Natural Capital Risk Register

A Technical Report for the State of Natural Capital Report for England 2024

October 2024

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Executive summary

Aim and Approach

This Natural Capital Risk Register provides an assessment of risk, to inform the State of Natural Capital Report (SONC) (Lusardi and others, 2024). The risk register identifies the level of risk to ecosystem assets (marine; coastal margins; freshwater and wetlands; woodlands; mountains, moorlands and heaths; semi-natural grasslands; enclosed farmland; urban) and the benefits they provide.

Information from this technical report has informed the SONC. The main report considers the consequences of risk to natural capital benefits for the following policy areas: economic resilience, water security, food security, Net Zero, climate adaptation, and health and wellbeing.

England's natural capital is at risk – the extent and condition of our ecosystems are deteriorating, and this will impact the provision of benefits that we get from nature. It is crucial that we act now. Risks to ecosystems and benefits are likely to escalate, and the costs of acting later are orders of magnitude greater than the costs of acting now. The more degraded our ecosystems are (based on impacts to date), the less able they are to cope with additional impacts now and in the future. This risks pushing ecosystems towards thresholds, beyond which they cannot recover, and puts the benefits they provide at risk. Asset restoration becomes more challenging and expensive the longer we wait.

Risk registers can be compiled in the absence of full knowledge of a system (Mace and others, 2015), and can be vital in identifying priority areas for action based on the severity of the risk. We have applied a transparent and evidence-based approach to assessing risk, which allows us to be clear about what is driving it.

Our assessment of risk is based on how impacted our ecosystem assets are to date from five main drivers of change, and the severity of these drivers now and in the future. These drivers are: land- and sea-use change; pollution; natural resource use and exploitation; climate change; and invasive species (UK National Ecosystem Assessment, 2011; IPBES, 2019).

We reviewed the natural capital risk register developed by the Natural Capital Committee (Mace and others, 2015) and incorporated their 'progress against targets' approach into our method. Our approach builds on this to give a fuller picture of risk (beyond only indicators with targets) and clearly identifies what is driving the risk. This is important for decision-making, highlighting where to prioritise action to reduce the future impacts of drivers of change.

By building on robust work from the UK National Ecosystem Assessment and using best available evidence and expert opinion, our method enables reporting on risks to ecosystems and benefits, making our risk register actionable and useful for decision-making now.

Method and Results

Risk scores were assigned by assessing the severity of impacts to date, plus current and ongoing impacts of drivers of change. This was based on an updated version of the UK National Ecosystem Assessment (2011) matrix of the impact of drivers on ecosystems. The matrix was updated using expert opinion, informed by supporting evidence (summarised in Appendix 1). This evidence included a review of the SONC indicators (see the Indicators and Data Appendix of the SONC report - Craven, Bell & Dobson, 2024), to identify progress towards policies/targets, and any trends in the indicators. Uncertainty was assessed for each impact and trend rating, based on the type of evidence that was used to inform the expert opinion.

Impacts and trends of direct drivers on the eight ecosystem assets

Ecosystem asset	Land- and sea-use change	Pollution	Natural resource use and exploitation	Climate Change	Invasive Species
Marine	↑	→	↗	↑	↑
Coastal margins	↗	→	↘	↑	↗
Freshwaters and wetlands	→	→	↗	↑	↗
Woodlands	↗	↗	↘	↗	↑
Mountains, moorlands and heaths	↗	→	↗	↑	→
Semi-natural grasslands	↗	↗	→	↗	→
Enclosed farmland	↗	→	→	↗	↗
Urban	↗	→	↗	↗	↗

Key to Table

Driver's impact on extent and condition of ecosystem assets

Low
Moderate
High
Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact
↗ Increasing impact
→ Continuing impact
↑ Very rapid increase of impact

A risk rating was assigned to the impacts of drivers of change on ecosystems, based on a matrix of impacts to date, in combination with current and ongoing impacts:

Risk matrix, showing risk ratings for ecosystem assets based on the impact of drivers of change to date, plus current (since the UKNEA) and ongoing trends.
Note: The colour-coded cells show the final risk score. Risk ratings may be low (L), medium (M), medium-high (M-H) or high (H). Impact and trend levels for each ecosystem asset are taken from the updated UKNEA matrix.

		Ongoing trend			
		↘	→	↗	↑
Impact to date	**Very high**	M	M	M-H	H
	High	L	M	M-H	H
	Moderate	L	M	M	M-H
	Low	L	L	M	M

The risk rating was assigned based on the highest impact to date and the highest current and ongoing driver score, from all the drivers. This follows a concept from The Orange Book: Management of Risk (UK Government, 2023), that states that “when assigning a consequence rating to a risk, the rating for the highest, most credible worst-case scenario should be assigned.” Even where the drivers were different in the past, than now and in the future, impacts on ecosystems makes them less able to cope with future change.

The approach was applied first to ecosystem assets and then to the key benefits they provide (results are shown below). The benefit risk ratings took account of whether a driver negatively impacts on a particular benefit, or not. For example, pollution impacts on the provision of clean water but not on the role ecosystems play in flood protection. This was determined through a logic flow diagram using the information from Chapter 3 of The UK National Ecosystem Assessment Technical Report (Winn & Tierney, 2011). Uncertainty was assigned to each of these assessments based on the type of evidence that was used. Impacts on cultural benefits were assessed based on different uses of nature: experiential; physical; scientific; educational; aesthetic; spiritual and/or emblematic.

The benefit risk rating also took account of whether a driver increases the demand for a benefit. For example, climate change increases the likelihood of extreme weather events including droughts, flooding and heat waves. This increases the burden on our ecosystems in the provision of clean and plentiful water, flood protection, erosion control and urban cooling, putting these benefits at risk.

Discussion and Conclusion

Any reporting of natural capital risk involves simplification of a complex system. Evidence on this system is incomplete. To communicate the risk to benefits we have taken an approach based on the degradation of ecosystem assets due to past, present, and future drivers of change.

Our risk register highlights the benefits at highest risk, due to growing pressures on complex interconnected systems. Despite existing evidence gaps, the risk ratings underscore the need for urgent and direct attention to where it is most needed. Without action, there is increased likelihood that unknown thresholds will be crossed, leading to irreversible impacts to ecosystems and higher future adaptation costs.

Combined risk ratings for benefits provided by each broad ecosystem asset. Note, some cells are left deliberately blank

	Marine	Coastal margins	Fresh-waters and wet-lands	Wood-lands	Moun-tains, moor-lands and heaths	Semi-natural grass-lands	Enclo-sed farm-lands	Urban
Timber and other wood products				H				
Produce from the sea	H	H						
Plant-based energy								
Aquaculture	M	M						
Cultivated crops							M-H	
Plentiful water			H	M	H	M-H	M-H	M-H
Reared animals and outputs					H	M	M	
Clean water	M	H	H	M	H	M-H	M-H	M-H
Clean air				M				M-H
Noise regulation								M-H
Urban cooling								M-H
Erosion control		H	H	M-H	H		M-H	

	Marine	Coastal margins	Fresh-waters and wet-lands	Wood-lands	Moun-tains, moor-lands and heaths	Semi-natural grass-lands	Enclo-sed farm-lands	Urban
Flood protection		H	H	M-H	H	M-H	M-H	M-H
Pollination						M-H	M-H	
Thriving plants and wildlife	H	H	H	H	H	M-H	M-H	M-H
Pest and disease control							M-H	
Climate regulation	H	H	H	M-H	H	M-H	M-H	M-H
Cultural benefits	H	H	H	M-H	H	M-H	M-H	M-H

For risk ratings: L = low; M = medium; M-H = medium-high; H = high.

Note: White cells indicate that the ecosystem asset has not been linked to the provision of the benefit. Grey cells indicate that a lack of evidence has meant we were not able to determine a risk rating.

Table of Contents

List of Tables

List of Figures

1. Aim

This Natural Capital Risk Register provides an assessment of risk, to inform the State of Natural Capital Report (SONC) (Lusardi and others, 2024). The risk register identifies the level of risk to ecosystem assets (marine; coastal margins; freshwater and wetlands; woodlands; mountains, moorlands and heaths; semi-natural grasslands; enclosed farmland; urban) and the benefits they provide.

Information from this technical report has informed the SONC. This includes consideration, in the main report, of the consequences of risk to natural capital benefits for the following policy areas: economic resilience, water security, food security, Net Zero, climate adaptation, and health and wellbeing.

Developing the risk approach involved:

- Analysis of impacts from drivers of change on ecosystem assets, and
- Assignment of risk status to ecosystem assets and benefits

By building on robust work from the UK National Ecosystem Assessment (2011) and using best available evidence and expert opinion, our method enables reporting on risks to ecosystems and benefits despite variation in data collection and indicator reporting. Our approach produces an evidence-based method which can be consistently applied to incorporate risk to ecosystems and benefits into decision-making now.

This report provides details on the methods and results, followed by a discussion of issues encountered, conclusions, and recommendations.

1.1. Approach to Natural Capital Risk

We developed our approach to assessing risk to natural capital after reviewing other methods, in particular the natural capital risk register of Mace and others (2015), undertaken for the Natural Capital Committee (NCC). Our natural capital risk register builds on the NCC method, which assesses risk using ecosystem asset status (progress towards policy targets) and trends.

While a number of policy targets and/or indicator trends are available for marine, coastal margin and freshwater assets, there are fewer targets and trend data for land-based ecosystems. Policy targets are also predominantly not designed to assess the provision of benefits from natural capital assets.

We therefore build on the Mace method, to improve the assessment of how well an ecosystem asset is delivering its benefits. The available indicator data is complemented by additional evidence and interpreted through expert opinion, to assess the impact of five drivers of change on natural capital assets and benefits: land- and sea-use change; pollution; natural resource use and exploitation; climate change; invasive species. The risk to ecosystems and benefits is assessed based on this impact to date, and the ongoing

impact. This provides a fuller picture of natural capital risk than is possible from consideration of asset status and trends alone.

Recent risk work in aquatic ecosystems recognises how drivers of change can impact on the capacity of ecosystems to provide benefits (Borgwardt and others, 2019; Culhane and others, 2019). Farrell and others (2022) also highlight how ongoing pressures on degraded peatlands may result in increased risks to the provision of benefits.

Drivers of ecosystem change are also being considered in national risk assessments; the Third UK Climate Risk Independent Assessment (CCRA3) (UK Climate Risk, 2021) reports on the increasing impacts of climate change on ecosystems and recognises it leads to both risks and opportunities. This informs the National Adaptation Programme (NAP3), which reports on the actions that the government and others will take to adapt to the impacts of climate change in the UK. Box 1 sets out the 8 highest priority risks identified by the Third UK Climate Risk Independent Assessment (Climate Change Committee, 2021). All eight of these risks relate to the provision of benefits from nature.

Box 1 Third UK Climate Risk Independent Assessment: 8 highest priority headline risks for further adaptation in the next two years.

All eight of the highest priority headline risks identified by CCRA3 relate to the role of natural capital. The eight risks are listed below, with their associated benefits from nature in brackets. These priorities were identified to inform national adaptation plans and wider action (Climate Change Committee, 2021).

- Risks to the viability and diversity of terrestrial and freshwater habitats and species from multiple hazards (thriving plants and wildlife)
- Risks to soil health from increased flooding and drought (cultivated crops; plentiful water; clean water; erosion control; flood protection; thriving plants and wildlife; pest and disease control; climate regulation)
- Risks to natural carbon stores and sequestration from multiple hazards leading to increased emissions (climate regulation)
- Risks to crops, livestock and commercial trees from multiple hazards (timber, cultivated crops, reared animals)
- Risks to supply of food, goods and vital services due to climate-related collapse of supply chains and distribution networks (produce from the sea; cultivated crops; reared animals; erosion control; flood protection)
- Risks to people and the economy from climate-related failure of the power system (erosion control; flood protection)
- Risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings (urban cooling)
- Multiple risks to the UK from climate change impacts overseas (overseas natural capital)

In our risk register, we consider the impacts of climate change alongside four other drivers of change, to identify how they affect the capacity of ecosystems to supply benefits to

people. By reporting on what is driving the risks, we can identify actions, in the SONC report, to adapt to and mitigate them. Using best available evidence to inform expert opinion ensures that our risk register is actionable and can be used to inform decision-making now.

2. Method

2.1. Impacts of drivers of change on ecosystems

The approach to assessing impacts of drivers of change on ecosystems is based on the UK National Ecosystem Assessment (Winn & Tierney, 2011). The UKNEA developed a matrix showing the impact and trend of five direct drivers of change on eight ecosystem assets (Figure 1).

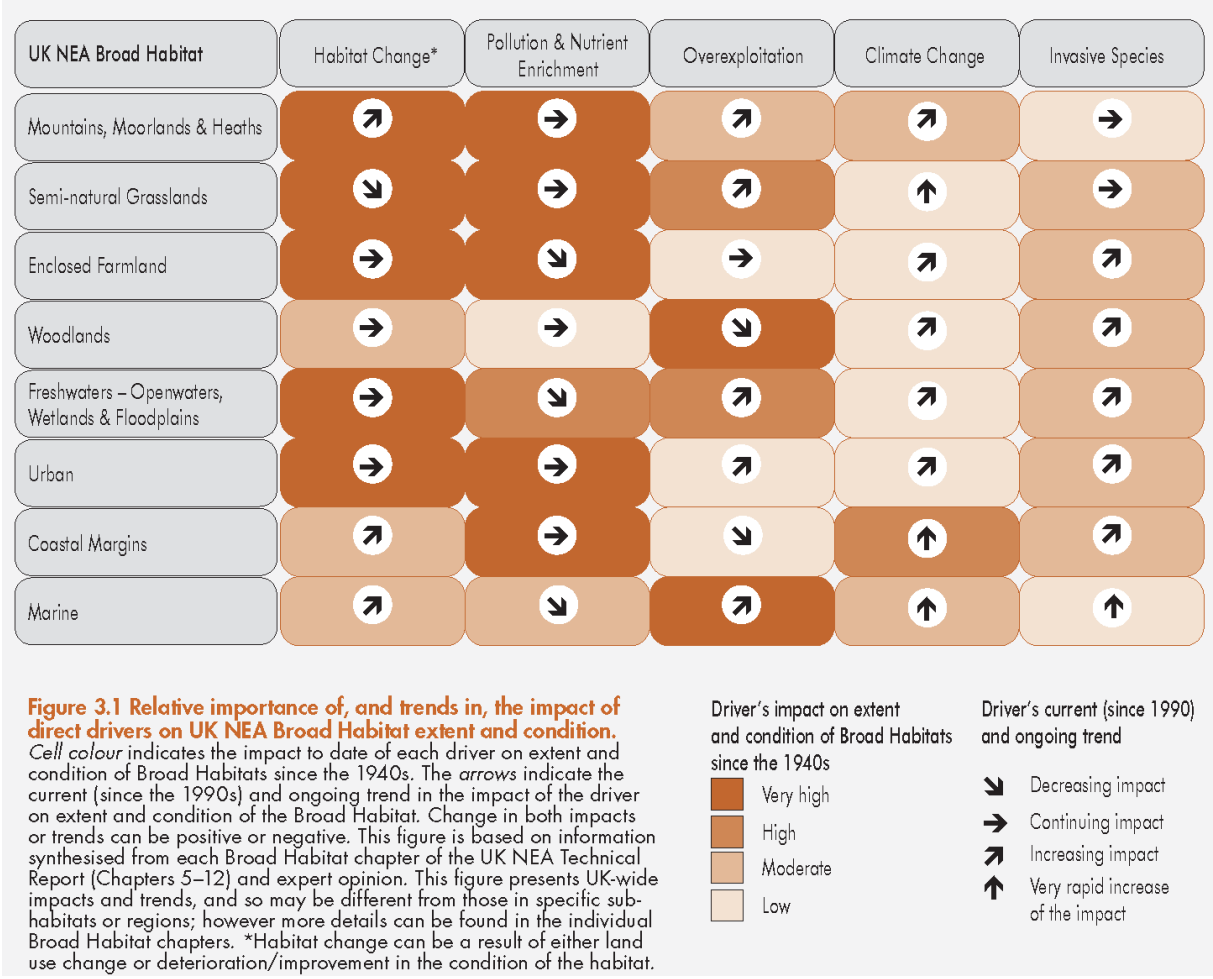

Figure 1. Extract from the UKNEA of the original matrix that shows the relative importance of, and trends in the impact of direct drivers on UKNEA broad habitat extent and condition. See Winn and Tierney (2011) for the original figure.

The UKNEA was commissioned by a range of government organisations including Defra and the Devolved Administrations of Scotland, Wales, and Northern Ireland. As a peer reviewed, independent ecosystem assessment which involved an expert panel of 27 natural scientists, economists, and social scientists, as well as a user group including government agencies, non-governmental organisations, and the private sector, the UKNEA provided a robust starting point for this risk register. It presented the first analysis of the UK's natural environment that considered the benefits that the environment provides to society and economic prosperity and remains a valuable evidence base.

Chapter 3 of the UKNEA, which covers drivers of change, gave an overview of the drivers that have had the greatest impact on the UK, and considered driver trends and their impacts on the extent and condition of eight broad habitats (Winn & Tierney, 2011). This overview drew on the habitat specific chapters, which brought together evidence and expert input, to produce Figure 1 above, showing the impact and trend of the five direct drivers on eight broad habitats. This figure represents a peer reviewed synthesis of the evidence across all eight broad habitats. It therefore provided a firm base from which to begin to consider the current impact and trend of drivers of change. Drawing on more recent evidence and expert input, our work provided an updated version of the UKNEA matrix.

Our risk register used the same broad habitats as the UKNEA, referring to them as ecosystem assets. The direct drivers from the UKNEA were matched with those more recently identified by the Intergovernmental Panel Science-Policy Platform on Biodiversity and Ecosystem Servies, IPBES (2019) to produce a final list: land- and sea-use change; pollution; natural resource use and exploitation; climate change; invasive species.

The UKNEA matrix was updated using expert opinion informed by evidence on the status and trend of natural capital indicators (Box 2), plus additional evidence including the 25 Year Environment Plan D1 indicator of habitat quality report (Maskell and others, 2023, unpublished), and Natural England's report re-evaluating the sensitivity of habitats to climate change (Staddon, Thompson & Short, 2023). Evidence used to update the table is summarised in Appendix 1. Where there was insufficient post-2011 evidence for any change to be made, the default (UKNEA 2011) impact or trend was retained.

Box 2: Assessing the status and trend of natural capital indicators

Where possible, indicators were linked to targets from existing policies and strategies, and an assessment of whether these targets were being met was undertaken. Targets were drawn from sources including the Environmental Improvement Plan, UK Marine Strategy, and 25 Year Environment Plan. Table 1 outlines the categories and criteria used for the target assessment, adapted from the risk register scoring matrix in Mace and others (2015).

Table 1. Categories and criteria used for the target assessment.

Performance category	Abbreviation	Criteria for assignment
Met/Exceeded	M/E	Assigned if the metric value meets the target value exactly or is above it
Below	B	Misses the target by up to 50%
Substantially below	SB	Misses the target by over 50%
No applicable target	NAT	No relevant policy or target could be found

Trends were assessed to understand changes to the extent and condition of ecosystems since the UKNEA was published in 2011. However, not all the indicator data identified went back this far. In other cases, due to the nature of the indicator (e.g., a long-term indicator) or the need to use more data points for a robust assessment of change, trends were assessed over longer periods of time. Table 2 provides the criteria for the trend assessment; the most recent values were assessed against benchmark values. The date ranges over which trends were assessed are included in the Indicators and Data Appendix of the SONC report (Craven, Bell & Dobson, 2024).

Table 2. Trend assessment criteria.

Performance category	Abbreviation	Criteria for assignment
Significantly positive	++	Assigned if the metric value is >50% of the benchmark value
Positive	+	Up to 50% over the benchmark value
No change	+/-	The value for the metric is the same as benchmark value
Negative	-	Up to 50% under the benchmark value
Significantly negative	--	>50% under the benchmark value
No trend ascertained	NT	No trend could be assessed because historical data are not available

It was not possible to link all indicators used in the SONC to existing policy targets, and some indicators did not have enough previous data points to allow trend assessments. For the list of indicators that did have target or trend information, and additional detail (e.g., on

identified policy targets, and time ranges used for trend assessments) see the Indicators and Data Appendix of the SONC report.

By basing our approach on expert opinion informed by evidence, we ensured that our method is actionable now. Risk ratings can be produced for all relevant ecosystem assets and benefits even if there is variability in the amount or quality of evidence across ecosystems. For example, in the assessment of indicator status and trend (Box 2), some ecosystems were well-represented (including marine and coastal margins), while others, including semi-natural grasslands and urban ecosystems, had fewer targets or historical datasets to draw from. Our approach allowed experts to consider additional evidence sources to update the UKNEA matrix for all ecosystem assets.

Uncertainty was assessed for each impact and trend rating, based on the type of evidence that was used to inform the expert opinion. All the decisions used the UKNEA rating as a starting point; the uncertainty assessment considered the extent to which post-2011 evidence sources were available and supported the decision-making. The three categories used for the uncertainty assessment were:

A – based on UKNEA plus post-2011 evidence
B – based on UKNEA plus expert judgment, and
C – based on UKNEA only (decision to retain due to lack of post-2011 evidence).

2.2. Ecosystem asset risk scoring

The updated version of the UKNEA matrix provided the updated impacts and trends of direct drivers on the eight ecosystem assets, based on evidence and expert input.

Our assessment of risk was based on how impacted our ecosystems are to date from all five main drivers of change, and the severity of drivers now and in the future. In ecosystems where drivers have had a low level of impact to date, and the ongoing trend shows improvement, the risk is low. If impact to date is very high, and/or the ongoing trend shows a rapid increase of impact, the risk to our ecosystems is also high. Deterioration means that ecosystems are less able to cope with future change, risking pushing them towards thresholds beyond which they cannot recover.

Table 3. Risk matrix, showing risk ratings for ecosystem assets based on the impact of drivers of change to date, plus current (since the UKNEA) and ongoing trends.
Note: The colour-coded cells show the final risk score. Risk ratings may be low (L), medium (M), medium-high (M-H) or high (H). Impact and trend levels for each ecosystem asset are taken from the updated UKNEA matrix.

		Ongoing trend			
		↘	→	↗	↑
Impact to date	**Very high**	M	M	M-H	H
	High	L	M	M-H	H
	Moderate	L	M	M	M-H
	Low	L	L	M	M

Risk ratings for each ecosystem asset were based on the highest (worst) impact and trend ratings out of all drivers (Table 3). This follows a concept provided in The Orange Book: Management of Risk (2023), which states that “when assigning a consequence rating to a risk, the rating for the highest, most credible worst-case scenario should be assigned.” The risk matrix is based on the impact to date of the driver on the ecosystem asset (vertical axis) and the current and ongoing trend of the impact (horizontal axis). Slightly more

weight is given to ongoing trend compared to impact score in the matrix, to reflect future risk. This means that ‘high’ risk ratings are only applied in cases where the driver of change trend is recorded as ‘very rapid increase of impact.’

2.3. Ecosystem-benefit risk scoring

The method was extended to assign risk scores to the provision of individual benefits from each of the eight ecosystem assets. To do this the following were assessed:

- **Is this a key benefit from this ecosystem asset?** This was based on the UKNEA (2011), the prioritised relationships from the NCC risk register (Mace and others 2015), and natural capital indicators work (Lusardi and others, 2018).
- **Is this benefit, from this ecosystem asset, impacted by this driver of change?** (See Section 2.3.1. on driver/benefit relationships).

2.3.1. Driver/Benefit Relationships

The potential for each driver of change to have impact on a benefit was assessed for each driver/benefit relationship. This was informed by UKNEA work which assessed the impact, and trend of impact of drivers on the delivery of benefits (**Figure 2**).

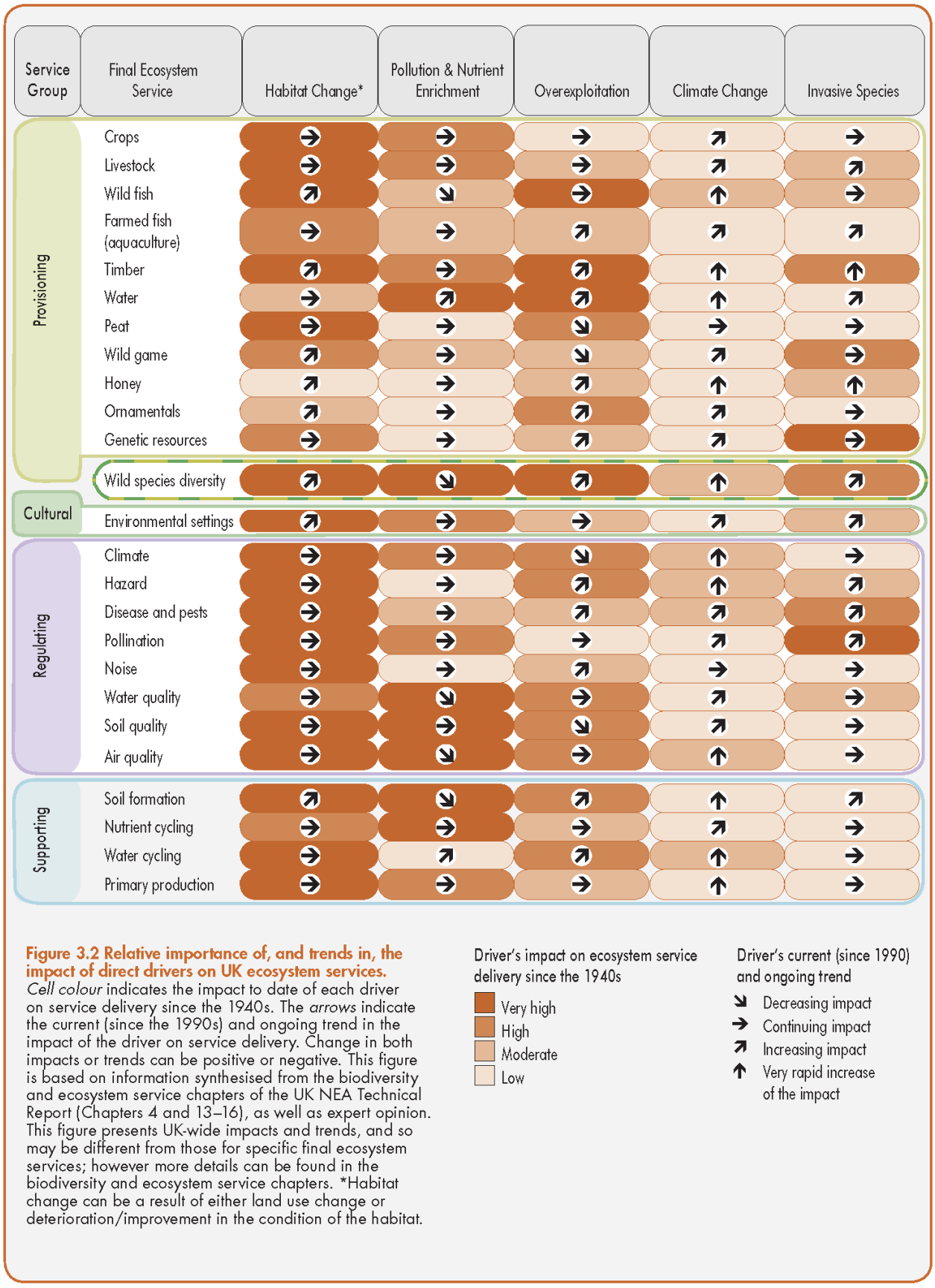

Figure 3.2 Relative importance of, and trends in, the impact of direct drivers on UK ecosystem services.
Cell colour indicates the impact to date of each driver on service delivery since the 1940s. The *arrows* indicate the current (since the 1990s) and ongoing trend in the impact of the driver on service delivery. Change in both impacts or trends can be positive or negative. This figure is based on information synthesised from the biodiversity and ecosystem service chapters of the UK NEA Technical Report (Chapters 4 and 13–16), as well as expert opinion. This figure presents UK-wide impacts and trends, and so may be different from those for specific final ecosystem services; however more details can be found in the biodiversity and ecosystem service chapters. *Habitat change can be a result of either land use change or deterioration/improvement in the condition of the habitat.

Figure 2. Extract from the UKNEA of the original matrix that shows the relative importance of, and trends in the impact of direct drivers on UK ecosystem services. See Winn and Tierney (2011) for the original figure.

Importance was assigned through rating each driver/benefit relationship as one of:

a. **Major -** the driver of change has a major negative impact on the provision of the benefit and/or greatly increases the demand for the benefit,
b. **Minor -** the driver of change has a minor negative impact on the provision of the benefit and/or slightly increases the demand for the benefit,
c. **Unclear** - the driver of change can have both positive and negative impacts on the provision of/demand for the benefit, so the overall impact is less clear, or,
d. **Negligible -** the driver of change has a negligible impact on the provision of/demand for the benefit.

Figure 3 shows the logic and steps applied to produce the importance ratings, informed by the original UKNEA work (**Figure 2**).

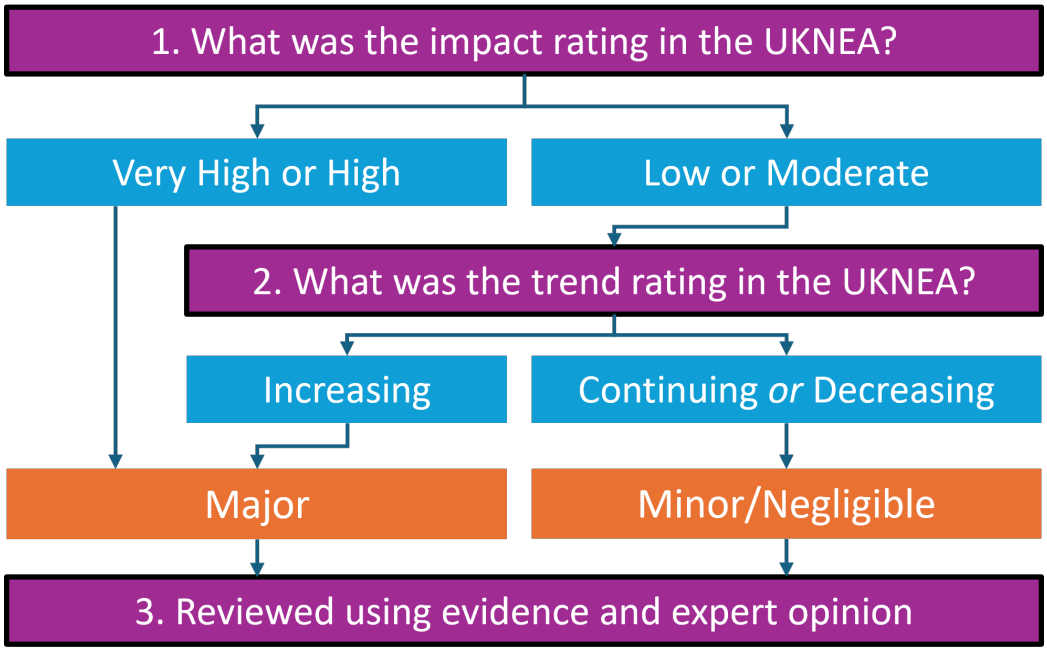

Figure 3. Importance ratings logic flow. Initial scores of major, minor, or negligible were produced based on the UKNEA matrix. These scores were then reviewed and updated if necessary, using more recent evidence and expert opinion.

Importance ratings were initially produced based on the UKNEA, with **Figure 2** acting as a starting point for our assessment. More recent evidence and expert opinion was then used to determine whether the rating needed to be changed. While the UKNEA table provided a general overview of the impact of the driver on the benefit across all ecosystems, our ratings were assessed at the asset level, and therefore needed checking based on impacts on specific ecosystem assets. 'Unclear' ratings were also assigned in the review phase (step 3 of Figure 3) in cases where experts felt the driver of change had both positive and negative impacts on the provision of, or demand for a benefit.

Uncertainty was assessed for each driver-benefit relationship, based on the type of evidence that was used to inform the expert opinion. As in section 2.1, the three categories used for the uncertainty assessment were:

A – based on UKNEA plus post-2011 evidence
B – based on UKNEA plus expert judgment, and
C – based on UKNEA only (decision to retain due to lack of post-2011 evidence).

Appendix 1 outlines cases where the initial ratings produced following step 2 were changed from major to negligible (or vice versa) following expert input, and the rationale behind these decisions. It also provides detail on the importance ratings given to every driver/benefit relationship at the end of step 3, and the associated uncertainty ratings.

2.3.2. Risk ratings

For each ecosystem asset, the benefits identified as relevant were added to a matrix along with the direct drivers of change. Where a driver was identified as having a major impact on a benefit (Section 2.3.1), the impact and trend rating for that driver/ecosystem relationship was applied in the matrix.

For each benefit, the highest impact and trend rating applied was taken forward to determine the overall risk rating using Table 3. This is in line with the concept of assigning the rating for the highest, most credible worst-case scenario described in The Orange Book (UK Government, 2023).

This approach was followed for all eight ecosystem assets, resulting in risk ratings for the provision of each of the key benefits from the eight ecosystem assets.

2.3.3. Cultural benefits

The method was adapted to assess whether cultural benefits are impacted by drivers of change.

Cultural benefits are broad, subjective, and experienced in diverse ways. All eight ecosystem assets were identified as important providers of cultural benefits which are delivered through various cultural flows and uses. To better reflect the risk status for cultural benefits, we considered how practices related to the following uses of nature can be affected by drivers of change:

- **Experiential use**: e.g. in-situ wildlife watching; snorkelling; personal participation in citizen science; collecting wild food; beachcombing; management of the environment (stewardship); volunteering,
- **Physical use**: e.g. walking, climbing, boating; leisure fishing and hunting; cycling; paddling; dog walking; picnics; etc.,
- **Scientific use**: e.g. subject matter of research (in-situ and ex-situ); conduct of citizen science,
- **Educational use**: e.g. subject matter of education (in-situ and ex-situ),
- **Aesthetic use**: e.g. sense of place; art; poetry; writing; photography; and

- **Spiritual and/or emblematic use**: e.g. emblematic plants and animals; sacred plants, animals and places.

Changes in ecosystem extent and condition can impact these uses of nature, which can then affect the benefits received by individuals. The following driver of change questions were applied to each of these categories in turn:

- **Does the driver affect the capacity of the asset to provide the use?** (for example: does pollution affect the capacity of woodlands for practices related to experiential use, e.g., bird watching?)
- **Does the driver increase the demand for the use?** (for example: does climate change increase the demand for practices related to physical use, e.g. swimming, in freshwaters and wetlands?)

If at least one use of nature was majorly impacted by a specific driver, the driver impact and trend rating was included in subsequent risk scoring. This gave additional context to the risk scores and made it clear which uses were underlying the risk ratings (Appendix 1).

3. Results

3.1. Impacts of drivers of change on ecosystems

Table 4 presents the updated assessment of the impact and trend of impact, of the five drivers on the eight ecosystem asset types. See Appendix 1 for a detailed breakdown of the evidence used to inform the decisions for each ecosystem asset.

Table 4. Impacts and trends of direct drivers on the eight ecosystem assets.

Ecosystem asset	Land- and sea-use change	Pollution	Natural resource use and exploitation	Climate Change	Invasive Species
Marine	↑	→	↗	↑	↑
Coastal margins	↗	→	↘	↑	↗
Freshwaters and wetlands	→	→	↗	↑	↗
Woodlands	↗	↗	↘	↗	↑
Mountains, moorlands and heaths	↗	→	↗	↑	→
Semi-natural grasslands	↗	↗	→	↗	→
Enclosed farmland	↗	→	→	↗	↗
Urban	↗	→	↗	↗	↗

Key to Table 4

Driver's impact on extent and condition of ecosystem assets

Low
Moderate
High
Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact
↗ Increasing impact
→ Continuing impact
↑ Very rapid increase of impact

3.2. Ecosystem asset risk

Table 5 presents the risk ratings for each ecosystem asset, based on how impacted they already are from the direct drivers of change, and the severity of the impact of these drivers both now and into the future.

Table 5. Overall risk ratings for ecosystem assets, based on the impacts to date, and current/ongoing trends of the 5 IPBES direct drivers of change. Note: For risk ratings: L = low; M = medium; M-H = medium-high; H = high.

Ecosystem asset	Land- and sea-use change	Pollution	Resource Exploitation [a]	Climate Change	Invasive Species	RISK
Marine	↑	→	↗	↑	↑	H
Coastal margins	↗	→	↘	↑	↗	H
Freshwaters and wetlands	→	→	↗	↑	↗	H
Woodlands	↗	↗	↘	↗	↑	H
Mountains, moorlands and heaths	↗	→	↗	↑	→	H
Semi-natural grasslands	↗	↗	→	↗	→	M-H
Enclosed farmland	↗	→	→	↗	↗	M-H
Urban	↗	→	↗	↗	↗	M-H

[a] Natural resource use and exploitation.

3.3. Ecosystem-benefit risk

Table 6, on the next page, shows the risk ratings for all benefits, across all eight ecosystem assets. Tables 7-14 present more detail on the impact and trend ratings driving the benefit risk ratings, for each ecosystem asset. The risk ratings are based on the highest (worst) impact and trend ratings out of all drivers assessed as relevant to a particular ecosystem-benefit relationship. This is based on The Orange Book (UK Government, 2023) principle of assigning the rating for the highest, most credible worst-case scenario.

Table 6. Combined risk ratings for benefits provided by each broad ecosystem asset. Note some cells have been left deliberately blank

	Marine	Coastal margins	Fresh-waters and wet-lands	Wood-lands	Moun-tains, moor-lands and heaths	Semi-natural grass-lands	Enclo-sed farm-lands	Urban
Timber and other wood products				H				
Produce from the sea	H	H						
Plant-based energy								
Aquaculture	M	M						
Cultivated crops							M-H	
Plentiful water			H	M	H	M-H	M-H	M-H
Reared animals and outputs					H	M	M	
Clean water	M	H	H	M	H	M-H	M-H	M-H
Clean air				M				M-H
Noise regulation								M-H
Urban cooling								M-H
Erosion control		H	H	M-H	H		M-H	
Flood protection		H	H	M-H	H	M-H	M-H	M-H
Pollination						M-H	M-H	
Thriving plants and wildlife	H	H	H	H	H	M-H	M-H	M-H
Pest and disease control							M-H	
Climate regulation	H	H	H	M-H	H	M-H	M-H	M-H
Cultural benefits	H	H	H	M-H	H	M-H	M-H	M-H

Note: For risk ratings: L = low; M = medium; M-H = medium-high; H = high. White cells indicate that the ecosystem asset has not been linked to the provision of the benefit. Grey cells indicate that a lack of evidence has meant we were not able to determine a risk rating.

Table 7. Marine: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Marine	Land- and sea-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Produce from the sea	H ↑	M →	VH ↗	VH ↑		H
Aquaculture		M →				M
Clean water		M →				M
Thriving plants and wildlife	H ↑	M →	VH ↗	VH ↑	L ↑	H
Climate regulation	H ↑	M →	VH ↗	VH ↑		H
Cultural benefits	H ↑	M →	VH ↗	VH ↑		H

[a] Natural resource use and exploitation.

Table 8. Coastal margins: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Coastal margins	Land- and sea-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Produce from the sea	VH ↗	VH →	L ↘	VH ↑		H
Aquaculture		VH →				M
Clean water	VH ↗	VH →		VH ↑		H
Erosion control	VH ↗			VH ↑		H
Flood protection	VH ↗			VH ↑		H
Thriving plants and wildlife	VH ↗	VH →	L ↘	VH ↑	M ↗	H
Climate regulation	VH ↗	VH →	L ↘	VH ↑		H
Cultural benefits	VH ↗	VH →		VH ↑		H

[a] Natural resource use and exploitation.

Table 9. Freshwaters and wetlands: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Freshwaters and wetlands	Land-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Plentiful water	VH →		H ↗	VH ↑		H
Clean water	VH →	VH →	H ↗	VH ↑		H
Erosion control	VH →			VH ↑		H
Flood protection	VH →			VH ↑		H
Thriving plants and wildlife	VH →	VH →	H ↗	VH ↑	H ↗	H
Climate regulation	VH →	VH →	H ↗	VH ↑		H
Cultural benefits	VH →	VH →	H ↗	VH ↑		H

[a] Natural resource use and exploitation.

Table 10. Woodlands: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Woodlands	Land-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Timber and wood products				M ↗	H ↑	H
Plant-based energy						N/A
Plentiful water				M ↗		M
Clean water		M ↗				M
Clean air	M ↗	M ↗		M ↗		M
Erosion control	M ↗		VH ↘	M ↗		M-H
Flood protection	M ↗		VH ↘	M ↗		M-H
Thriving plants and wildlife	M ↗	M ↗	VH ↘	M ↗	H ↑	H
Climate regulation	M ↗	M ↗	VH ↘			M-H
Cultural benefits	M ↗		VH ↘	M ↗		M-H

[a] Natural resource use and exploitation.

Table 11. Mountains, moorlands and heaths: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Mountains, moorlands & heaths	Land-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Plentiful water	VH ↗		M ↗	VH ↑		H
Reared animals and outputs				VH ↑		H
Clean water	VH ↗	VH →	M ↗	VH ↑		H
Erosion control	VH ↗		M ↗	VH ↑		H
Flood protection	VH ↗			VH ↑		H
Thriving plants and wildlife	VH ↗	VH →	M ↗	VH ↑	L →	H
Climate regulation	VH ↗	VH →	M ↗	VH ↑	L →	H
Cultural benefits	VH ↗			VH ↑		H

[a] Natural resource use and exploitation.

Table 12. Semi-natural grasslands: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Semi-natural grasslands	Land-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Plentiful water	VH ↗		H →	M ↗		M-H
Reared animals and outputs				M ↗		M
Clean water	VH ↗	VH ↗		M ↗		M-H
Flood protection	VH ↗			M ↗		M-H
Pollination	VH ↗	VH ↗	H →	M ↗	M →	M-H
Thriving plants and wildlife	VH ↗	VH ↗	H →	M ↗	M →	M-H
Climate regulation	VH ↗	VH ↗	H →			M-H
Cultural benefits	VH ↗			M ↗		M-H

[a] Natural resource use and exploitation.

Table 13. Enclosed farmlands: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Enclosed farmlands	Land-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Cultivated crops	VH ↗			L ↗		M-H
Plentiful water	VH ↗		L →	L ↗		M-H
Reared animals and outputs				L ↗		M
Clean water	VH ↗	VH →	L →	L ↗		M-H
Erosion control	VH ↗		L →	L ↗		M-H
Flood protection	VH ↗		L →	L ↗		M-H
Pollination	VH ↗	VH →	L →	L ↗	M ↗	M-H
Thriving plants and wildlife	VH ↗	VH →	L →	L ↗	M ↗	M-H
Pest and disease control	VH ↗	VH →	L →	L ↗	M ↗	M-H
Climate regulation	VH ↗	VH →	L →	L ↗		M-H
Cultural benefits	VH ↗			L ↗		M-H

[a] Natural resource use and exploitation.

Table 14. Urban: summary of information contributing to the risk ratings for each benefit. Note: White cells indicate that the driver was not assessed as having a major impact on the benefit.

Urban	Land-use change	Pollution	Resource exploitation [a]	Climate change	Invasive Species	RISK
Plentiful water	VH ↗		L ↗	L ↗		M-H
Clean water	VH ↗	VH →		L ↗		M-H
Clean air	VH ↗	VH →		L ↗		M-H
Noise regulation	VH ↗					M-H
Urban cooling	VH ↗			L ↗		M-H
Flood protection	VH ↗			L ↗		M-H
Thriving plants and wildlife	VH ↗	VH →	L ↗	L ↗	M ↗	M-H
Climate	VH ↗	VH →	L ↗	L ↗		M-H
Cultural benefits	VH ↗	VH →				M-H

[a] Natural resource use and exploitation.

4. Discussion

Here we present a novel approach to assessing natural capital risk, using best available evidence to inform expert opinion and decision-making. Our risk register identifies risks at the ecosystem asset and benefit level, resulting from the degradation of ecosystem assets due to past, present, and future drivers of change.

Despite the known issues and data gaps, discussed below, this first iteration of a natural capital risk register provides a guide for decision-making in terms of priorities for nature recovery. Drivers of change underlying the risk ratings are highlighted to enable actions to be identified, to reduce future impacts. The process of developing this risk approach has highlighted areas for ongoing work, and gaps for future data collection, to improve the evidence base supporting the risk ratings.

The State of Natural Capital Report (SONC) also sets out the consequences of these natural capital risks to the delivery of key policy areas across government.

4.1. Building on the Natural Capital Committee risk register approach

This work builds on the approach to assessing natural capital risk developed by Mace and others (2015) for the Natural Capital Committee (NCC). The NCC approach uses information on the status and trends of natural capital assets and benefits across eight broad habitat types. They estimate the status and trends of asset-benefit relationships across quantity, quality, and location categories, relative to existing policy targets. Asset-benefit relationships are then described as high-, medium-, or low-risk. The high-risk category reflects cases where ecosystem asset status is poor, and/or the trends in asset status are strongly negative. The NCC risk register therefore tells us reasons why benefits might be at higher risk – for example, the quality of the habitat, or unfavourable spatial configurations – but it does not tell us what is driving these risks.

Our risk register draws on drivers of change to report on how pressures on ecosystem assets are driving risks to the delivery of benefits. This is supported by other natural capital risk work which recognises that drivers of change can impact the capacity of ecosystems to provide benefits to people (Borgwardt and others, 2019; Culhane and others, 2019; Farrell and others, 2022). Doing this enables the risk rating to incorporate both impacts to date (which affect the extent and condition, and therefore the resilience of an ecosystem) and expected future impacts of the 5 direct drivers of ecosystem change (Winn & Tierney, 2011; IPBES, 2019). This is important for decision-making, highlighting where to prioritise action to reduce the future impacts of these drivers.

Table 4 represents an assessment of the relative importance of, and trends in, the impact of direct drivers on ecosystem asset extent and condition, building on work from the UKNEA (2011). Expert opinion, supported by the best available evidence (Appendix 1),

was used to produce this updated assessment. This was required due to evidence gaps for some ecosystem assets, particularly in terms of ongoing and future impact. Expert opinion was essential in interpreting the available evidence, particularly when it was partial or conflicting.

The evidence used to produce Table 4 included an assessment of the status and trends of natural capital indicators (see Bell & Craven, 2024; Craven, Bell & Dobson, 2024 for more detail). The status and trend criteria used in Mace and others (2015) were here applied at the indicator level (Box 2). There were limited instances where assessments of both status and trend were feasible. Status assessments were possible for 54 indicators, and trend assessments were possible for 53 indicators, however only 47 indicators across the eight ecosystem assets had information enabling both status and trend assessments. Marine and coastal margins, and freshwaters and wetlands, were the best-represented ecosystem assets using indicator status and trend. Using experts to interpret the best available evidence (including, but not limited to, natural capital indicators) was central to our approach, as this allowed ratings for all ecosystem assets to be produced regardless of whether policy targets or historical data sets were available.

It is important to report on risks to society arising from complex systems, even when the evidence base is partial. The Orange Book (UK Government, 2023) advises that risk reporting can include both qualitative and quantitative information; even in the absence of quantitative data, qualitative scores based on expert opinion can prove vital in identifying high risk areas for priority action. Risk registers can be compiled in the absence of full knowledge of a system (Mace and others, 2015). This is crucial in the case of natural capital risks, where the evidence base is likely to remain incomplete, but delays to mitigating action can escalate both risks, and restoration costs.

4.2. Assessing status and trend

Targets to assess status were drawn from existing policies. More target information was available for marine and coastal margins, and freshwaters and wetlands, due to reporting commitments and strategies including the Water Environment (Water Framework Directive) (England and Wales) Regulations, 2017 (HM Government, 2017), and UK Marine Strategy (Defra, 2019). Urban ecosystems only had target information for indicators related to accessible green space (Houghton & Warburton, 2023).

A drawback to using existing policy targets is they are largely not designed to assess the ability of ecosystems to provide benefits. This is particularly relevant for cases where changes to assets do not result in linear changes to the benefit provided. It also applies in cases where thresholds or tipping points may exist but have not been identified. At the same time, indicators can be relevant for more than one benefit in an ecosystem. Thresholds may differ depending on the benefit being considered.

Due to changing methodologies, assessments of change were not always possible for indicators. For example, the assessment of chemical status of water bodies was updated in 2019 to include new standards and improved methods, meaning that 2019 values could not be compared to previous water body classification data (Environment Agency &

Natural England, 2023). For the indicators where time series data was available, data were drawn from a range of programmes with different monitoring and reporting cycles. Where possible, indicator trends were considered since the UKNEA, but it was not feasible to use the same time range across all indicators. Comparing the most recent value of an indicator to a baseline value also meant that more recent upticks or declines may be masked.

Further, not all indicators will be appropriate for trend analysis. Extent is unlikely to be a reliable indicator for subtidal environments in most cases, as data is poor at the national scale. Broad scale habitat information for subtidal areas (particularly offshore) tends to be modelled based on factors such as depth and current speed, and so substantial changes in extent are not expected. Even where survey data exists, collection is sporadic.

Other than notable exceptions like urban indicators linked to the Accessible Greenspace Standard, location indicators cannot easily be linked to policy targets or assessed over time without further complex analysis. Quality indicators may therefore be most suited to this approach.

4.3. Cultural benefits

Any reporting of natural capital risk will involve simplification of a complex system. Cultural benefits are especially difficult to articulate and monitor, because they are intangible and stem from our individual relationships with the natural environment.

When assessing driver-benefit relationships in Tables 7-14, the broad nature of cultural benefits made it challenging to assess them at a high level. To provide a more informed picture of what might be driving risks to cultural benefits for each ecosystem asset, different practices relating to uses of nature were considered. Some uses, such as experiential and physical uses, were easier to assess in a robust and consistent manner. Spiritual and emblematic uses were more difficult to capture as they can be affected by individuals' motivations, experiences, and perceptions.

4.4. Uncertainty

Uncertainty ratings are provided in Appendix 1 for the key outputs underlying our risk ratings: the driver impact and trend ratings (Table 4), and the assessment of driver-benefit relationships (Section 2.3.1.).

Ratings were based on the type of evidence used to inform the expert opinion. All the decisions used the UKNEA rating as a starting point. The uncertainty assessment then considered the extent to which post-2011 evidence sources were available and supported the decision-making.

4.5. Communication of risk

This report presents a novel approach to assigning natural capital risk to ecosystem assets and benefits, using the best available evidence. We consider the impacts of drivers of change, to enable identification of actions to mitigate these risks. An important next step in this work will be to communicate the outputs to audiences including government departments and delivery bodies.

Risk registers are tools commonly used by organisations to highlight high-priority risks to business operations that require immediate attention (Mace and others, 2015). The Taskforce for Nature-related Financial Disclosures (TNFD) is a framework which already encourages organisations to consider how their business activities both impact, and depend on, specific attributes of natural capital. Benefits provided by ecosystem assets can also be crucial in mitigating acute risks including floods and heatwaves, lowering direct damage costs, but also preventing indirect economic and social impacts through supply chain disruptions or market shifts (National Audit Office, 2021).

5. Conclusions and Recommendations

This report provides a novel approach to assessing risk to ecosystem assets and benefits, using expert input and judgment informed by the best available evidence.

We have applied a transparent and evidence-based approach to assessing risk, which allows us to be clear about what is driving it. In summary, we analyse the **changes in natural capital assets due to past, present, and future drivers of change**. These changes are assessed to produce risk ratings at the ecosystem asset and benefit level, making our risk register actionable and useful for decision-making now.

Our approach reports on which drivers of change have had high impacts to date, and which drivers of change are expected to have increasing ongoing impacts. This helps us to identify opportunities for nature recovery, and opportunities for mitigating or adapting to negative drivers.

Any reporting of natural capital risk involves simplification of a complex system. Evidence on this system is incomplete. Building the evidence base, including on indicator status, will help to inform expert judgment in the future, particularly for land-based ecosystems. However, changes in data collection methods and standards may mean it will remain difficult to report trends, as previous data will not be comparable. Expert judgment will still be needed to interpret partial and conflicting evidence.

An important next step will be to communicate the outputs to audiences including government departments and delivery bodies. The State of Natural Capital Report builds on the work in this risk register, by considering the consequences of risk to natural capital benefits for the following policy areas: economic resilience, water security, food security, Net Zero, climate adaptation, and health and wellbeing. The corporate and financial sectors are increasingly reviewing their impacts and dependencies on nature, through frameworks including the Taskforce for Nature-related Financial Disclosures. Organisations already reviewing their impacts and dependencies can use this risk register to understand which benefits they rely on are most at risk.

Benefits provided by ecosystem assets can also be crucial in mitigating acute risks identified in risk registers such as the National Risk Register (HM Government, 2023) and the Third UK Climate Change Risk Assessment (2021). Understanding the link between the state of ecosystems, the provision of benefits, and the severity of threats such as flooding or drought could be a useful practice for risk managers and policymakers.

Our risk register highlights the benefits at highest risk, due to growing pressures on complex interconnected systems. Despite the existing evidence gaps, our risk ratings underscore the need for urgent and direct attention to where it is most needed. Without action, there is increased likelihood that unknown thresholds will be crossed, leading to irreversible impacts to ecosystems and higher future adaptation costs. In the face of

increasing pressures on our natural capital assets, this work can help to secure the continued provision of the benefits most at threat.

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Appendices

Appendix 1 Evidence and additional information for risk register scoring

This Appendix sets out the evidence used to inform the update of the UKNEA's 2011 assessment of the relative importance of, and trends in the impact of direct drivers on ecosystem asset extent and condition.

It also provides information on the importance ratings given to each driver-benefit relationship, including where changes were made from the UKNEA evidence.

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