failed on the basis of levels of a single element. In 2018, this had increased to 40%.[135]

While phosphorus undoubtedly plays a pivotal role in driving the decline of biodiversity in freshwater habitats, dissolved inorganic nitrogen from agriculture and sewage exerts a considerable impact on inshore and coastal areas such as Belfast Lough, upper Strangford Lough and Quoile Pondage.[124] Nitrogen inputs to coastal and inshore areas increases growth of algae, macrophytes and seaweeds, and increases sedimentation. Of the 12 coastal areas failing to achieve good status under the WFD, ten are failing due to dissolved inorganic nitrogen.[16]

Sources of nutrients

While there may be some uncertainty regarding their relative contributions, it is indisputable that agriculture and wastewater are the primary sources of nutrients affecting the environment in NI. However, while nutrients from wastewater add to nutrient loadings to water, the combined input of ammonia, phosphorus, nitrates and nitrous oxide to the environment means that the overall impact of agricultural nutrients on biodiversity is likely to exceed the impact of those from wastewater.

Agriculture has operated with a nutrient surplus of 10-12 kg P/ha and 110-132 kg N/ha over the past decade.[136] The phosphorus surplus has increased from a low of 8.2 kg P/ha in 2008 to over 12 kg P/ha in 2023, meaning that significantly more phosphorus is being used than is needed for livestock and crop production. This increase has largely been driven by an increase in the use of animal feed concentrate.[136]

Government is developing an objective in its roadmap for improving farm nutrient efficiency and profitability. A surplus of 5 kg P/ha is being considered.[129] However, while reducing to 5 kg P/ha would help minimise environmental losses, evidence supporting whether this reduction is adequate to meet environmental targets remains unclear.

Data available for 2016 compared agricultural soil phosphorus balances (excluding rough grazing) across the UK.[137] NI had a soil phosphorus surplus of 12.1 kg/ha compared to 7.6 kg/ha and 11.8 kg/ha for Scotland and Wales, respectively. Soil phosphorus balance in England ranged from -3.2 kg/ha in the east to 13.5 kg/ha in the north-west, reflecting the predominance of arable agriculture in the east and of livestock in the north-west of England.

Agriculture accounts for the majority of ammonia emissions, with 86% arising from livestock, 8% from chemical nitrogen fertilisers containing nitrogen, and the remaining 6% from the application of sewage sludge and digestate.[16] The evidence on what constitutes an environmentally sustainable nitrogen surplus in NI is limited. The current 170 kg organic N/ha limit and derogation to 250 kg organic N/ha is based on the risk of losses to water and not on the ammonia impacts on terrestrial habitats. In 2023, we published our response to DAERA's consultation on the proposed Ammonia Strategy.[138] While the proposed strategy[125] will go some way to addressing emissions of ammonia, the proposed 30% reduction in emissions is predicted to reduce ammonia concentration below critical levels at only two protected sites.[138]

Nutrients in wastewater arising from domestic and industrial sources contribute to inputs to freshwaters. These include inputs from wastewater treatment plants and septic tanks. The significant contribution of wastewater to the nutrient loads of waterbodies has been highlighted by NI Water.[110] Current estimates of the contribution of wastewater may be underestimating losses due to a lack of monitoring data on the circa 2,500 combined sewer overflows[110] as well as uncertainty in the number and condition of many small wastewater treatment plants, and insufficient data on the condition, siting and management of septic tanks.

One issue highlighted by the evidence is that although the annual nutrient load from smaller wastewater treatment plants and septic tanks may be lower than that from agriculture in some areas, its impact on river biodiversity may be greater and may be critical, due to the timing of these contributions during low-flow periods in the summer.[42] However, the current evidence supporting this claim is limited and warrants further investigation.

Nutrients from historic practices

The persistent, long-term historical impact of nutrient management practices poses a significant challenge to society's efforts to reduce nutrient inputs to the environment sufficiently and reverse the decline in biodiversity. This challenge is especially pronounced in freshwater ecosystems, where 'legacy' phosphorus has accumulated in the natural environment and adds to the overall nutrient load released into lakes and rivers.[129] 'Legacy' phosphorus refers to phosphorus that has built up in soils and sediments in ditches, rivers and lakes as a result of historical inputs from wastewater and agricultural sources.[129]

The most striking example of this is in Lough Neagh, where even in the absence of new inputs from the catchment, ongoing release of phosphorus from the lake sediment alone would delay achieving 'good status' for over 20 years.[139] Similarly, where soils have excess phosphorus, built up over many years, research has demonstrated it could take a decade or more before they return to a level that does not pose a risk to water quality.[129,140]

Chemicals

Chemical inputs (Box 10) to the environment come from a range of sources including industrial, domestic, veterinary, agricultural, urban, medical, waste and contaminated land[141]. However, unlike nutrients, no work has been carried out in NI on source apportionment of chemicals. This has the potential to significantly hamper mitigation efforts, as the extent of the problem is unknown and evidence on which to develop and target mitigation strategies is lacking.

Box 10. Chemical pollution.

Chemical pollution, resulting from the release of harmful substances into the environment, poses significant threats to both the environment and human health. These include poly- and perfluoroalkyl substances (PFAS) (so-called forever chemicals), heavy metals, such as mercury and chromium, pesticides, such as cypermethrin, and many other chemicals arising from human activities.

These pollutants originate from sources including industrial processes, human and animal medicines and domestic cleaning and personal care products. They enter the environment through a wide variety of pathways including wastewater treatment plants, urban and rural runoff, and industrial discharges. Chemical pollution contaminates soil, water and air, disrupts ecosystems, harms species and habitats, and can lead to serious health issues in humans.

Chemicals are of particular concern in the aquatic environment. All NI water bodies currently fail to achieve the targets set by the WFD.[25,142] This failure is attributed to 45 ubiquitous, persistent, bioaccumulative and toxic chemicals (uPBTs) listed in the Directive.[25] These substances exert a wide range of lethal and sub-lethal impacts on organisms, including acting as endocrine disruptors.[142,143]

For instance, cypermethrin, an insecticide, is categorised as highly toxic to aquatic life. It originates from various sources including forestry, landfill sites, domestic biocides, veterinary drugs and effluents from wastewater treatment plants.[144] Despite its detection in 48% of the lakes monitored for compliance within the WFD,[25] the extent of its impact on biodiversity in NI remains unknown. Cypermethrin bioaccumulates in organisms and

persists in the environment within soils, sediments and suspended particles.[146] Other chemicals, such as non-steroidal anti-inflammatory drugs, including diclofenac, ibuprofen, and naproxen, are widely used but are currently not included in monitoring programmes.[142] Diclofenac, for instance, is classified as having long-lasting toxic effects on aquatic life, yet its acute impact remains uncertain due to insufficient data.[146]

In preventing input of chemicals into the environment, identifying sources is crucial, and within NI, several areas warrant particular attention. The evidence remains unclear whether current wastewater treatment processes can effectively remove the range of chemicals stemming from urban and domestic sources. Discharges from circa 2,500 combined sewer overflows in NI will not only contain chemicals from domestic wastewater but also those from runoff on a wide range of hard surfaces in urban areas such as roads and industrial estates.

Chemical pollution may also emanate from waste sites. Legal landfill sites are expected to have been constructed and managed to prevent the leaching of contaminants into the environment. Our recently commissioned report on *Waste Management and Illegal Dumping in NI* highlighted a lack of environmental monitoring of historical landfills and the extent of illegal dumping.[45]

Contaminated land is also a potential source of chemicals pollution. However, due to the lack of implementation of Part III of the Waste and Contaminated Land (Northern Ireland) Order 1997,[147] there is currently no contaminated land regime aimed at identifying and remediating land that could pose a risk to human or environmental health.[148] Contaminated land is presently only identified and remediated as part of the planning process. Consequently, the magnitude, location and impacts of chemical pollution from contaminated sites on biodiversity remain unknown.

Agriculture serves as a key source of chemical inputs to the environment. Pesticides (herbicides) such as 2-methyl-4-chloro-phenoxyacetic acid (MCPA), used to control docks and rushes on grasslands, and glyphosate, used as a broad-spectrum herbicide, are widely used across NI.[149] For example, recent studies in the cross-border Derg catchment have revealed that current monitoring programs significantly underestimate the concentration and loads of MCPA in rivers, with 25% of samples surpassing the drinking water threshold of 0.1 µg/l.[150] The impact of MCPA on soil and aquatic biodiversity remains uncertain.[149] MCPA is just one of the many pesticides used in agriculture, in addition to other chemicals, such as those for veterinary use. However, limited evidence exists regarding their presence in the environment and their impact on biodiversity.

Waste management and disposal

The production, management and disposal (lawful or unlawful) of waste contributes to climate change, habitat loss and pollution of air, water and soil.[45] Within this sub-pressure we have assessed the impact of waste management and disposal on terrestrial and freshwater biodiversity.[45] The implication of greenhouse gas emissions, and material extraction driven by the production and management of waste are considered in the climate change and natural resource use sections, respectively.

Waste, including litter, and its management are responsible for 3% of cited sub-pressures affecting priority species and 12% affecting priority habitats. This includes the impact of clearing of land for landfill (habitat loss), open dumping, burning, and leachate of chemicals into soil, ground water and surface water. Improperly managed or disposed waste (for

example, plastic items) can lead to entanglement or ingestion, including of harmful chemicals, resulting in starvation and death.[45] Ecosystems and public health can be affected when harmful substances leach out of landfill or illegal disposal sites, particularly if drinking water sources are affected.[45]

The impact of waste management and disposal sites on biodiversity has not been fully assessed. For example, the requirement to limit environmental contamination through linings, covers and monitoring of chemical levels does not apply to sites that closed prior to 2001. As there is no systematic environmental monitoring of earlier sites, the scale and type of damage and pollution caused by these sites is unknown.[45] The implications of incomplete data on waste types, including commercial, and construction has also been identified by the NI Audit Office as creating challenges for environmental and economic forecasting.[151]

The impact of waste management and disposal is likely to increase. Assessment in 2017 suggested that NI will have reached its landfill capacity in 2028.[152] Subsequently there will be a need to find more space for disposal, which requires more complete data on waste types and disposal.[151] This will lead to habitat loss, and creates further risk of wider impacts of pollution.[45]

Risks to biodiversity are increased by the unlawful and improper disposal of waste, when compared to regulated disposal.[45] The unlawful disposal of waste including littering and dumping is of significant public concern in NI.[16] Evidence on the scale and impact of unlawful disposal is limited, with requirements to report incidents not standardised across NI.[45] For six of 11 councils, data relating to frequency and quantity of fly-tipped material is incomplete or not reported.[45]

The illegal dumping of waste at the Mobuoy Road waste site is a stark illustration of the potential implications of unlawful disposal. Current estimates suggest 1.165 million tonnes of waste were illegally dumped in a 46 ha area adjacent to the River Faughan.[153] The Faughan and its tributaries provide 60% of the Derry and Strabane District drinking water, and are protected due to the internationally important Atlantic salmon population, and to rich plant and animal communities.[153] The site also supports wet woodland and oligotrophic and dystrophic lakes, both of which are priority habitats.[154]

The ecological and human impact of the dumped waste at Mobuoy Road is not fully understood. For example, the condition of the River Faughan was last assessed between 2008–2015, with the river found to be in unfavourable condition. We could not identify the cause of this determination of poor condition and no more recent assessment has been undertaken. To date, water sampling has demonstrated that there is no contamination leaching from the dump into the river.[155] Assessment of remediation options has however identified potential harm or damage that could be caused through disturbance of the contaminants that exist on the site.[154]

Other pollutants

Limited direct evidence of the impact of air pollution on biodiversity is available in NI, except for that of ammonia, as covered above. The impacts of air pollution on human health are more widely understood.[156,157] In addition to the impact ammonia has on biodiversity, it impacts on human health by contributing to the formation of particulate matter 2.5 (PM2.5). Nitrogen dioxide is the other air pollutant of key concern for human health in NI, and in some areas will contribute to nitrogen deposition on aquatic and terrestrial habitats. Nitrogen dioxide levels have decreased significantly over the past 10 years.[16] Ground

level ozone can have an impact on growth rate of plants but there is no evidence of this impacting on biodiversity in NI. The deposition of sulphur dioxide, nitrous oxides and ammonia can cause acidification in terrestrial and aquatic habitats, however, this issue has largely been addressed since the 1990s and evidence of any long-term impacts is not available.

Other pollutants of note are noise and light,[109] but their impacts on biodiversity in NI are unclear. Elsewhere, there is strong evidence to show the impacts of light and noise pollution on animal and insect behaviour, bird migration and plant phenology.[11,12,158–160]

3.3 Natural resource use and exploitation

Natural resource use and exploitation activities such as extraction, waste generation and recreational use of natural areas put significant pressure on wildlife populations and ecosystems. Extraction industries such as logging, quarrying and mining provide a wide range of raw materials to society which, if not recycled, generates waste. Recreational activities, such as water sports, hiking and camping can lead to habitat trampling, wildlife disturbance and the introduction and spread of invasive species.

3.3.1 Key findings

Natural resource use and exploitation	
Confidence	Key findings
High	A range of natural resource use and exploitation pressures are affecting biodiversity in NI.
High	Recreational activities, including related development and infrastructure, are a growing pressure affecting biodiversity. Coastal habitats are particularly impacted by these activities.
High	NI has an unsustainable material and ecological footprint due to above average resource consumption and extraction rates.
High	Aggregate extraction is negatively affecting biodiversity in NI.
High	The evidence base concerning the impact of natural resource use and exploitation activities on biodiversity should be scaled up, including cumulative impacts.

3.3.2 Strength of evidence

Overall, there is medium evidence and high agreement (high confidence) for the impact of natural resource use and exploitation on terrestrial and freshwater biodiversity. The extent of this evidence base varies by sub-pressure (Table 1).

There is medium evidence and high agreement (high confidence) of the impact of recreation and sporting activities, which includes tourism, related infrastructure, and instances of disturbance. However, this is largely spatially specific and focuses on key recreational areas, including the Mourne Mountains and coastal areas.

For aggregate extraction including infilling, and peat and turf cutting, there is medium evidence and high agreement (high confidence) of the impact on biodiversity. Again, the evidence base is largely spatially specific, focused on individual sites of extraction, and cumulative impacts are not sufficiently assessed.

There is limited evidence but with high agreement (medium confidence) of the impacts of other resource use sub-pressures including commercial fishing, and accidental death caused by, for example, bird strikes and energy infrastructure.

There is medium evidence and high agreement (high confidence) that the current ecological footprint is unsustainable. There is robust evidence and high agreement (high confidence) that the current material footprint is also unsustainable.

3.3.3 Our assessment

Our analysis shows that natural resource use and exploitation accounts for 14% of cited sub-pressures affecting priority species and 13% for priority habitats (Figure 4). This comprises a range of sub-pressures affecting terrestrial and freshwater biodiversity (Table 1). Of these, our analysis shows that for species, recreation and sporting activities including tourism (37%) and disturbance (18%) are the most frequently cited pressures. For priority habitats, recreation and sporting activities (50%), and material extraction (33%) (including aggregate extraction and peat and turf cutting) are the most frequent sub-pressures.

The significance of recreational activities and of aggregate extraction was reflected in responses to our call for evidence. Disturbance and damage caused by these activities are negatively impacting biodiversity across NI and specific hotspots such as the Mourne Mountains, Cuilcagh Mountain[161] and Lough Neagh. However, the current evidence base on impacts of recreation, extractive industries, accidental deaths from collision, and commercial fishing is largely habitat and/or species specific. There is a need for the monitoring and cumulative assessment of the impacts of resource exploitation and use.

The ecological footprint of Northern Ireland

In assessing the overall impact of resource use and overexploitation in NI, we adopt the metric of the 'Ecological Footprint' (Box 11).This metric provides a measure of the impact of human activities on the environment within and outside of NI and quantifies the level of consumption of natural resources required to sustain current lifestyles.[162] It is a globally adopted metric for sustainability decision-making.[4,162]

Box 11. Ecological footprint

As global human population and income levels rise, so does demand for resources for fuel, food and development. The extraction of such resources comes with ecological costs, including habitat loss, fragmentation and pollution.

The Ecological Footprint is a tool for measuring and communicating this relationship between human demand for natural resources and their sustainable supply, that is, the earth's biocapacity. When the Ecological Footprint exceeds the biocapacity of a region, it leads to resource depletion and environmental degradation.

The Ecological Footprint estimates how much land and water area is used by a population to produce all the resources it consumes and absorb the wastes it generates, including carbon dioxide (CO_2). It estimates the biologically productive area needed for various activities, including:

- Carbon Footprint: land needed to absorb carbon dioxide emissions.

- Built-up Land: land covered by infrastructure.
- Forests: for timber and paper products.
- Cropland and Grazing Land: for food and fibre production.

The Ecological Footprint is measured in global hectares (gha), which represent the average productivity of biologically productive areas. To live within the earth's biological limits, the average footprint per person should be 1.6 gha. In 2022, the average global Ecological Footprint was 2.58 gha per person. In Europe, Luxembourg has the highest footprint at 12.3 gha per person, while Albania has the lowest at 2.1 gha per person.[162]

There is a relationship between the Ecological Footprint and biodiversity trends.[163] Increasing human demand for natural resources leads to habitat alteration or destruction, declining biodiversity, reduced wildlife habitats, species overexploitation, pollution and climate change. Therefore, reducing the Ecological Footprint is crucial for the health of biodiversity and society.

The Ecological Footprint has been adopted by organisations such as the European Environment Agency,[164] IPBES[4] and World Wildlife Fund,[7] with the Global Footprint Network providing annual updates.[162] Countries such as Switzerland include the Ecological Footprint in their metrics to monitor sustainable development.[165]

While the Ecological Footprint approach is a useful aggregate indicator, combining it with other indicators such as material and carbon footprints can provide a more complete picture.

The NI Sustainable Development Strategy published in 2010[166] adopted the Ecological Footprint as a target and contained a commitment to stabilise the Ecological Footprint by 2015. The most recent estimate of the Ecological Footprint of NI was 5.6 gha per person in 2003. [167] Of this, 78% of the total Ecological Footprint can be attributed to household final demand. Of this percentage, housing contributes most to the Ecological Footprint

of residents at 39%, followed by food (26%) with transport and consumables contributing 14%.[167]

While the Ecological Footprint of NI has not been updated since 2003,[167] it is of a similar magnitude to that of the UK and RoI. Since 2003, the Ecological Footprint of the UK has declined from 5.74 to 3.57 gha per person in 2022.[162] Biocapacity has also declined from 1.24 gha per person to 1.02 gha per person over the same period.[162] Similarly, the Ecological Footprint for RoI has declined from 6.34 gha per person in 2003 to 4.51 gha per person in 2022.[162] RoI's biocapacity has also declined from 4 gha per person to 3.11 gha per person during the same period.[162] While the reduction in Ecological Footprints is welcome, they remain at an unsustainable level.

The concept of the material footprint is very closely related to the Ecological Footprint, the former influencing the latter through resource extraction, energy use and waste generation. Recent data on the material footprint is available from the Circularity Gap report 2022.[168] NI consumes resources totalling 33.6 million tonnes annually, or 16.6 tonnes/person, which is typical for a high income country, but well above the global average of 11.9 tonnes. The United Nations recommends that a sustainable level of resource use is an average of 6-8 tonnes/person per year.[168]

The urban and agriculture sectors are the primary users of natural resources. Housing and infrastructure alone account for 35% of total material use, equating to 11.6 million tonnes. The agricultural sector uses 8.2 million tonnes of materials, which includes 3 million tonnes of biomass for animal feed, imported each year.[168]

NI relies on significant amounts of virgin materials, most of which are imported. Imports comprise two thirds of the raw materials consumed in NI (for example, metal ores, fossil fuel). Of these, 12% of are sourced from the UK, with metal ores and fossil fuels largely sourced from outside of the UK.[168] With only 7.9% of its material use being circular, NI faces a Circularity Gap of over 92%, indicating a heavy reliance on virgin materials.[168]

There is also a high rate of resource extraction, in terms of biomass and minerals within NI, much of which is exported. At 14.6 tonnes per person per year, extraction rates within NI significantly surpass the UK average of 5.5 tonnes/person per year.[168]

Recreational activities

Including instances of disturbance, recreational activities such as leisure, sport and tourism are a key natural resource use pressure in NI (Table 1). Our assessment suggests that coastal habitats are particularly susceptible to the impact of recreational activities. This includes for example habitat destruction caused by trampling and destruction of sand dunes,[169] wildfires, disturbance of ground nesting birds by dogs, and planning and development (for example accommodation, golf courses).[50]

The evidence base demonstrating the effect, including scale of impact, on biodiversity is piecemeal, and largely spatially restricted. Recreational pressures appear to be confined to hotspots across NI. This includes for example, the Mourne Mountains, north coast, and Cuilcagh Mountain. The consequence of this is concentrated pressure points, as evidenced through path wear on Slieve Donard and the Mourne Mountains more widely.[170]

Patterns and types of recreation and tourism are comparable across the UK. For example, assessments of the UK uplands suggests that around 40 types of recreational activities are

causing harm.[171] This includes trampling, disturbance, pollution (for example, by lead shot) and raptor persecution.[48,171] However, within this evidence base, there is a taxonomic bias towards birds, with less known about other species groups.[171]

Recreational activities are a growing pressure. Between 2011–2019, the gross value added of outdoor recreation in NI rose by 24% to £131.3 million.[172] This represents an increase of commercial operators by 48% since 2011, and rising rates of participation in activities such as water sports, which has doubled between 2011-2017.[172] The tourism industry has also seen growth in activity following the covid pandemic.[173] Whilst there are examples of environmentally sustainable recreation and tourism,[161] there remains a need to better monitor and assess the impact of these activities on biodiversity.

Extractive activities/industries

While geographically small, NI consumes and extracts a substantial amount of raw materials including minerals, metal ores, fossil fuels and biomass.[168] Our assessment suggests that extraction of materials amounts to 9% and 33% of cited sub-pressures affecting priority species and habitats, respectively.

NI has a high rate of resource extraction.[168] Of the materials extracted in NI, around one third (36%) is used within NI, one third (34%) goes to the rest of the UK, and the remainder (29%) is exported internationally, including a large proportion to RoI.[168] Excluding biomass related products, 16.9 million tonnes of materials are extracted annually in NI. This includes 16.5 million tonnes of non-metallic minerals (for example, basalt and igneous rock, sandstone, sand, gravel and limestone), extracted from approximately 160 quarries across NI.[168] Of which, many operate under historic licences granted prior to the existence of environmental assessment regimes.[44]

A further 0.4 million tonnes of peat are extracted for fuel and horticulture.[168] By area, 78% of lowland bogs and 46% of blanket bogs have been cut in the past in NI.[174] Once commonly used for fuel, peat extraction has decreased.[24,41] The scale of impact caused by cutting is dependent upon the method and frequency of peat extraction, and can be magnified by other upland pressures (Box 7 and Box 10).[41] The continuation of cutting is, however, causing the release of greenhouse gases,[175] undermining the ecological functioning of peatland habitats, damaging plant assemblages, and impacting migratory and wetland birds.[24] Increasing sediments in freshwaters mobilised is also adversely affecting spawning and nursery beds of salmonids.[24]

Whilst these rates of extraction and consumption are stark, they only demonstrate potential rather than actual impacts on terrestrial and freshwater biodiversity. Evidence of the direct impact of extractive activities is limited in NI and where it exists it is largely site, species and habitat specific.[44] For example, the disturbance and loss of priority habitats of purple moor grass and rush pasture at Craigall Quarry.[44]

Extractive activities also have negative human health implications. However, the cumulative impact of aggregate activities on the natural environment and human health in NI has not been assessed. As such the monitoring and reporting of quarrying and aggregate extraction across NI should be significantly scaled up and improved.

Other natural resource use and exploitation pressures

Our assessment of priority species suggests that accidental collision of animals with infrastructure and vehicles accounts for 16% of citations of natural resource use pressures affecting species (Table 1). For example, there is a growing body of evidence considering the impact of wind farms in upland areas on species including hen harrier, and other ground nesting birds. The evidence base is however limited and due to these limitations, we cannot assess the scale or importance of any impact on biodiversity.

Commercial fishing of freshwater and marine species is responsible for 8% of sub-pressures cited for priority species in NI (Table 1). This includes species such as salmon and eels, the life cycles of which include phases in both freshwater and marine environments. This complicates identification of the causes of their declines. For example, the eel population in Lough Neagh has declined since the 1980s, with likely contributions from multiple pressures in the marine and freshwater habitats including climate change, hydrological modification of rivers, eutrophication and commercial fishing. In theory, the current enrichment of Lough Neagh should result in a 50% increase in the carrying capacity of the lake's eel fishery. However, there has instead been a 35% reduction in production.[176]

While there is currently no commercial fishing of Atlantic salmon, their populations have also experienced significant declines over decades, due to multiple pressures in freshwater and marine environments. In 2014 a series of measures was introduced to reverse the decline in the salmon population including controls over commercial coastal salmon fishing and implementation of angler catch bag limits, carcass tagging and a catch and release policy on most rivers.[177] While there are some indications that the measures are having an impact, the species remains in overall decline and ongoing data collection is required.[177,178]

3.4 Climate change

Climate change, driven by anthropogenic emissions of greenhouse gases, alters temperature and precipitation patterns globally. These changes increase the frequency and severity of extreme events including storms, floods, and drought. Climatic changes also impact species distributions, phenology (seasonal timing), genetics, ecosystem functioning and food webs. Some species may migrate, but others may not be able to move and thus face an increased risk of extinction. Changes in climate can also result in new invasive species and diseases that put further pressure on native habitats and species.

3.4.1 Key findings

Climate change	
Confidence	Key findings
High	There is robust evidence on causes of climate change, including sectoral responsibility for emissions of greenhouse gas emission in NI.
High	Impacts of climate change on biodiversity at the global scale are well established.
Medium	Climate change is affecting biodiversity in NI.
Medium	The effects of climate change individually and interactions with other pressures create uncertainty in predicting the outcome of strategies to improve biodiversity in NI.
High	There is a pressing need for a more systematic assessment of the effect of climate change including under future emission scenarios on biodiversity
High	Nature-based solutions will be vital for improving biodiversity and mitigating and adapting to climate change.

3.4.2 Strength of evidence

There is robust evidence and high agreement (high confidence) that human-induced climate change is affecting biodiversity across terrestrial and freshwater ecosystems globally.[4,58] There is robust evidence and high agreement (high confidence) of emissions sources,[179] and of the changes to the climate in NI. [16]However, there is limited evidence and high agreement (medium evidence) of the current and predicted effects of climate change on biodiversity in NI.[180,181] The evidence base that exists is largely species and habitat specific.[10,11,15] There is a lack of consideration of NI wide impacts, including the implications of negative feedback loops, and tipping points. There remain uncertainties in disaggregating the impacts of climate change (for example, increasing temperature, altered hydrology) from other pressures affecting biodiversity (for example, habitat loss).

3.4.3 Our assessment

Our analysis suggests that climate change is responsible for 5% and 9% of pressures affecting species and habitats respectively. Submissions to our call for evidence described climate change as an all-encompassing pressure. There was consensus throughout submissions of the causes of climate change, including the rising rate of emissions from the agricultural sector in NI.[16] The impact of climate change on biodiversity is already visible in NI. For example, increasing temperatures are altering species ranges (for example invertebrates),[10–12,15] and affecting growing seasons causing alterations to habitats, species and ecosystems.[11,12]

Evidence received demonstrates the challenges in disaggregating the impact of climate changes from other pressures acting on biodiversity. The role of biodiversity in adapting and mitigating future climate change was stressed, with clear examples of restorative actions creating positive change for climate and biodiversity.

Evidence of Climate Change

Emissions of greenhouse gases from human activities are causing global warming.[58] Global surface temperature in 2023 was 1.45°C above 1850-1900 levels.[182] These emissions have been caused by historic and ongoing unsustainable energy use, land use change (for example, agricultural intensification, forestry on peatland), and consumption patterns.[58] In NI, emissions arise from agriculture (29%), transport (18%), building and product uses (15%), electricity supply (14%), land use (10%), industry (10%) and waste (4%).[179] There has been a 26% reduction in NI's emissions since 1990. In recent years, agriculture is the only sector in NI from which there have been consistent increases in emissions.[16]

The UK has warmed at a slightly higher rate than the observed change in global mean temperature, with unprecedented heatwaves in 2022.[183] NI has experienced the highest above normal temperatures across the UK.[183] The knock-on effect of increasing global temperatures include sea level rise, altered hydrology (for example droughts, flooding), and increased frequency of extreme weather events and wildfires.[58]

Impact of climate change on biodiversity

Climate change is affecting terrestrial and freshwater biodiversity across the globe, the UK, and the island of Ireland.[4,58] Changing global weather patterns and increasing temperatures are altering species ranges,[10–12,15] affecting growing seasons and altering habitats and ecosystems.[11,12] Changes in abundance and distribution have been observed at the individual, population and community level.[4,181] This includes, changes to seasonal timing (phenology), genetic selection, food webs, range shifts and movement (bioclimatic suitability), community structure and composition, and extinctions.[4,58,181] Northward shifts in species ranges can, for example, alter ecosystem structure and function through direct competition.[10,11]

Within NI, current evidence demonstrates various localised impacts of climate change on terrestrial and freshwater species and habitats.[180,181,183,184] For example, in the case of Lough Neagh, the water temperature of the lough has increased by 1°C[185] and climate change impacts have been suggested as a contributing factor in the decline in the eel population[186] and in causing the distribution of wintering waterfowl to shift northeast, impacting on their abundance at the Lough.[187]

Unless there are significant reductions in greenhouse gas emissions in the coming decades, global temperatures will rise by 2.1 – 3.5°C.[188] This will exacerbate adverse climatic conditions (for example precipitation, wildfires), and is predicted to dramatically shrink the range of terrestrial species globally.[4] The potential for loss, extinction, or gain of species, at both local and national scale is high.[180] For example, in the example of the Irish hare (Box 4), predictions are that climate change will negatively alter the bioclimatic suitability of much of the island of Ireland.[189] Concurrently, the suitability of habitats for the invasive European hare will increase, providing opportunity for its spread.[189]

Climate change can act individually or in combination with all other pressures, compounding the effect on biodiversity.[10–12,63,181] For example, evidence reviewed for this report demonstrated that coastal habitats in NI are affected by pressures such as coastal squeeze created by development and landward defences,[190] grazing, nutrient pollution, and recreational use.[191] Extreme weather events and sea level rise due to climate change in turn cause coastal erosion which compounds these pressures. Whilst there is limited information on coastal change in NI, estimates suggest that 20-30% of the coastline is either eroding or at risk of erosion.[180]

We consider that the low frequency with which climate change was identified as a pressure is reflective of insufficiencies in the evidence base, rather than an absence of the pressure itself. There remain significant uncertainties in the current, and future impacts of climate change on terrestrial and freshwater biodiversity in NI. As such, there is a need to systematically assess the effect of climate change on biodiversity in NI with consideration of impact on ecosystems across the biogeographic region of the island of Ireland.

Mitigating and adapting to climate change

Terrestrial and freshwater habitats are carbon sinks, providing nature-based solutions to climate change. Nature-based solutions involve the protection, restoration, and sustainable management of species and habitats and of ecosystems more broadly.[192,193] Delivery of nature-based solutions is essential for mitigating and adapting to climate change in both rural (for example afforestation, peatland restoration), and urban areas (for example sustainable drainage, and community gardens).[4,192,194,195]

Restoration of peatland on Cuilcagh Mountain[196] or the Garron Plateau in the Antrim Hills[20] highlights the benefits for climate and biodiversity. These sites are key habitats for many species including golden plover, merlin, large heath butterfly, Irish hare and a rare ground beetle *Bembidion geniculatum*. Assessment of the works on Garron Plateau, which included drain blocking and reduced livestock grazing, demonstrates that restoration avoids around 9000 tonnes of carbon loss from the soils, and has increased area of site as being in favourable condition. In addition, there has been an improvement in the raw water quality which lowered the cost of water treatment.[20]

The inclusion of a biodiversity target, and a commitment to the delivery of carbon reductions through nature-based solutions within the Climate Change Act (Northern Ireland) 2022, is welcome and should deliver significant benefits for biodiversity. Delivery of further nature-based solutions across NI's urban and rural landscapes will be essential if NI is to achieve its carbon and its biodiversity commitments. Recent assessment by the Climate Change Committee demonstrates that there has been insufficient progress on adapting to climate change in terrestrial, freshwater and coastal habitats.[197] The Climate Change Committee also state there needs to be significant increase in peatland restoration and afforestation to achieve Net Zero.[65]

3.5 Invasive species

Invasive species are non-native organisms that outcompete, prey upon, or bring diseases to native species. This can lead to significant ecological disruptions, including the decline of native species and changes to habitat structures and ecosystem processes. The spread of invasive species is often facilitated by global trade, travel and climate change.

3.5.1 Key findings

Invasive species	
Confidence	Key findings
High	A range of invasive species are affecting biodiversity in NI and across the island of Ireland.
High	The impacts of invasive species and pathogens are expected to worsen under predicted climate change and due to increasing global trade and travel.
High	Pathogens are affecting biodiversity in NI and are a growing threat due to climate change.
High	Cross border responses are required to address invasive species and pathogens
High	The prevention of, and rapid response to, invasive species and pathogens are essential to effectively protect terrestrial and freshwater biodiversity.

3.5.2 Strength of evidence

There is a robust evidence-base and high agreement (high confidence) in relation to the establishment and impact of invasive species on terrestrial and freshwater biodiversity across the island of Ireland. The evidence demonstrates clearly how a range of invasive flora and fauna are negatively impacting species, habitats, ecosystems and the economy across the island of Ireland.

There is also a robust evidence-base and high agreement (high confidence) in the vectors and pathways of establishment of invasive species, through a variety of human activities operating over a range of scales. There is also a medium evidence base and high agreement (high confidence) of the expected future establishment of invasive species and pathogens.

There is a medium evidence base and high agreement (high confidence) in relation to the environmental and economic impact of pathogens, impacting flora and fauna naturally occurring on the island of Ireland. We consider that there is a robust evidence-based and high agreement (high confidence) of the effective response to invasive species and pathogens.

3.5.3 Our assessment

Our analysis suggests that invasive species are currently responsible for 3% and 6% of pressures affecting priority species and habitats, respectively (Figure 4). Whilst these figures are not disaggregated, the evidence base points to a range of invasive flora and fauna creating impacts competition and spread of pathogens.

Global assessments place invasive species as one of the largest threats to terrestrial and freshwater biodiversity.[4,198] Such global assessments, however, consider the impact of invasive species in the context of a range of other pressures causing habitat destruction (for example pollution and land use change). Evidence at the European and UK scale however suggests that invasive species are a less significant pressure, relative to other pressure categories.[10,52]

There was consensus among submissions to our call for evidence that invasive species are a current and growing threat to terrestrial and freshwater biodiversity in NI. There was agreement in the evidence that species including zebra mussel, roach, grey squirrel, rats and Japanese knotweed are already negatively affecting biodiversity.[15,63,199] This includes evidence of invasive species causing the unfavourable condition of protected sites,[63] exacerbating the algal bloom in Lough Neagh[134] (Figure 7), and harming species at risk of extinction, such as puffins on Rathlin Island.[200] Submissions also agreed that there is a significant threat of more establishments, and wider impacts of invasive species and pathogens under predicted climate change.

When assessing evidence of the establishment and impact of invasive species and pathogens we adopted the island of Ireland as the scale of focus. As a single biogeographic region, when species become established within NI or the RoI they tend to spread rapidly across the island.[201] An effective response to invasives also requires aligned priorities and actions across the island of Ireland.[201]

Introduction and establishment of invasive species

Invasive species are defined as a non-native (in other words 'alien') species, the introduction and/or spread of which threaten biological diversity'.[202] The spread and establishment of invasive species is increasing, with no sign of slowing, either globally[4,203] or across the island of Ireland.[15,204]

Intentionally and unintentionally, humans have introduced most of the invasive species on the island of Ireland (Table 2),[201] including New Zealand flatworms, zebra mussels, muntjac deer, grey squirrels, ferrets, European hares, roach, carp, Himalayan balsam, giant hogweed, rhododendron and Japanese knotweed.[10,15,63,201] These species have arrived through a range of pathways and vectors, resulting from multiple human activities occurring over a range of scales in time and space (Table 2).[201,203]

The vulnerabilities (to invasive species) of habitats across the island of Ireland differ. The spread of species across the island is facilitated by the highly interconnected nature of ecosystems, society and the economy. Hence, well connected, particularly freshwater habitats, such as rivers and loughs, are more vulnerable due to their connectivity and accessibility (for example through canals and navigable waterways).

From the point of primary introduction (for example, shipping or game stocking) the secondary spread of invasive species resulting from range expansion tends to include a wider range of vectors. This post-establishment spread is a key determinant of the impact of invasive species. However, there are significant uncertainties related to the spatial and temporal rate of any secondary spread for invasive species. This is due to the unknown impacts of interventions, climate change and interaction with other elements of ecosystems.[203]

The arrival and establishment of further invasive species is predicted to rise in the coming decades, both globally[203] and across the island of Ireland.[204] Expert assessments have identified the 40 species (18 freshwater, 15 terrestrial, seven marine) that are most likely to arrive on the island of Ireland by 2027.[204] The prominence of freshwater species reflects their connectivity, combined with the challenges of management or eradication once species are established.

Table 2. Vectors for the introduction of invasive species to Northern Ireland (Source: Stokes et al. 2004).[201]

Vector	Introduction	
	Intentional	Accidental
Biological control	Psyllid parasitoid wasp, Myxoma virus	
Wildfowl and game stocking	Pheasant, Roach	
Horticulture, amenity and ornamental planting, stocking and collections	Rhododendron	New Zealand flatworm
Pet shops, aquaria and scientific institutions	Common carp	Spring viraemia of carp
Fur farming	American mink	
Forestry	Sitka spruce	
Agriculture	Oil seed rape	
Aquaculture and mariculture	Pacific oysters	Red seaweed
International freight, tourism, and travel		New Zealand flatworm
Fishing equipment, angling, pleasure boats and inland waters		Zebra mussel
Ports, shipping a. hull fouling b. ballast water and its sediments		Tubeworm
Parasites and pathogens carried by invasive species		Nematode bladder parasite, Crayfish plague

Pathogens

Pathogens cause disease and harm to ecosystems and pose a risk to human health.[203] They can be introduced through invasive species. This includes the crayfish plague introduced and spread by the invasive signal crayfish which is lethal to the native white-clawed crayfish.[122] Pathogens can also be introduced and spread by naturally occurring species, such as Highly Pathogenic Avian Influenza (HPAI) by common guillemot.[10,205] Ash dieback is caused by a fungus which has devasted the population of ash trees on the island of Ireland since its introduction 30 years ago. It is one of many plant diseases that pose a risk to biodiversity in NI. For the purposes of this report, we have assessed the impact of pathogens in the context of the invasive species pressure category.

Impact of invasive species and pathogens on biodiversity

Not all non-native species become invasive or cause environmental, social, and economic harm. Some of the species introduced to the island of Ireland have now been here for generations and are considered part of the landscape, causing no adverse impact (for example, sycamore, rabbits).[201]

Where species become invasive, their impact on biodiversity can be dramatic, and in some cases irreversible.[4,201,206] Invasive species can affect native species through competition, predation, alteration of habitats and food webs, introduction of parasites and pathogens, and the dilution of native gene pools, and they can ultimately cause extinctions.[4] On the island of Ireland, direct competition with native species, alteration of habitats, and influence of parasites and pathogens are the most prominent negative impacts of invasive species.[201]

Islands are particularly at risk of the negative impacts of invasive species when compared to the continent.[201,203] There is a well-established evidence base demonstrating the effects of invasive species across NI and RoI.[201] These include the poor condition of our protected sites,[63] devastating internationally important seabird populations such as puffins, razorbills, and kittiwakes,[15,200] genetic hybridization, disrupting ecological relationships and community structures, exacerbating the effects of the hypereutrophic state of Lough Neagh, and extinction of native species (for example, swan and duck mussels).[199] The establishment of invasive species (for example, Himalayan balsam) in riparian corridors, and within the river systems (for example, parrot feather) has also been shown to affect sedimentation and flow rates.[42]

The economic harm of invasive species is predicted to increase in the near and longer term.[203,204,207] As more species arrive, and the impacts of climate change provide for ecological expansion of those already established, the environmental and economic costs are likely to rise.[203,207] The prevention of new invasive species establishing on the island of Ireland is therefore essential.

There is limited evidence quantifying the cumulative and synergistic impact of invasive species with other pressures. Available evidence includes, for example, the well documented role of the invasive zebra mussels in exacerbating the hypereutrophic state of Lough Neagh (Box 12). The combined impact of high ammonia levels, and invasive species has also been shown to negatively impact native amphipods.[208] However, there remain significant uncertainties regarding the wider ecosystem or landscape scale relationship between invasive species and other pressures.

Response to invasive species

Where species become invasive, their impact on biodiversity can be irreversible and costly to manage or eradicate.[4,201,206,207,209] For example, the eradication of rats and ferrets on Ratlin Island alone will cost £4.5 million over five years.[210] While continued mitigation of the impact of invasive species is important, prevention is critical because of the costs and risks associated with management.

There is a well-established evidence base of the preventative and mitigative measures required to respond to invasive species and their consequences on the island of Ireland and across GB.[201] This includes improvements in the detection and recording of invasive species, the inspection of goods and people, as well as policy and legislative review. An example of the possible need for legislative review is the Fisheries Act (Northern Ireland) 1966, which includes the protection of roach, the spread of which has had significant consequences on other species and habitats including Lough Neagh.[204]

3.6 Multiple pressures

3.6.1 Key findings

Multiple pressures	
Confidence	Key findings
High	Global evidence demonstrates the importance of understanding interactions of multiple pressures and their effects on biodiversity.
Medium	There is a limited evidence base in NI demonstrating the interaction of multiple pressures and how to mitigate the impacts.
High	The impact of, and interactions between multiple pressures creates significant uncertainty in protection and restoration of biodiversity.
High	The ecological crisis at Lough Neagh is an example of the negative effects of multiple pressures acting on an ecosystem.

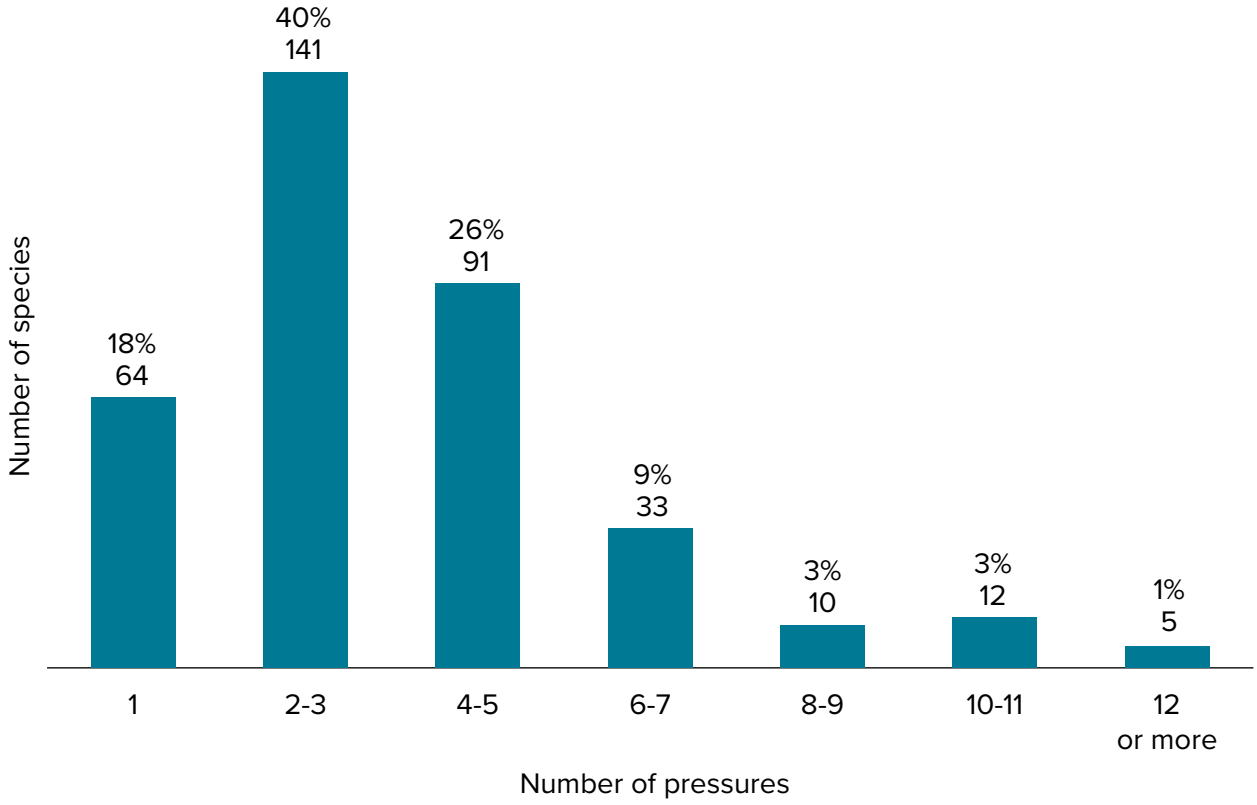
3.6.2 Strength of evidence

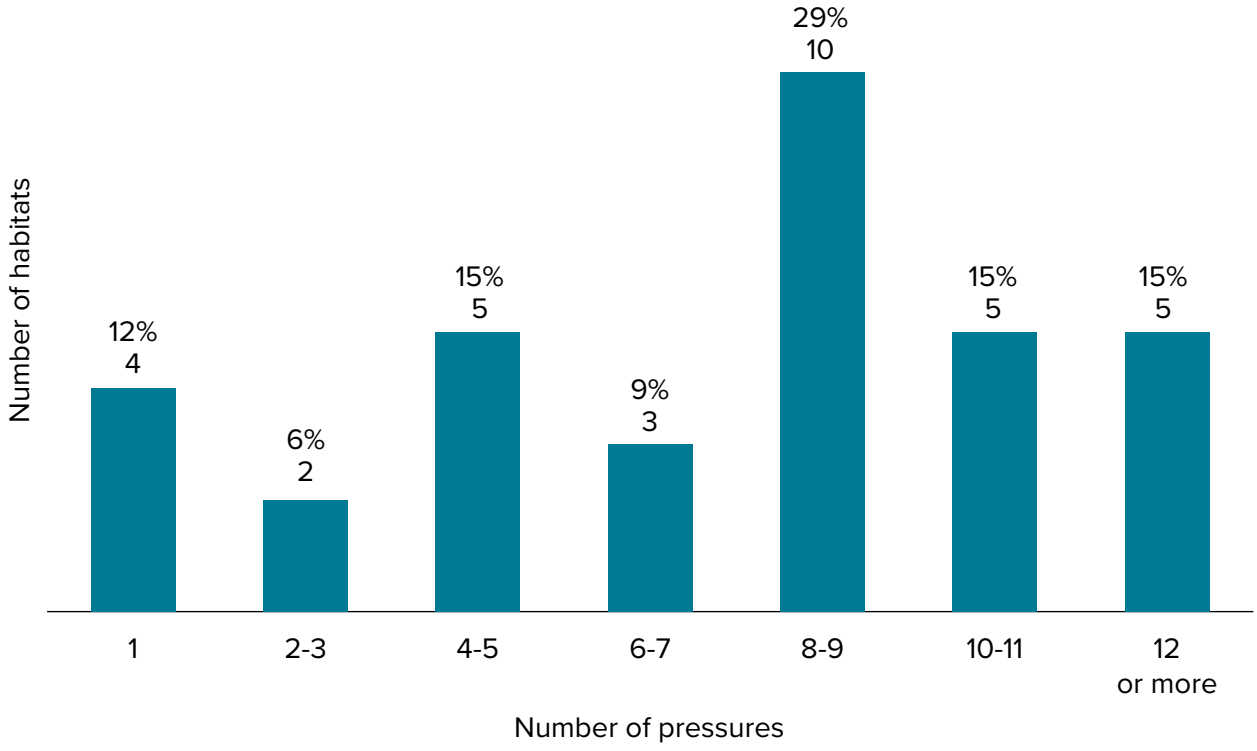
There is medium evidence and high agreement (high confidence) globally of the interaction between multiple pressures on biodiversity. The evidence is clear that pressures often act together, leading to compounded negative effects that are greater than the sum of their parts. However, the science of understanding multiple pressures is complex, and is still developing evidence of how a wide range of pressures interact over time and space. There is limited evidence and medium agreement (medium confidence) on this issue in NI. However, there is robust evidence and high agreement (high confidence) that multiple pressures have combined to cause ecological deterioration in Lough Neagh.

3.6.3 Our assessment

Our assessment of priority species and habitats illustrates how multiple pressures are affecting biodiversity. Over 80% of the 356 priority species (excluding the species with no data for pressures recorded) we assessed have two or more pressures recorded as affecting them, compared to just 18% which only had one pressure (Figure 6). Most priority species had between two and five pressures acting on them. For priority habitats, 30 of the 34 habitats we assessed are affected by two or more pressures, with most habitats being impacted by eight or more pressures (Figure 6).

Figure 6. The number of (a) priority species and (b) priority habitats in Northern Ireland affected by one or more land use, pollution, natural resource use and exploitation, climate change, and invasive species pressures.





It is widely acknowledged that the interaction of multiple pressures poses a significant challenge for the protection and restoration of biodiversity.[211–213] The combined effects of multiple, or co-occurring, pressures acting on the same habitat or species are complex. They can, for example, act simultaneously to multiply or negate the effect of other pressures, occur over varying timeframes, and hinder the outcome of conservation efforts.[212,213]

The ecological crisis at Lough Neagh is a stark example of the consequence of multiple pressures acting in NI (Box 12). There is, however, limited evidence available on a wider basis across NI. Our assessment, demonstrates clearly that the majority of priority species and habitats are affected by more than one pressure (Figure 6).[214] This is further underscored by the species and habitat case studies presented within this report. Multiple pressures emerged as a key threat within each of the commissioned literature reviews.[41,42,44]

The science behind multiple interacting pressures is complex and has received significant attention globally. The challenges stemming from the impact of multiple pressures are not unique to NI, with scientists and policymakers worldwide challenged by how to account for multiple pressures.[211,213] It is imperative for government to improve its understanding of this issue through research and to consider how it can be addressed in policy development and implementation. However, this should not be a reason to delay the response to the individual pressures impacting biodiversity.

Box 12. The Lough Neagh ecological crisis

Lough Neagh is an example of multiple pressures acting over time to impact on biodiversity. Each of the five IPBES pressure categories cited within this report has played a role in the deterioration of this freshwater ecosystem (Figure 7).

The interaction of pollution from nutrients, invasive species (zebra mussels), and climate change resulting in observed changes in water temperature has been widely acknowledged as responsible for the toxic blue-green algal bloom that occurred in the lake during the summer of 2023. Pressures from land use change and the exploitation of natural resources have also contributed to the overall decline in the ecological status of Lough Neagh.

Pollution

Lough Neagh is hypereutrophic, with a total phosphorus concentration of 139 µg/L.[185] Under the WFD 2020 classification, the lake has been assigned bad ecological potential.[135] Current and historical inputs of nutrients from agriculture and wastewater management are responsible for the current hypereutrophic status of the lake. Records show that enrichment of Lough Neagh started as far back as the 1880s, with phosphorus input pre-1960s, largely coming from wastewater. Post-1960s, with an increase in agricultural intensification, diffuse phosphorus input increased.[215]

In addition to nutrient enrichment, recent studies have also demonstrated the presence of microplastics in Lough Neagh, adding to the multitude of pressures already impacting on its biodiversity. Out of the 38 lakes and reservoirs assessed globally, Lough Neagh ranked 11th highest in microplastic concentration in the water column.[216]

Invasive species

Two key invasive non-native species (zebra mussel and roach) exert pressures on the ecology of Lough Neagh. Both were introduced to the lake through activities related to commercial and recreational fishing, such as boat movement between waterways and stocking.

Zebra mussels were first recorded in Lough Neagh in 2005.[217] Following this there has been a rapid expansion of the population. Filtering of water by zebra mussels has enabled light to penetrate to greater depths, increasing algal growth.[218] Zebra mussels are also associated with increased blue-green algal blooms as they preferentially consume other algal species instead of blue-green algae.[218]

The introduction and expansion of roach to the lake in the early 1970s has altered the lake's ecological structure, competing with native fish such as rudd and brown trout.[219] Roach have been implicated in the decline of eels and diving duck populations due to competition for food.[176,220]

Land use change

Water levels in the Lough have been lowered twice (in the 1850s and 1930s) to prevent flooding, reclaim land and improve navigation.[219] This resulted in the loss of wetland habitats such as reedbeds, fens, and wet woodlands.

Changes to hydromorphology, such as the installation of structures to improve navigation and flood control, have directly impacted eel, lamprey and salmon migration routes on the Lower Bann river.[219]

Arterial and land drainage has been carried out throughout the Lough Neagh catchment to support the intensification of agriculture and reduce flooding.[219] This has had consequences for the hydrological regimes of the rivers draining into Lough Neagh, and the transfer of nutrient and sediment from land to water.

Natural resource use and exploitation

The Lough bed is the basis of a locally important sand extraction industry providing the raw material for a range of products. Large-scale dredging commenced around 1930s and increased when sand pumping starting in the 1950s.[221] There is ongoing concern for the ecological impact that sand extraction is having on the lake ecology. [222] A recent study of a 0.5 km^2 area of the lake revealed that sand extraction has resulted in a 16-17 m lowering of the lake bed, with 2 million tonnes of sand extracted from this area.[222]

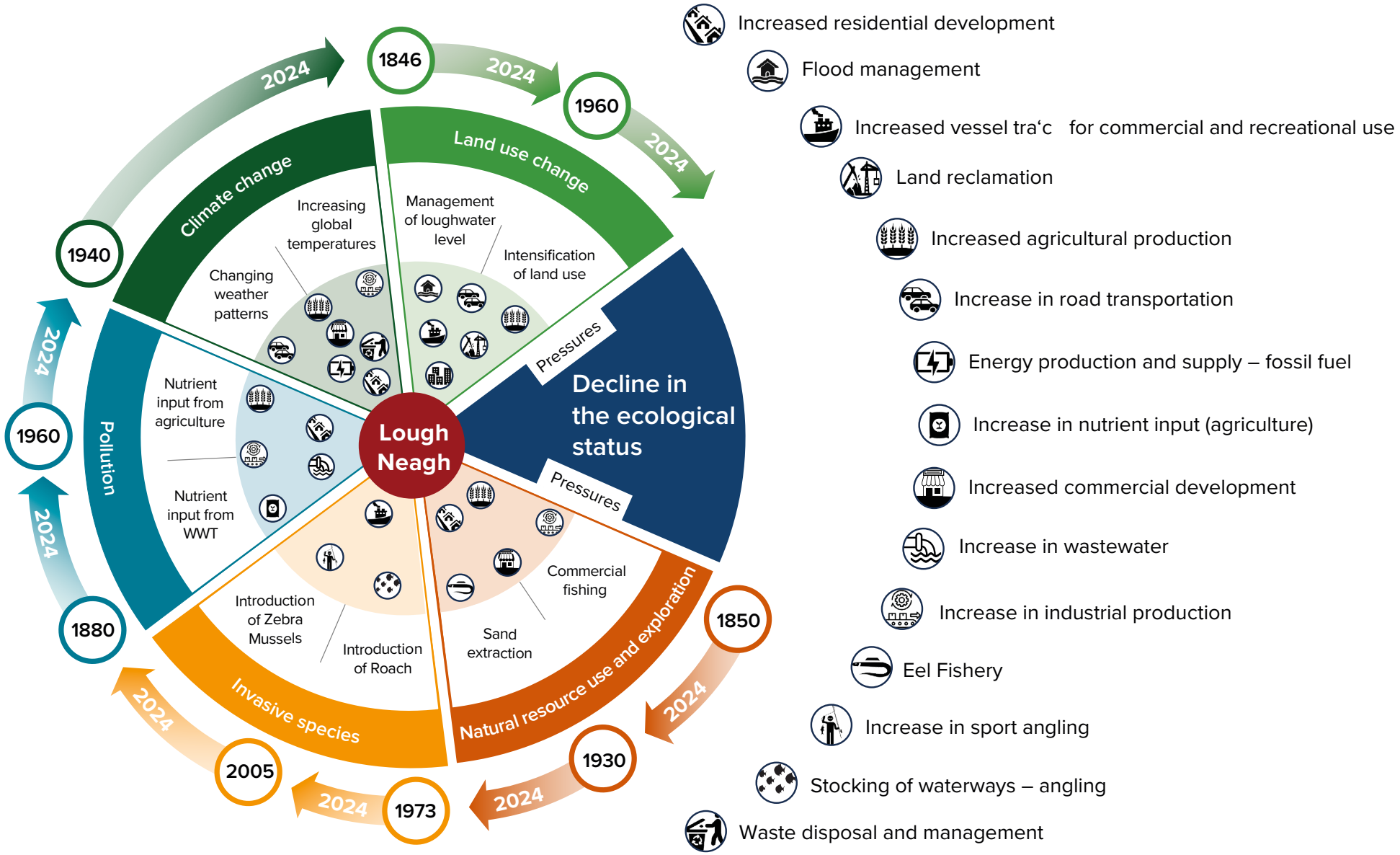
The eel population in the lake has declined since the 1980s, caused by multiple natural and anthropogenic factors.[176] In theory, the current enrichment of the lake should result in a 50% increase in the carrying capacity of the lake's eel fishery. However, there has instead been a 35% reduction in production.[176]

Climate Change

Climate change has impacts on Lough Neagh. The average annual water temperature has risen by 1°C since 1974.[185] The increase in temperature in the lake has contributed to the blue-green algal bloom but may also played a role in the decline in the eel and bird populations in the Lough.[176,187]

Climate change will also have an impact on the nutrient load in the lake, with rising water temperatures increasing phosphorus release from the lake sediment.[185] High-intensity storms and the increasing intensity of drying-wetting events will exacerbate nutrient export from the soils in the catchment to the Lough.[223]

Figure 7. Representation of the multiple pressures impacting the ecological status of Lough Neagh over different timeframes.



3.7 Cross border pressures

3.7.1 Key findings

Cross border pressures	
Confidence	Key findings
High	As part of a single biogeographic unit of the island of Ireland, several pressures affecting biodiversity in NI need to be managed on an all-island basis.
High	Specific cross border pressures of note on the island of Ireland include ammonia pollution, nutrients in water, waste transferral and invasive species.
Medium	Over two-thirds of the resources consumed within NI are imported, rates of consumption are creating cross border pressures affecting biodiversity.

3.7.2 Strength of evidence

There is robust evidence and high agreement (high confidence) demonstrating that NI is part of the biogeographical unit of the island of Ireland. This means that many of the species and habitats on the island of Ireland are cross border in their distributions and ecologies, and need to be managed as such.

There is medium evidence and high agreement (high confidence) that a range of pressures are acting cross-border, including ammonia on terrestrial sites and phosphorus in waterbodies. Waste management and disposal are affecting biodiversity within NI and beyond its boundary. There is robust evidence and high agreement (high confidence) of the impact of, and need for, the cross-border management of invasive species, particularly on the island of Ireland. There is medium evidence and medium agreement (medium confidence) on the direct impact on biodiversity of NI's high rates of imported raw material consumption.

3.7.3 Our assessment

As part of the single biogeographic unit of the island of Ireland, many of NI's most important terrestrial and freshwater habitats are cross border in nature. This includes protected areas which are important for biodiversity such as Cuilcagh, Sliabh Beagh, Lough Melvin and the Magheraveely Marl Lake cluster.

The importance of cross border pressures was reflected across responses to our call for evidence. Evidence submitted demonstrated a range of cross border pressures including pollution and land use changes. This included for example, ammonia pollution, peat extraction within RoI on the boundary with Slieve Beagh (ASSI, SAC), and hydromorphological change and barriers in rivers that are impacting on cross border movement of fish, such as Atlantic salmon.

The governance of cross border pressures was cited as a particularly significant driver throughout responses to our call for evidence.[38] Commitments and global frameworks such

as the CBD were emphasised as playing a key role in ensuring common standards and ambitions related to biodiversity across borders. However, divergence in legislation on the island of Ireland, including in standards and implementation, was suggested as risking the operational effectiveness of protections for biodiversity.[38]

Each of the five pressures discussed so far are inherently cross border in nature. The causes and impacts of climate change (section 3.4) and of invasive species (section 3.5) clearly demonstrate this. Similarly, as discussed in section 3.3, over two thirds of the materials consumed within NI are imported.[168] Whilst the evidence of the ecological impact of this is limited, there is high agreement that consumption patterns within the global north are a leading cause of biodiversity loss in the global south.[7] There is, therefore, a clear need to move from a linear to circular economy in NI.[224]

Nutrients exemplify the need for the cross border management of pollution across the island of Ireland. For example NI exports more atmospheric nitrogen than it receives from the rest of the UK and elsewhere.[225] Studies have demonstrated the need to manage phosphorus in cross border river catchments such as Blackwater river, Lough MacNean, and Lough Melvin.[226,227] Coordinated management of International River Basins such as the Neagh-Bann, North-Western and Shannon is established through the WFD.[25,227]

The management and disposal of waste is another example of the need for a cross border approach to addressing pressures. Notwithstanding limitations in the monitoring and reporting of waste in NI, waste flow analysis demonstrates that the cross border movement of waste has increased in recent years.[45] For example, between 2017–2021 the amount received from the RoI rose from 7% to 12%, while the waste NI exported to the rest of the world increased from 17% to 19%.[45]

Assessment of these flows identified future challenges and risks related to this import and export of waste. For example, the majority of waste that was exported was sent to Scandinavia, a region that whilst, historically invested heavily in energy from incineration, is looking to reduce incineration capacity and carbon emissions.[45] With NI's landfill capacity likely to be exceeded within the next 5–10 years, the loss of waste export pathways creates risks for waste management and consequently for biodiversity. On the island of Ireland, divergence in waste management regulations that make it cheaper to dispose of waste in one jurisdiction over the other, and increases the risk of illegal cross border transportation and disposal of waste.[45]

Chapter Four: Our conclusions and recommendations

4. Chapter Four: Our conclusions and recommendations

In this report, we demonstrate the range and significance of pressures causing unprecedented decline of biodiversity in NI. The effects of land use change, pollution, natural resource use and exploitation, climate change, invasive species and other pressures are clear. These are not distant threats. They have pushed species such as freshwater pearl mussel and curlew to the brink of extinction. They destroy globally important habitats, such as peatland. The continued loss of biodiversity will lead to a less certain and prosperous future for NI and its people.

Lough Neagh is the canary in the coal mine, warning of imminent peril. However, our assessment shows that Lough Neagh's predicament is far from unique. The ongoing declines of species, such as farmland birds, are an indicator that biodiversity as a whole in NI is under significant pressure. Unless urgent action is taken now to reverse these declines, it will become progressively more difficult to address this challenge in the face of climate change.

For many pressures, there is already sufficient evidence and understanding to start taking decisive action. Where the evidence is still being developed, this should not stop government from taking positive steps to address the pressures.

We recommend that there are four key areas of activity, stemming from our assessment, that should be prioritised. We have identified these priorities based on the weight of the available evidence, the scale of impact on biodiversity, and the opportunity for action.

1. **Reduce pollution by nutrients from farming and sewage.** NI has an unsustainable nutrient surplus. Government should prioritise addressing nutrient pollution arising primarily from the agri-food industry, and from sewage treatment.

Nutrient pollution from farming and sewage is a widespread and pervasive problem in aquatic and terrestrial ecosystems. Unless the nutrient issue is addressed, biodiversity will not recover. There has been at least 30 years of research on the source and impact of nutrients in NI. There is high confidence in the evidence regarding the sources and impacts of nutrient pollution on biodiversity. While some nutrient pollution arises from historical practices, the current nutrient surplus is unsustainable and should be reduced. Government has the opportunity to take action on the agricultural sources through the Nutrient Action Programme, Soil Nutrient Health Scheme, the Ammonia Strategy, and Farming for Nature scheme. For sewage, opportunities to act exist through the full implementation of, and compliance with, the Urban Waste Water Treatment Regulations (Northern Ireland) 2007,[228] the Water (Northern Ireland) Order 1999,[229] and the Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013.[230]

2. **Change land use to restore habitats.** Most seminatural habitats have been destroyed or become fragmented by land use change. A focus on restoration and nature positive land use change is essential to provide space for nature and increase biodiversity in urban and rural areas.

Most of the seminatural habitats in NI have been destroyed or fragmented due to land use change. Key habitats such as peatland are largely degraded, lowland meadows have been converted to improved grassland, rivers have been straightened, degraded, and impeded,

woodlands and hedgerows have been removed, and wetlands have been drained. With the loss of these habitats comes the forfeit of space for nature, and essential services upon which society is reliant, such as carbon sequestration and flood alleviation. The restoration of habitats should be prioritised, so as to provide space for biodiversity across urban and rural areas.

Government has the opportunity to act on the restoration of habitats through the Nature Recovery Strategy, Peatland Strategy, Farming with Nature scheme and through the prioritisation of nature-based solutions as required through the Climate Change Act (Northern Ireland) 2022.[66] Government should also ensure that the Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 are fully implemented and complied with,[84] including that protected sites series are effectively managed to secure favourable condition.

3. **Reduce the material and ecological footprint.** The extraction, consumption and disposal of raw materials are causing widespread damage to biodiversity within NI and beyond. Action should be taken to reduce the impact of society on the environment to achieve a sustainable footprint.

Relative to its area and population, NI consumes a disproportionately large quantity of resources and as such its material footprint is well above the level required for sustainability. There are significant challenges to be addressed in terms of resource extraction, consumption, energy generation and waste management, each of which has consequences for biodiversity locally and internationally. The combined pressures of these activities on biodiversity are best encapsulated by the ecological footprint approach. We have high confidence in the evidence that the current material and ecological footprints are unsustainable.

If the decline in biodiversity is to be reversed, government should take action to reduce the material and ecological footprint of society. Government has the opportunity to act through the Climate Action Plan, Food Strategy, Circular Economy Strategy, Waste Strategy and Energy Strategy, and associated regulations.

4. **Act urgently and effectively.** Not only should action be taken to address these priority areas, but evidence is clear that unless action is taken immediately, problems will be exacerbated, and solutions will become harder. In urgently addressing these three priority areas, we recommend that the government should:

    a. Adopt an adaptive management approach that will provide an iterative process of implementation, monitoring, and learning, enabling the informed adjustment of actions when necessary.

    b. Ensure there is coherence between approaches that address multiple pressures across sectors, so that benefits are realised and trade-offs and unintended consequences are managed effectively.

    c. Develop detailed implementation plans and clear targets to ensure coherence across government and ensure resources are coordinated and actions are aligned to deliver improvements in biodiversity.

    d. Address the knowledge gaps identified in this report related to interactions among multiple pressures, chemicals, species abundance, climate change, urban and rural

development, and cumulative impact activities such as resource extraction, recreation and waste management.

e. Develop a monitoring, evaluation and learning framework that focuses on outcome-based targets, such as increases in species abundance and reductions in ecological footprint. This framework should account for the pressures outlined in this report and set a baseline for evaluation of progress with the EIP.

The new EIP is crucial in delivering these recommendations. It should provide a comprehensive framework for addressing the key environmental challenges facing Northern Ireland, including habitat restoration, pollution control, and sustainable land management. The EIP should provide a clear vision and the ambition to drive action to reverse the decline in biodiversity and ensuring the protection and enhancement of the natural environment for future generations.

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Annexes

Annex One: Glossary of terms and acronyms

Term	Description
Abundance	The number of individuals of a particular species in an area.[4]
Adaptive management	A process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.[4]
Agrochemical	An agrochemical or agrichemical is a chemical product used in agriculture. Agrochemical refers to pesticides including insecticides, herbicides, fungicides and nematicides. It may also include synthetic fertilisers, hormones and other chemical growth agents, and concentrated stores of raw animal manure.[231]
Assessment	Assessment is the process of considering all the information about a situation and making a judgement. Assessment is used in its broadest definition here, encompassing evaluation, appraisal, monitoring and analysis.
Baseline	Baseline data is a set of information used to compare data acquired afterwards to determine changes from the baseline position. In an environmental context, the baseline determines the condition or health of the environment prior to an intervention.
Biodiversity	The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems.[4]
Biodiversity intactness index	An indicator of the average abundance of a large and diverse set of organisms in a given geographical area, relative to their reference populations.[232]
Biomass	The mass of non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms in a given area or volume.[4]
Carrying capacity	In ecology, the carrying capacity of a species in an environment is the maximum population size that the environment can sustain. The term is also used more generally to refer to the upper limit of habitats, ecosystems, landscapes, waterscapes or seascapes to provide goods and services (including aesthetic and spiritual services) in a sustainable way.[4]
CBD **Convention on Biological Diversity**	Convention on Biological Diversity is a global treaty to protect and share the benefits of biodiversity, signed by 196 countries in 1992. CBD sets the Kunming-Montreal Global Biodiversity Framework.[26]
Call for evidence	A call for evidence is an information gathering exercise that seeks expertise from individuals, organisations, and stakeholders with knowledge of a particular issue. The call for evidence for this report was published on our website.[38]

Term	Description
Climate adaptation	The process of adjustment to actual or expected climate change and its effects, in order to moderate harm or exploit beneficial opportunities.[233]
Climate mitigation	Interventions to reduce emissions or enhance the sinks of greenhouse gases.[233]
Coherence	The situation in which the parts of something fit together in a natural or reasonable way. In the policy context, this means multiple areas or activities aligning towards the achievement of government's goals.
Commitments	Statements that commit to do something but do not define a desired level of performance or include a measurable indicator.
Consultation	Act of external organisations exchanging information/opinions to increase understanding or give advice to government.
DAERA	Department of Agriculture, Environment and Rural Affairs.
Delivery (plan)	Details of how goals, targets and/or policies are implemented, including the changes that are expected within sectors, who is involved and in what role, and the processes that shape decision making.
Drivers	Drivers are the underlying causes of change affecting biodiversity and ecosystem processes. Examples of drivers include economic, demographic, governance, technological and cultural ones, among others. These drivers operate by altering and influencing pressures as well as other drivers. Socio-economic and demographic trends, for example, heavily influence consumption patterns with subsequent environmental implications. In addition to interacting with socio-economic and demographic drivers, technological innovation can lead to the adoption of cleaner and more sustainable energy production but can also indirectly contribute to environmental degradation through material demand, and electronic and other waste. While difficult to model, understanding the role of societal drivers such as culture and government is crucial to sustainable ecosystem management, as these are strong drivers of value sets and decision frameworks that affect behaviours.[36]
Ecosystem	A geographic area where plants, animals and other organisms interact with the abiotic (non-living) environment.[4]
Ecosystem services	The benefits people obtain from ecosystems. Ecosystem services can be divided into supporting, regulating, provisioning and cultural, although many services can sit under more than one category.[4]
The Environment Act 2021 (The Act)	The Environment Act provided a new governance framework for the environment in Northern Ireland, with three key provisions: a new oversight body (The OEP); long-term Environmental Improvement Plans (EIPs) to be reviewed and refreshed by government every five years; and an Environmental Principles Policy Statement applicable across government.

Term	Description
Environmental monitoring	Environmental monitoring is the process of detecting, observing and measuring environmental conditions and trends. Consistent observations over time help to ensure accurate determination of environmental change. This provides information to support policy development and its implementation and make assessments of progress.
EIP **Environmental Improvement Plan**	A statutory plan for significantly improving the natural environment in the period to which the plan relates, which is required to be prepared under the Environment Act 2021.
Eutrophication	Enrichment of water by nutrients (agrochemicals) resulting in changes to water quality and species composition.
Extinction	Species may go extinct locally (population extinction), regionally (for example, extinction of populations in a country or continent) or globally.
GBF **Global Biodiversity Framework**	Kunming-Montreal Declaration - Global Biodiversity Framework was adopted by 196 countries at the United Nations Biodiversity Conference (COP15) in December 2022 and sets out a roadmap for a world living in harmony with nature. [234]
Genetic diversity	The variation at the level of individual genes, which provides a mechanism for populations to adapt to their ever-changing environment. The more variation, the better the chance that at least some of the individuals will have an allelic variant that is suited for the new environment and will produce offspring with the variant that will in turn reproduce and continue the population into subsequent generations.[4]
gha	Global hectares is a measurement unit for the ecological footprint of people or activities
Governance	The system by which entities are directed and controlled. It is concerned with structure and processes for decision making, accountability, control and behaviour, and with influencing how an organisation's objectives are set and achieved, how risk is monitored and addressed, and how performance is optimised.
GB **Great Britain**	Comprises England, Scotland and Wales.
ha	Hectare (10,000 m^2)
Habitat	The place or type of site where an organism or population naturally occurs. Also used to mean the environmental attributes required by a particular species.[4]
Habitat connectivity	The degree to which the landscape or waterscape facilitate the movement of organisms and other environmentally important resources (for example, nutrients and moisture) between similar habitats. Connectivity is reduced by habitat fragmentation.[4]
Habitat modification	Changes in an area's primary ecological functions and species composition due to human activity and/or non-native species invasion.[4]

Term	Description
Headwaters	Headwaters are the ephemeral and permanently flowing tributaries feeding a river system. The make up a significant proportion of the total length of rivers and are essential for a well-functioning river systems.[115]
Indicators	Indicators are statistics used to measure current conditions or trends over time.
Invasive non-native species	Invasive non-native species are species that are introduced, intentionally or unintentionally, outside of their natural geographic range, sometimes causing environmental, social and/or economic impacts.
IUCN	International Union for Conservation of Nature
IUCN Red List	The IUCN Red List is an indicator of the health of biodiversity. It provides taxonomic, conservation status and distribution information on species that have been globally evaluated using the IUCN Red List Categories and criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction.[235]
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.
IPCC	Intergovernmental Panel on Climate Change.
JNCC	Joint Nature Conservation Committee
kg N/ha	Kilograms of nitrogen per hectare.
kg P/ha	Kilograms of phosphorus per hectare.
Landscape	An area of land that contains a mosaic of ecosystems, including human dominated ecosystem.
MCPA	2-methyl-4-chloro-phenoxyacetic acid. A herbicide used to selectively control broadleaf weeds and rushes in pastures
Micro-plastics	Plastic debris that are less than five millimetres in length.
Monitoring	The repeated observation of a system in order to detect signs of change in relation to a predetermined or expected standard.
Nature-based solutions	Nature-based solutions are the sustainable management and use of natural features and processes to tackle socio-environmental issues.
Natural capital	The parts of nature which directly or indirectly underpin value to people, including ecosystems, species, freshwater, soils, minerals, the air and oceans, as well as natural processes and functions. Natural capital forms part of our wealth, that is, our ability to produce actual or potential goods and services into the future to support our wellbeing.[4]
NI	Northern Ireland.
Nitrogen deposition	The nitrogen transferred from the atmosphere to the Earth's surface by the processes of wet deposition and dry deposition.

Term	Description
The OEP	The Office for Environmental Protection – a statutory body established by Parliament under the Environment Act 2021. Our mission is to protect and improve the environment by holding government and other public authorities to account in England and Northern Ireland
PFAS **Poly and perfluoroalkyl substances**	PFAS are a large group of synthetic organofluorine chemicals known for their strong carbon-fluorine bonds, making them highly resistant to chemical attack and degradation. They have been widely used since the 1940s in various consumer and industrial applications due to their oil and water repellent properties. However, their stability leads to long-term environmental contamination and continuous exposure to humans and wildlife.[143]
Pesticides	Pesticides, often referred to as 'plant protection products,' are used in farming and other sectors to control pests, weeds and diseases. They encompass a range of products like insecticides, fungicides, herbicides, molluscicides, and substances that regulate plant growth. Available in diverse forms including solids, powders, and liquids, pesticides are composed of active ingredients combined with other substances.[236]
Policies	The core measures that government takes that affect environmental change, either directly or through influencing the actions of the public and private sector. These vary in scale and type (for example, regulation, standards, information campaigns, grants/subsidies).
Pressures	Pressures directly influence biodiversity and ecosystem processes. Anthropogenic pressures, including include land use change, climate change, pollution, natural resource use and exploitation, and invasive species, are driven by the aforementioned drivers. For example, population growth causing a demand for housing drives the pressures caused by aggregate extraction including habitat loss, and pollution. Pressures impact biodiversity and ecosystem change at a more proximate level, frequently involving synergies with other pressures, and ultimately feeding back into drivers.[36]
Proxy indicator(s)	A proxy indicator is an indirect measure that can approximate or can be representative of a phenomenon without the presence of a direct measure.
Regulation	A rule made and maintained by a relevant authority and often having the force of law.
Resilience	The capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks. A concept initially developed and applied in ecology, which progressively gained usage in the social and environmental sciences.
Restoration	Any intentional activities that initiate or accelerates the recovery of an ecosystem from a degraded state.

Term	Description
Seminatural habitat	An ecosystem with most of its processes and biodiversity intact, though altered by human activity in strength or abundance relative to the natural state.[237] Most habitats in the UK are seminatural habitats.
Species	An interbreeding group of organisms that is reproductively isolated from all other organisms, although there are many partial exceptions to this rule in particular taxa. Operationally, the term species is a generally agreed fundamental taxonomic unit, based on morphological or genetic similarity, that once described and accepted is associated with a unique scientific name.[4]
State	A measure of the condition or health of the environment. This may include the abiotic condition of soil, air and water, or the biotic condition of ecosystems, habitats and species.[36]
Strategies	Provide an overarching rationale and approach to reaching specific targets. Typically, they define the problems and solutions, using principles and/or a vision of the future to propose a set of actions. They should consider, and ideally incorporate, multiple priorities within and across government departments.
Succession	The natural process whereby communities of plants, animals and microorganisms are replaced by others, usually more complex, over time as an area is colonised.
Taxon, taxonomic	A category applied to a group in a formal system of nomenclature, for example, species, genus, family etc. (plural: taxa).[4]
UK **United Kingdom**	The United Kingdom comprises Great Britain (England, Scotland, and Wales) and Northern Ireland.
UK NEA **UK National Ecosystem Assessment**	The UK National Ecosystem Assessment was the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. Part of the Living with Environmental Change initiative, the UK NEA commenced in mid-2009 and reported in June 2011. It was an inclusive process involving many government, academic, NGO and private sector institutions.
uPBTs	Ubiquitous, persistent, bioaccumulative and toxic substances.[25]
Urbanization	The increase in the proportion of a population living in urban areas; the process by which a large number of people become permanently concentrated in relatively small areas, forming cities.
WFD **Water Framework Directive**	Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2017.
µg/m^3	Microgram per cubic meter.

Annex Two: Methodology and expert review

This report draws on several sources of evidence and methods of analysis. This Annex describes the methods used to collect and evaluate the drivers and pressures impacting terrestrial and freshwater biodiversity in Northern Ireland (NI) and the process of expert review of the report.

Development of our methodology

The complexity of biodiversity, and the availability of data in NI posed challenges and opportunities for our assessment. We adopted a multi-source and multi-analysis methodology that included:

- Analysis of the pressures affecting priority species and habitats in NI.
- Information collected via our call for evidence.[38]
- Literature reviews of the prioritised pressures.[41–44]
- Desk-based research.
- Review of approaches to assessing and monitoring the status of species in NI.
- An evidence baseline assessment of the monitoring and reporting framework for waste management and illegal disposal.

These methodologies and evidence sources supported and informed each other (Figure 2). The analysis of pressures affecting priority species and habitats, for example, informed our assessment of submissions received through the call for evidence. These findings subsequently guided the prioritisation of pressures for further in-depth evaluation through the externally commissioned literature reviews.

Analysis of the pressures affecting priority species and habitats

Our assessment began with a frequency analysis of the pressures affecting priority species and habitats in NI. There are 592 priority species,[238] and 51 priority habitats in NI,[239] as identified by the Department for Agriculture, Environment and Rural Affairs (DAERA). They are of principal importance for the purpose of conserving biodiversity due to their decline, rarity and importance in an all-Ireland and UK context.[240] Whilst there are limitations to the collection and availability of biodiversity data,[33] there is a relatively complete evidence base for the priority species and habitats in NI. Therefore, we consider that an assessment of the pressures affecting priority species and habitats provides a proxy for the pressures NI's wider terrestrial and freshwater biodiversity which includes more than 2,500 species,[15] and a range of complex ecosystems.

NI's priority lists include terrestrial, freshwater, and marine species and habitats. Due to our focus on terrestrial and freshwater biodiversity we excluded 114 marine species, and 17 marine habitats. These exclusions are listed in the spreadsheet available on our website.[40] In excluding species and habitats we have used Joint Nature Conservation Committee (JNCC) classification of terrestrial, freshwater, and marine (only) habitats and species.[120,241] Through this approach coastal habitats (for example, coastal sand dunes) are considered as a terrestrial habitat.[241] In the case of birds, 15 were identified within DAERA's list as 'marine' only (for example, puffin).[238] However, we have included them in

our assessment due to their use of terrestrial habitats for breeding, and, for some species, wintering.

Data sources

Our assessment of 478 terrestrial and freshwater species and 34 habitats drew upon publicly available evidence sources. We principally sourced data from DAERA, the Northern Ireland Environment Agency (NIEA), and National Museums NI through www.habitas.org[50] and the NI priority habitats guides.[51] These sources did not include information on the drivers affecting species or habitats.

Within these NI focused sources, no data were available for 173 species and 15 habitats. Alternative evidence on pressures affecting priority species and habitats were sought from sources including the International Union for Conservation of Nature (IUCN) Red List,[6] the Irish List co-produced by National Parks and Wildlife Services (NPWS) and NIEA,[242–245] and JNCC.[120,241,246]

The use of multiple evidence sources provided us with a rich but incomplete data set. Data were available for all priority habitats. However, for 122 (~26%) species data were either not available via any source checked, or species accounts were not completed.[247,248]

We recognise that there are limitations to the use of the priority species and habitats lists for our analysis. We have assessed the pressures affecting 76% of the terrestrial and freshwater priority species, and 100% of the priority habitats, data gaps and the proportion of species and taxonomic groups within the lists affects our assessment. For example, 8 of 11 (72%) native freshwater fish found in NI are included in the list[249] and [85] of [211] bird species (40%) found in NI[ii] are included in the list. We have accounted for these limitations through sensitivity analysis and the use of multiple methods of collection and analysis used within this report. Our frequency analysis is, therefore, representative rather than exhaustive.

Frequency analysis

We identified pressures affecting 356 terrestrial and freshwater species and 34 habitats. To structure our analysis, we applied the IPBES categorisation of pressures, namely land use change, climate change, pollution, natural resource use and exploitation, and invasive species.[36] Application of this framework across all species and habitats helped ensure that the analysis was consistent and robust.

Where pressures could not be assigned to an IPBES category they were recorded within an 'Other/unspecified' category. Examples of these pressures included predation, and instances where evidence stated that there was an unknown pressure affecting the species or habitat. Other pressures which we included within this category reflect instances where the source or cause of the pressure could not be easily identified (for example wildfires, or species persecution).

Where the evidence allowed, we disaggregated the five IPBES pressures to identify more granular sub-pressures. This included, for example air pollution or deforestation, under the pollution and natural resource pressure categories. Often, the description of pressures was inconsistent within the published sources. We applied reasonable judgement when

ii As assessed as part of the Birds of Conservation concern Ireland report.

categorising and consolidating pressures. Our definition of sub-pressures is presented in Annex Three.

The identification of pressures was an iterative process through which we inductively recorded and categorised pressures impacting species and habitats. During the first round of analysis, we recorded each pressure as stated in the published sources, assigning them to one of the IPBES categories, or as 'other/unspecified'.

Following this, we reviewed the categorisation and definitions of each pressure, and consolidated pressures where appropriate. Under the pollution category, for example, pressures including eutrophication, deposition and nutrient enrichment were consolidated under the overarching term of 'nutrient enrichment'.

Where necessary, and to facilitate the consolidation process, further iterations of this process review and consideration were carried out. Our analysis subsequently identified 38 pressures affecting terrestrial and freshwater species and habitats in NI. A spreadsheet of these data is available on our website.[40]

Sensitivity testing

To account for limitations of the species lists and data used, we undertook sensitivity analysis of the pressures identified. We did not carry out sensitivity analysis of priority habitats due to having a complete data set.

The purpose of this sensitivity analysis was two-fold. First, as noted, for 122 priority species there were no data available on pressures affecting them. These data gaps were particularly noticeable for insects and vascular and non-vascular plants (see data sheet on our website).[40] Such gaps create uncertainty that the 33 pressures identified for 76% of priority species are reflective of the pressures affecting all priority species. Secondly, some taxonomic groups represent a greater proportion of the total number of priority species. For example, groups such as flowering plants account for over 20% of priority species whereas mammals were just 3% of priority species. Such proportional differences were identified as a potential source of bias in our assessment.

We used two approaches (tests) to the sensitivity analysis for species. We aimed to compare the pressures recorded for each taxonomic group, as classified within DAERA's dataset, to the totals recorded for all priority species. For each taxon group, we calculated the total frequency of pressures affecting the species within that group. In our first test, we identified the 10 most frequently recorded pressures for each taxon group. These represent the most common stressors affecting those species. In the second test, we identified the top 50% of pressures affecting each taxonomic group. This was adopted to allowed us to capture a wider range of pressures. The results from both approaches were compared and the pressures impacting each taxonomic group were found to be consistent with the pressures affecting all priority species. This alignment reinforces the validity of our findings and eliminating any bias that could have resulted from the data gaps.

Call for evidence and thematic analysis

We undertook a call for evidence between 7 September and 3 November 2023.[38]
We invited individuals and organisations to submit evidence on the drivers and pressures affecting terrestrial and freshwater biodiversity in NI. We published the call for evidence on

our website,[38] promoted it via social media, and notified key stakeholders from government, academic, and non-governmental organisations.

We sought evidence and data considered by respondents to be of relevance. Our call for evidence was particularly concerned with the following areas including:

- The time period and spatial scale over which the drivers or pressures are affecting biodiversity.
- The cumulative and synergistic relationships between drivers, pressures and their effects.
- Actions needed to address the drivers and pressures, including trade-offs.
- How should drivers and pressures be prioritised for action.
- Barriers and opportunities to addressing drivers and pressures.
- Transboundary drivers and pressures.

We received 14 submissions from stakeholders from across NI, the RoI, and the UK. Our approach to using information and evidence provided was detailed within the call for evidence.[38]

Those listed below submitted evidence for our research. We are grateful to all these organisations and individuals for their valuable contributions to this study.

- Butterfly Conservation
- Council for Nature Conservation and the Countryside
- Institute of Fisheries Management
- James Hutton Institute
- Loughs Agency
- Lough Neagh Partnership
- Northern Ireland Agricultural Producers' Association
- Northern Ireland Environment Link
- Royal Society for the Protection of Birds Northern Ireland
- Ulster Angling
- Ulster Wildlife

We also received submissions to our call for evidence from three individuals not associated with organisations.

We received evidence from NIEA following the close of the call for evidence. We did not assess this information as part of the analysis, as described below. However, we did take it into consideration during the development of the report.

Through these submissions we received 10 original documents (i.e. submissions written specifically for the call for evidence), 27 supporting documents including consultation responses, and reports; and the identification of 139 evidence sources which included peer-reviewed literature, government reports, and blogs. These are listed within the summary of responses report which is available on our website. All documents submitted or identified were analysed.

Analysis of submissions was undertaken using NVivo. Submissions were thematically analysed by three members of the project team. The choice and use of multiple 'coders' was purposefully done to enhance the analysis and interpretation of submissions. Each team member has specific relevant expertise covering ecology, urban planning and development, and agriculture and land use. The combination of expertise within the analysis team enabled development of shared meaning, and ultimately increased the quality of analysis. Our approach mitigates the impact of any biases created by one coder's perspective.

Submissions were manually analysed to identify themes relating to the drivers and pressures affecting terrestrial and freshwater biodiversity. Our analysis was guided by the questions set out within our call, the IPBES pressure categories, and the disaggregated sub-pressures identified through our frequency analysis. We used these as pre-defined themes, or codes, to assess submissions. We expanded upon this thorough an iterative and inductive analysis process allowing the data itself to shape the emerging themes. Following the first round of coding, the lead analyst undertook a review to reduce duplication of themes and refine our findings. This approach allowed comparison of results with frequency analysis, while facilitating critical examination of submissions, and minimising the influence of confirmation bias.

To support the cyclical coding and report development, analytic memos in the form of short notes were attached to submissions by the analysts during the coding process. The memos included the analyst's thoughts regarding the evidence base and themes. Subsequently the memos were collated for each response and support cross-team working and report writing. This approach to coding and memoing enabled a critical and detailed understanding of the evidence base to be developed of the evidence in the context of this project.

To ensure a consistent standard across all analysis the lead analyst quality assured the work of the other two analysts. This process consisted of a manual review of ~30% of responses analysed by the two other analysts. This quality assurance ensured that the analysis had been undertaken rigorously, and in a precise, consistent, and exhaustive manner, whilst retaining the value of the multi-disciplinary nature of the coding team.

Following the thematic analysis the evidence which we received was summarised by the lead analysts, and checked by the other team members to ensure it was representative. Evidence submitted is summarised in the report available on our website. We have used this evidence base to prioritise the commissioning of literature reviews, and our assessment of the pressures affecting terrestrial and freshwater biodiversity.

Literature reviews

We commissioned five literature reviews to be undertaken by experts. The first of which was a review of the literature and official reports on the drivers and pressures affecting terrestrial and freshwater biodiversity in NI. This commission sought to provide an independent assessment against which we could cross-check our assessment of the prioritised pressures (i.e. those listed below), and the strength of evidence.

The other four topics chosen related to the most commonly cited pressures impacting terrestrial and freshwater biodiversity in NI. This was based on the results of the frequency analysis, and the analysis of submissions received through our call for evidence.

1. Biodiversity impacts of development pressures in Northern Ireland.[44]

2. Changes in upland biodiversity resulting from agriculture in NI.[41]

3. An evidence review on the influence of lowland agriculture and land use change on biodiversity in Northern Ireland.[43]

4. Hydromorphological and eutrophication impacts on riverine biodiversity in Northern Ireland.[42]

Details of the methods, including search terms, used for each review are included within the reports which are available on our website.[39]

These reviews were primarily concerned with peer-reviewed literature but included within their scope grey literature including official/government reports. In some cases there was a lack of evidence, including for example planning and development. In such instances we relied more heavily of the expert judgement of those who carried out the review.

For each of the reviews, a case study on a habitat and/or a specific species. We have incorporated some of these cases within our report (Figure 5). Their inclusion in this report should not be taken as an indicator of their relative importance, rather they are exemplars of the evidence linking multiple drivers and pressures to impacts on biodiversity.

Desk based research

In addition to the commissioned literature reviews, internally we undertook desk-based assessment of evidence sources where required. We assessed a range of reports and research that describe the state of, and pressures affecting terrestrial and freshwater biodiversity in NI. These include DAERA's yearly environmental statistics reports,[16] Water Framework Directive (WFD) reports,[25] and statistical reports from the agri-food sector.[250] We also assessed reports and evidence produced by the NI Audit Office, Committee on Climate Change, and wider sources such as the State of Nature, and relative species or habitat specific reports (for example, Woods and Trees). This evidence base supported our assessment and understanding of the range of pressures, and the impact they are having on biodiversity in NI.

We also undertook desk-based assessment of the pressures not subject to detailed literature review, namely climate change, invasive species, and natural resource-use and exploitation. These pressures are affecting biodiversity across NI. However, due to the frequency with which they were referenced they were not selected for an in-depth literature review. Instead, we internally assessed evidence related to these pressures. This included previously commissioned work on waste management and illegal dumping in NI (available on our website),[45] and evidence received through our call for evidence, or identified through discussion with experts. We also carried out non-exhaustive searches on Google Scholar or Web of Science. The results of our desk-based assessment is included in Chapters 2 and 3, and source have been included in the reference list of this report.

Assessment and monitoring the status of species in Northern Ireland

We commissioned the UK Centre for Ecology and Hydrology (UKCEH) to critically appraise approaches to assessing and monitoring the status (abundance, extinction risk and wider conservation status) of species, including priority species in NI.[33] This work considered

terrestrial, freshwater, and marine species. Marine was included in this work to help inform another project focused on this topic. The report is available on our website.[33]

UKCEH's evaluation included two elements of stakeholder engagement, and a review of existing relevant reports. The first phase included a stakeholder consultation. Collectors and providers of biodiversity data, and relevant experts were invited to identify the availability of data to contribute to a biodiversity indicator or indicators in NI. Stakeholders were also asked to identify the methodologies and protocols have been adopted in the collation and processing of biodiversity data.

The second phase involved an in-person stakeholder workshop held in Belfast in December 2023. Data providers, experts and policy makers were invited to consider the practicalities and standards that should be adopted when using data in biodiversity indicators. This workshop explored the potential data, methods, and approaches available for developing indicators to track biodiversity change across NI. Specifically, the workshop focused on understanding the properties that indicators should have, followed by consideration of the monitoring schemes and data that may feed into any potential indicators.

Results of the invited consultation and in-person workshop were assessed and summarised by UKCEH. The report was used to support our work, including development of our recommendations. The report can be found on our website.[33]

Expert review

Prior to completion, we sent draft copies of our report to external experts for independent review. These were drawn from the OEP's College of Experts based on their subject matter expertise and availability to undertake the review.

The contributing experts were:

- Wendy McKinley
- Professor Nathalie Pettorelli

All reviewers returned comments which we have considered in finalising the report. The report remains the work and presents the conclusions of the OEP. It does not necessarily reflect the views of the reviewers.

Annex Three: Description of sub-pressures

In our analysis of the pressures affecting priority species and habitats (the results of which are presented in Figure 4 and Table 1) the land use change, pollution, and resource use and exploitation IPBES pressures were disaggregated into 30 sub-pressures. Here we provide a description of these 30 sub-pressures.

IPBES Pressure	Sub-pressure	Description of sub-pressure
Land use change	Afforestation	Establishing trees on priority habitats where there has not been recent tree cover can have positive or negative impacts and can result in the direct loss of that habitat.
	Agricultural intensification	Agricultural intensification describes the process of increasing inputs (such as fertiliser, labour, money, livestock) to increase agricultural productivity and outputs. Intensification can impact priority species and habitats as the landscape tends to become more homogenous.
	Agricultural nutrients	We have made the distinction between agricultural nutrients associated with land use change (i.e application of fertilisers and manure) and nutrient loss associated with pollution (below). Nutrients are essential for plant and animal growth, making them crucial for food production. Excess nutrients resulting from agriculture can be detrimental to freshwater and terrestrial biodiversity associated with priority species and habitats.
	Arable to pasture	The conversion of arable farmland to grasslands used to graze livestock can impact biodiversity. Intensive grasslands can lack heterogeneity present on arable farmland impacting priority species and habitats.
	Burning as management	The intentional use of fire as a habitat management technique can have direct impacts on biodiversity associated with priority species and habitats.
	Habitat loss & fragmentation – agriculture	The conversion of land to farmland can result in habitats being lost and/or fragmented. This will impact biodiversity associated with priority species and habitats on and off site.
	Habitat loss & fragmentation – development	New housing or industrial premises can result in habitats being lost and/or fragmented. This will impact biodiversity associated with priority species and habitats on and off site.

IPBES Pressure	Sub-pressure	Description of sub-pressure
Land use change	Habitat loss & fragmentation – unspecified	Some sources identified habitat loss and fragmentation as a pressure on priority species and habitats on but did not specify the cause. In such cases the pressure was allocated to this sub-pressure.
	Habitat management - inappropriate	Priority species and habitats can require management to maintain or improve their condition. Inappropriate management, whether intentional or unintentional, can impact priority species and habitats.
	Hydromorphological change	Changes to the physical character of rivers, the riverbed, the riparian zone and the flow of water can impact both terrestrial and freshwater priority habitats and species.
	Land drainage	Because of inefficient natural drainage and high rainfall some seminatural land requires drainage to enable land use change, such as housing or agriculture. This impacts priority species and habitats. A distinction can be made between land drainage described here and arterial drainage. Land drainage, also known as field drainage, tends to be carried out by individual landowners on a specific area of land. Arterial drainage describes changes to river channels, these changes tend to be carried out by public bodies. We categorised arterial drainage pressures within the hydromorphological change sub-pressure above.
	Livestock grazing	Livestock grazing can be used to manage vegetation on certain habitats and is also vital for feeding livestock. Either too much or too little grazing can impact priority species and habitats. The type of livestock, the timing and the location where grazing takes place can also be a pressure.
	Military use	The use of land by the military for training can affect priority species and habitats.
	Woodland management – inappropriate	Priority species and habitats can require management to maintain or improve their condition. Inappropriate woodland management, whether intentional or unintentional, can impact priority species and habitats.

IPBES Pressure	Sub-pressure	Description of sub-pressure
Pollution	Air pollution	The impact of air pollution on human health is well understood. Apart from ammonia/nitrogen deposition from agriculture, the impact of air pollution on priority species and habitats is less understood. However, the sources used cited air pollution as a pressure to the environment.
	Noise or light pollution	Noise and light pollution can affect priority species. This can be noise and light from urban environments and from the renewable energy sector.
	Nutrients	We have made the distinction between agricultural nutrients associated with land use change (above) and nutrient loss associated with pollution. Nutrients resulting from wastewater and ineffective wastewater treatment can be detrimental to freshwater and terrestrial priority species and habitats. This pressure is closely associated with urban development.
	Pesticides	Pesticides, also known as plant protection products, are used to control pests, weeds and diseases and will have a direct on priority species and habitats, especially when used inappropriately or excessively.
	Pollution – unspecified	Some sources identified pollution as a pressure on priority species and habitats but did not specify the cause. In such cases the pressure was allocated to this sub-pressure.
	Waste or litter	The production, management, and disposal (regulated, or unlawful) of waste can impact priority species and habitats.
	Water pollution – chemicals	Water pollution due to chemicals (industrial, domestic, veterinary, agricultural, urban, medical) can affect priority species and habitats.
	Water pollution – oil	Water pollution due to oil can affect priority species and habitats.
	Water pollution – silt	Water pollution due to silt can affect priority species and habitats. The amount of silt present in freshwaters is dependent upon land use, with activities such agriculture or afforestation increasing the amount of silt present.

IPBES Pressure	Sub-pressure	Description of sub-pressure
Natural resource use and exploitation	Accidental death of species	Priority species can be unintentionally killed by wind turbines or vehicles, for example.
	Aggregate extraction	Aggregates use for construction are obtained from quarries and dredged from freshwater bodies. Aggregates are also dredged from the sea, but this is outside the scope of this report. Aggregate extraction will affect priority species and habitats.
	Commercial fishing	Commercial fishing will impact priority species and habitats associated with the species targeted by the commercial fishery.
	Disturbance of species and habitats	Disturbance covers a wide range of activities impacting priority species and habitats. Disturbance includes the physical disturbance of soil, land or silt in freshwaters. Certain species require a degree of habitat disturbance, and the cessation of this can impact their success. Disturbance also involves the disturbance of species, such as the disturbance of breeding birds by farming activities or recreation.
	Erosion or infilling	Erosion can occur naturally or be the result of human activities, both can impact priority species and habitats. The infilling of historic ponds or quarries with a range of material can impact priority species and habitats.
	Peat extraction & turf cutting	The cutting and extraction of peat for fuel and for horticulture can affect priory species and priority habitats.
	Recreation, tourism, sporting activities	Recreational activities are vital in connecting people with the natural environment. Certain activities if not carried out appropriately can affect priority species and priority habitats.

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