Developing Species Abundance Indicators for Northern Ireland: A Comparative Assessment of Methodological Approaches

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Executive Summary

Northern Ireland has committed to ambitious biodiversity recovery goals through multiple policy frameworks, including the Environmental Improvement Plan's vision to 'halt and reverse the loss of biodiversity by 2030' and the draft Nature Recovery Strategy's mission for thriving and resilient nature by 2050. However, Northern Ireland currently lacks a comprehensive species abundance indicator to measure progress toward these commitments, creating a fundamental gap between policy ambition and assessment capability.

This analysis evaluates methodological options for developing species abundance indicators in Northern Ireland, drawing on international experience, stakeholder requirements, and implementation constraints to provide evidence-based recommendations for biodiversity monitoring framework development.

Key Challenges and Requirements

Northern Ireland faces significant constraints in developing biodiversity indicators across multiple domains. Resource limitations affect the Department of Agriculture, Environment and Rural Affairs, which receives the smallest budget allocation of any Northern Ireland department per capita. Data availability constraints include geographic coverage biases, with western areas significantly under-recorded due to volunteer density challenges, and taxonomic limitations that restrict trend analysis to well-monitored species groups. Co-ordination complexity across multiple agencies and organisations, combined with skills gaps in data management and statistical expertise, may further compound implementation challenges.

Commissioned by the Office for Environmental Protection, The UK Centre for Ecology and Hydrology conducted comprehensive stakeholder consultation with data providers, biodiversity experts, and policymakers to identify essential characteristics for Northern Ireland's biodiversity indicators. Eight core criteria emerged from stakeholder workshops, including representativeness, responsiveness to pressures, and feasibility within existing monitoring programmes. These were supplemented by four additional technical requirements covering Environmental Improvement Plan reporting capabilities, halt-and-reverse assessment potential, and forward-looking analytical capacity, creating twelve assessment criteria for methodological evaluation.

Case Study Evidence and Options Assessment

Analysis of international approaches reveals diverse methodological strategies reflecting different data landscapes and policy priorities. England's species abundance indicator demonstrates the risks of implementing methodologically problematic approaches for statutory assessment, with documented issues including excessive statistical smoothing and 50% false negative rates. Conversely, countries like Switzerland and Norway have developed comprehensive systematic monitoring programmes that provide robust biodiversity assessment through sustained institutional investment. Living Planet Index applications across multiple countries offer proven methodological frameworks, whilst expert-defined target-based approaches in Germany demonstrate how sustainability thresholds can help guide conservation management.

Six methodological approaches for Northern Ireland were systematically evaluated using Red-Amber-Green (RAG) scoring against the twelve stakeholder and technical criteria. Options included adaptations of England's methodology, Living Planet Index frameworks, expert-defined target-based approaches, Red List methodologies, suites of indicators, and innovative pressure-abundance frameworks. The assessment demonstrates that no single approach performs optimally across all criteria, reflecting fundamental trade-offs between methodological sophistication, resource requirements, and policy relevance.

Recommendations

Based on systematic assessment and international case studies, this analysis recommends implementing a suite of biodiversity indicators that begins immediately with well-monitored taxonomic groups whilst building analytical capacity toward innovative assessment frameworks. This phased approach enables immediate policy delivery through existing State of Nature data trends for birds, butterflies, and bats, whilst creating pathways toward sophisticated pressure-response modelling capabilities as institutional capacity develops.

The recommended strategy acknowledges that successful indicator development depends not on perfect methodological solutions, but on selecting approaches whose limitations align with available resources and policy priorities. Northern Ireland has committed to halting and reversing biodiversity decline through its policy frameworks, and ensuring this commitment is measurable requires implementing robust biodiversity indicators that can evolve with institutional capacity and guide Northern Ireland toward demonstrable nature recovery.

1. Introduction and Context Setting

1.1. Introduction

We are in the midst of a global biodiversity crisis, with species abundance falling by an average of 69% since 1970 (1). This paper addresses the critical gap by assessing options for the development of a species abundance indicator capable of supporting Northern Ireland (NI)'s biodiversity policy commitments. Drawing on international experience and NI specific challenges, six potential approaches are evaluated and scored against favourable biodiversity metric criteria covering e.g. resource requirements, policy relevance and the challenge of defining the 'halt and reverse' target.

The aim of this paper is to provide a comprehensive analysis of available options and the factors that should inform Northern Ireland's approach to biodiversity monitoring and indicators in the critical years ahead. The choice between different options involves inevitable trade-offs that decision-makers will need to navigate based on Northern Ireland's capacity and strategic priorities.

1.2. Regulatory and Policy Framework

Established at COP15 in December 2022, the Kunming-Montreal Global Biodiversity Framework details ambitious targets working towards halting and reversing global biodiversity loss (2). As a signatory to the Convention on Biological Diversity through the United Kingdom, Northern Ireland is required to contribute to this global effort.

This international commitment has been transposed into local regulatory and policy mechanisms, primarily through two key frameworks: the Environmental Improvement Plan stemming from the Environment Act 2021 (3), and the draft Nature Recovery Strategy under the Wildlife and Natural Environment Act 2011 (4). The Environment Act 2021 requires Northern Ireland to plan and deliver an Environmental Improvement Plan (EIP), first published in September 2024, which sets as a vision and outcome to 'halt and reverse the loss of biodiversity in Northern Ireland by 2030,' with a requirement that 'gains in biodiversity are real and measurable.' (5) The Climate Change Act (Northern Ireland) 2022 establishes an additional regulatory framework that places a thriving and resilient natural environment as central to climate mitigation and adaptation, requiring Climate Action Plans to address biodiversity considerations for net zero purposes (6). Most recently, the draft Nature Recovery Strategy includes an explicit mission to 'halt and reverse biodiversity loss to put nature on a path to recover' by 2032, with thriving and resilient nature by 2050 (7). These multiple biodiversity commitments across climate and nature recovery frameworks require measurable indicators to demonstrate progress and ensure accountability across interconnected policy objectives.

Northern Ireland's EIP commits to publishing annual biodiversity indicators to monitor and assess progress towards these important goals, in addition to the Outcome Indicator Framework for reporting on the EIP (5, 8). However, this commitment remains unfulfilled, with no species abundance indicator currently included in the annual suite. Both the draft Nature Recovery Strategy and the Department of Agriculture, Environment and Rural Affairs (DAERA)'s Annual Progress Report on the EIP acknowledge these current insufficiencies in biodiversity indicators (7, 8).

In addition to Northern Ireland's requirement of an EIP, The Environment Act 2021 created a legally binding species abundance target for England with a mandated assessment method (9). Research commissioned by the Office for Environmental Protection (OEP) found that England's assessment methodology has a 50% false negative rate when evaluating target achievement, highlighting fundamental flaws in the approach developed after the statutory target was established (10). Given that Northern Ireland's biodiversity commitments currently lack prescribed methodological requirements, this creates a strategic opportunity to design biodiversity indicators based on data availability and best methodological practices from the outset.

1.3. The Challenge and Scope

The lack of a comprehensive species abundance indicator, or suite of indicators, represents a fundamental barrier to evidence-led biodiversity policy in Northern Ireland. Multiple overlapping commitments reference targets surrounding 'halting and reversing biodiversity loss,' yet without robust data and statistically sound methodology, progress cannot be measured, limiting the scope for adaptive conservation management. This analysis examines methodological options for translating Northern Ireland's available monitoring data into policy-relevant abundance indicators that address identified stakeholder and technical requirements.

The technical complexity of multi-taxa species abundance indicators presents important considerations requiring careful solutions. Statistical uncertainty, geographic coverage, taxonomic representation and defining what it means to 'halt and reverse' are challenges perpetuated across many countries. Given the monitoring infrastructure and data availability, this analysis focuses on terrestrial and freshwater systems only. Currently, Northern Ireland's indicators relating to biodiversity focus on habitat types, protected areas and wild bird populations (10).

2. Implementation Considerations and Challenges

Northern Ireland faces several considerations in developing comprehensive biodiversity indicators that require practical solutions. These span resource availability, institutional coordination, and technical capacity.

2.1. Resource, Institutional and Governance Constraints

The Department of Agriculture, Environment and Rural Affairs (DAERA) operates under significant financial constraints, receiving the smallest resource allocation of any Northern Ireland department per head, with the recent draft financial budget for 2026-2030 demonstrating how small growth through the years falls well below inflation (11). These resource limitations extend to environmental governance bodies, where advisory and regulatory functions operate with constrained capacity.

Biodiversity monitoring involves co-ordination across multiple organisations including DAERA, Northern Ireland Environment Agency (NIEA), Agri-Food and Biosciences Institute (AFBI) and the Centre for Environmental Data and Recording (CEDaR). Several UK-wide NGOs also operate and contribute to monitoring in Northern Ireland (12). While this distributed approach can leverage specialised expertise, effective co-ordination is needed to translate monitoring data into policy-relevant indicators. A significant bottleneck in developing biodiversity indicators is a skills gap in data management and statistical expertise (13), highlighting the need for capacity building in these areas.

2.2. Data Availability and Coverage Constraints

Northern Ireland has established biodiversity recording schemes that enable important trend assessment for some species in key taxonomic groups. However, geographic and institutional limitations help to explain why comprehensive abundance indicators have not yet been developed. Several long-term, UK wide citizen science initiatives operate in Northern Ireland including British Trust for Ornithology's Breeding Birds Survey (14), the National Plant Monitoring Scheme (15) and the UK Butterfly Monitoring Scheme (16). In addition to these, All-Island data collections for some taxonomic groups, for example, bats (17) and bumblebees (18), are conducted across Northern Ireland and the Republic of Ireland. The State of Nature report for Northern Ireland demonstrates the value of these, and other monitoring schemes, successfully assessing trends for 64 breeding birds, 14 butterflies and 6 species of bats amongst other taxonomic groups (19).

Despite the presence of these initiatives, constraints on data collection persists. A comprehensive assessment of biological recording barriers in Northern Ireland surveyed stakeholders from 29 organisations, representing governmental agencies, conservation NGOs, recording initiatives and local councils (12). The most frequently cited constraints were staffing shortages (65% of respondents), geographic coverage challenges (65%), lack of engagement (50%), data flow complexity (50%) and technical expertise gaps (50%).

Geographic coverage can be limited, patchy and biased towards areas with high populations, with western locations being significantly under-recorded due to lower volunteer density and accessibility challenges. Volunteer retention compounds the geographic limitations, for example, training on the Wetland Bird Survey retained only 41% of volunteers after a two-year period (12). Data flow complexity creates additional integration challenges, where multiple submission pathways and verification processes can delay data availability and hinder accessibility. Despite CEDaR's role as Northern Ireland's central environmental records centre, it lacks access to all data held by individual organisations unless specifically requested, contributing fragmentation to this complexity (12).

Marine monitoring faces distinct constraints due to e.g. the need to specialised equipment and trained professionals, with systematic coverage limited compared to terrestrial schemes. The State of Nature report notes that only two seabird species are comprehensively monitored, despite 22 of 24 breeding seabirds being Red or Amber listed (19). Similar coverage limitations are evident across other taxonomic groups, with Northern Ireland producing trends for 38 bird species compared to 114 in England, and 14 butterfly species compared to 55 in England, reflecting volunteer constraints rather than the absence of species (12).

These data availability constraints help explain why a comprehensive multi-taxa abundance indicator has not been developed, though this is not an exhaustive explanation of all factors involved. The 2023 State of Nature report demonstrates that trend data exists for Northern Ireland, covering 91 terrestrial and freshwater species with abundance declining by 5% since 1994, alongside distribution trends for priority species (19). However, this trend data has not been translated into policy indicators for measuring progress against biodiversity commitments. The evidence suggests that meaningful trend assessment is achievable within existing constraints, requiring indicator designs that accommodate geographic and taxonomic biases while also meeting stakeholder needs and policy requirements. Table 1 summarises these key challenges and potential solutions identified in this section for not only indicator development, but long-term biodiversity monitoring, providing context for evaluating indicator approaches presented in later sections.

Table 1: A summary of challenges and potential solutions to biodiversity indicator development and biodiversity monitoring in Northern Ireland. Each challenge is classified by one of three types: Resource & Capacity, Coverage & Engagement and Data & Co-ordination.

Key Challenges for Northern Ireland Biodiversity Monitoring and Indicator Development			
Challenge	Description	Potential Solutions	Type
Resource constraints	Limited budget allocation affects monitoring investments and staffing	Secure adequate funding and leverage existing capacity efficiently	**Resource & Capacity**
Skills and expertise gaps	Gaps in data management and statistical expertise	Invest in training and capacity building for technical expertise	**Resource & Capacity**
Geographic coverage bias	Western areas under-recorded due to volunteer density and accessibility	Target engagement efforts in under-recorded areas	**Coverage & Engagement**
Data flow complexity	Complex submission pathways delay data availability	Streamline data submission and verification processes	**Data & Co-ordination**
Volunteer engagement	Low volunteer retention affects sustained monitoring	Develop sustainable volunteer engagement and retention strategies	**Coverage & Engagement**
Co-ordination complexity	Multiple organisations require effective co-ordination	Establish clear governance frameworks and collaboration protocols	**Data & Co-ordination**
Marine monitoring limitations	Specialised requirements limit systematic marine coverage	For indicator development, focus initial efforts on terrestrial and freshwater systems	**Coverage & Engagement**

3. Stakeholder Requirements: Defining 'Fit-For-Purpose' Indicator Criteria

Translating available data into effective policy indicators requires understanding diverse stakeholder needs and balancing often competing requirements. Despite the advances in biodiversity monitoring and the availability of sophisticated analytical methods, the translation of science into workable policy indicators remains a considerable challenge. Even in cases where data is plentiful and assessment options are abundant, developing indicators to meet diverse stakeholder needs whilst maintaining scientific rigour requires careful consideration of many, and often competing, requirements. Understanding requirements is essential for Northern Ireland to avoid repeating mistakes experienced elsewhere and to ensure that any abundance indicator framework can effectively support policy objectives from development through to assessment of apex targets such as halt and reverse species abundance decline.

3.1. Stakeholder Requirements and Assessment Criteria

To understand stakeholder requirements and preferences for biodiversity indicators in Northern Ireland, the Office for Environmental Protection commissioned the UK Centre for Ecology and Hydrology to conduct a comprehensive stakeholder engagement assessment (13). This involved both a written consultation and an in-person workshop, bringing together data providers, biodiversity experts and policy makers across Northern Ireland. The organisations represented in this assessment included government agencies (DAERA, NIEA, JNCC), environmental organisations (National Trust, Ulster Wildlife Trust), research institutions (AFBI), data centres (CeDAR) and conservation bodies (BTO). The workshop explored desirable properties that biodiversity indicators should possess, metrics for tracking species change over time and the data needed.

Stakeholders identified eight criteria for Northern Ireland's biodiversity indicator(s), ranging from technical requirements such as representativeness and quality assurance to institutional preferences such as multi-sector support and implementation flexibility. Drawing on these stakeholder priorities and supplementing them with requirements under the Environment Act 2021 (3) and lessons from international experience examined in subsequent sections (*Section 4*), twelve assessment criteria were established to evaluate potential indicator approaches (Table 2).

Stakeholders expressed a preference for a suite of indicators rather than a single composite metric, believing that biodiversity's complexity requires comprehensive assessment rather than a single metric (13). This consensus, combined with the emphasis on feasibility and annual reporting capability, provides essential guidance for selecting methodological approaches that can deliver both scientific credibility and policy utility within Northern Ireland's monitoring and institutional constraints.

Table 2: Assessment criteria for Northern Ireland biodiversity indicators, derived from stakeholder consultation and supplemented by broader technical and policy considerations

Assessment Criteria for Northern Ireland Biodiversity Indicators		
Criterion	Description	Source
Representative	Ensuring good representation for species groups, habitats and ecosystems	Stakeholder workshop
Responsive to pressures	Enable evaluation of current policy and inform future decisions	Stakeholder workshop
Meaningful and understandable	Understandable for non-experts and policymakers without misinterpretation	Stakeholder workshop
Supports multiple sectors	Utilizable across sectors to encourage broad buy-in	Stakeholder workshop
Quality assured	Science and expert assessed to ensure transparency and rigour	Stakeholder workshop
Repeatable and comparable	Allow comparisons across years and areas for trend detection	Stakeholder workshop
Flexible	Allow new data to be included when available	Stakeholder workshop
Stakeholder preference (suite)	Suite of indicators to capture biodiversity complexity	Stakeholder workshop
Feasibility	Supported by existing monitoring programmes and data availability	Additional criteria
EIP requirements	Annual reporting capability for Environmental Improvement Plan	Additional criteria

3.2. An Additional Note on Defining 'Halt and Reverse'

Beyond the stakeholder identified assessment criteria, the specific challenge of determining whether biodiversity decline has been 'halted and reversed' and that any gains in biodiversity are measurable (as per the EIP (5)), requires careful consideration of statistical methodologies, timeframes and uncertainty handling to ensure robust assessment. A recent analysis of England's species abundance indicator revealed significant limitations in retrospective assessment approaches, with simple point-estimate comparisons producing high rates of false conclusions and elevated uncertainty in final-year trend estimates (10, 20). Unlike England's legally mandated target to 'halt decline by 2030' as an interim step toward 2042 goals (9), Northern Ireland's draft Nature Recovery Strategy sets a 2032 mission for urgent biodiversity conservation and restoration action, with thriving and resilient nature by 2050, ultimately halting and reversing biodiversity loss (7). This presents opportunities to incorporate forward-looking predictive capabilities alongside retrospective trend analysis to assess progress toward both halting decline and achieving measurable recovery.

4. Learning from Experience

Northern Ireland is not alone in grappling with the challenges of developing robust species abundance indicators. Several countries have implemented or investigated multi-taxa abundance indicators with varying approaches, providing insight into methodological choices, statistical obstacles and policy integration. England's experience in particular serves as a cautionary tale, highlighting the importance of ensuring methodological robustness before indicators become the basis for statutory target assessment.

4.1. England's Species Abundance Indicator

England's species abundance indicator represents one of the first operational multi-taxa abundance indicators globally, made up of 1195 terrestrial and freshwater species (9). The indicator uses the Freeman method, a statistical approach that combines individual species trends into a composite geometric mean index (21). The Environment Act 2021 established legally binding targets for halting and reversing species abundance decline, with Schedule 2 listing the species included in the existing indicator framework (22), though critical assessment methodologies remain unresolved.

Multiple independent reviews have identified fundamental problems across the methodology, assessment and taxonomic representation in England's species abundance indicator. The implementation applies excessive statistical smoothing, a technique which is commonly used to reduce short-term fluctuations and reveal longer-term trends. The 'double smoothing' method used may remove ecologically meaningful signals and makes year-to-year detection unfeasible (20). The Department of Environment, Food and Rural Affairs (Defra)'s justification for this modification relies on problematic reasoning: the 'proof' that pre-smoothed data performs better is inherently circular, as smoothed data is simply easier to fit statistically (23). Defra acknowledges that smoothed data makes it more challenging to detect 'notable change' between two years – a significant limitation given that the legal assessment for successfully achieving their target of halting biodiversity decline by 2030 requires comparison between 2029 and 2030 values (9, 23). An analysis of the statutory target assessment method showed that it has a 50% false negative rate – meaning only a 50% chance of detecting target achievement even when it has truly occurred (10).

The indicator is also limited by severe taxonomic biases, with moths comprising over one-third of species (38%) whilst entire taxonomic groups such as fungi and marine invertebrates, are completely absent (9). An equal weighting for species means that the indicator becomes dominated by trends in well-monitored taxa and the pressures affecting these, rather than by conservation priorities (20). Additionally, the statistical method for the legally required 2029-2030 comparison remains undefined, with Defra still investigating critical parameters including smoothing intervals and whether to adopt credible interval methods used in other biodiversity indicators (23).

England's experience demonstrates the critical importance of ensuring robust monitoring infrastructure can reliably measure statutory targets. Despite sophisticated statistical techniques and resource investment, the fundamental methodological problems mean it is highly unlikely the indicator can reliably measure the threshold for 'target achievement' required by legislation. This highlights that ambitious biodiversity targets require robust monitoring systems capable of delivering the assessment precision that policy frameworks demand.

4.2. United Kingdom and Ireland Approaches

Scotland, Wales and Ireland all face similar data constraints to Northern Ireland yet have different approaches to biodiversity monitoring and indicators. Scotland maintains multiple biodiversity indicators separated by domain and data type rather than a single composite metric. These include a terrestrial abundance indicator (407 species), terrestrial occupancy indicator (2,466 species), and marine indicators covering seabirds and fish (24). Scotland uses the same Freeman method statistical approach as England to combine species trends but applies it separately to each indicator rather than combining all data types into one composite index (21, 25). This approach covers significantly more species than England's due to the inclusion of occupancy data for more invertebrates, bryophytes, and lichens, whilst maintaining transparency about taxonomic and habitat-specific variation. This provides more nuanced habitat-specific information; however, this approach cannot produce simple statements about overall biodiversity progress.

Wales illustrates the challenge of translating biodiversity data into policy relevant indicators. The 2023 State of Nature report produced abundance trends for Wales for the first time using standard UK methodology (Freeman method), covering 380 species across birds, butterflies, mammals and moths (26). However, Wales acknowledges that these trends hide detail and are taxonomically limited, requiring examination of individual species for further understanding. A report produced by the Environment and Rural Affairs Monitoring and Modelling Program (ERAMMP) in 2022 recommended developing a multi-species abundance indicator, recognising the value of having insights into biodiversity change (27). Despite this and having the State of Nature trend data available, Wales, like Northern Ireland, has not adopted a composite abundance indicator for government policy assessment (28). This reflects the boarder challenge of translating research monitoring into policy-relevant indicators suitable for measuring progress against environmental commitments.

Ireland demonstrates strong institutional commitment through its 71 National Biodiversity Indicators structured around eight focal areas including 'Status of biodiversity,' using a traffic light system to assess current, short-term, and long-term trends for individual taxonomic groups including birds, bees, butterflies, plants, and EU protected species (29). Ireland's 4th National Biodiversity Action Plan (2023-2030) includes statutory targets, with a specific 'halt and reverse by 2030' target for pollinators, and broader targets for all wild birds and EU protected species (30). However, Ireland lacks a composite multi-taxa abundance indicator and whilst individual taxonomic trend indicators exist, only pollinators have a quantified 'halt and reverse' commitment assessed through trend-based analysis. Ireland's biodiversity indicator network measures trends for multiple facets of biodiversity through individual taxonomic assessments, with comprehensive progress evaluation relying on synthesis across these separate indicators rather than a single composite metric.

4.3. International Case Studies

International case studies demonstrate diverse approaches to developing species abundance indicators, reflecting varying data availability, resource constraints and policy priorities. Whilst comprehensive multi-taxa abundance indicators remain relatively rare globally, several countries have developed methodologies ranging from adaptations of the Living Planet Index (originally developed by the World Wide Fund for Nature (WWF) (31)), see *Section 4.3.1.)* to target-based assessments and comprehensive biodiversity monitoring frameworks. These approaches offer valuable insights for Northern Ireland, and the different approaches are assessed to identify practises that could help inform Northern Ireland's own biodiversity indicator development.

It is important to note that the following analysis focuses on approaches with sufficient English-language documentation and detailed methodological information available. Whilst other countries may have developed abundance indicators, language barriers and limited access to policy documents constrain comprehensive analysis of all international examples. The selected cases represent the most well-documented and methodologically transparent approaches that offer clear lessons for Northern Ireland's indicator development.

4.3.1. Living Planet Index (LPI) Approaches (The Netherlands, Canada)

Several countries have adopted variations of the Living Planet Index (LPI) methodology, which uses a geometric mean of species populations trends to create composite abundance indicators (32). This differs from England's previously discussed indicator by using a simpler geometric mean approach without the problematic 'double smoothing' which removes year-to-year detection capability. The Netherlands has developed a sophisticated national LPI adaptation, tracking 376 species disaggregated by habitat (freshwater and terrestrial) with 1990 as the baseline year indexed to 100 (33). The Dutch approach incorporates occupancy data for species without detailed abundance records and additionally developed TRIM (Trends and Indices for Monitoring data), a program designed for estimating trends when data is sparse (34, 35). The Netherlands integrates their LPI into nature policy frameworks as a monitoring tool for biodiversity targets related to the UN Convention on Biological Diversity and EU biodiversity strategies, demonstrating how LPI style indicators can be translated into policy assessment tools. (33).

Canada operates a taxonomically broader scope for their LPI based indicator with approximately 980 species representing 52% of native vertebrates (36). Australia uses LPI methodology for their Threatened Species Index, which has been integrated into national policy reporting (37). Other countries using LPI include Uganda, China and South Africa (32). However, all LPI applications remain retrospective and are unable to provide forward projections for policy planning. The well-documented approach offers advantages including methodological transparency, international standardisation and statistical robustness but may face limitations due to its dependence on high-quality and high-quantity time-series biodiversity data and sensitivity to outliers. Additionally, this approach typically uses equal weighting, which treats declines in abundant and rare species identically which can potentially mask conservation priorities.

4.3.2. Expert-Defined Target-Based Approaches (Germany, Europe, Norway)

Germany's target-based approach represents a distinctive methodology that measures distance from sustainability rather than just trend direction. The Federal Environment Agency's Species Diversity and Landscape Quality indicator tracks 51 bird species across five habitat types – agricultural land, forests, settlements, inland waters and coasts/seas. An expert panel sets a sustainability target value to represent the abundance each species should achieve under sustainable land use (39). The indicator expresses progress as a percentage of the target, with 100% meaning full achievement of sustainability goals. Germany currently sits at 80% and aims to reach 100% by 2030, with agricultural habitats (made up of 11 species) performing particularly poorly, whilst settlements and forests being closer to the goal (39). This approach provides a direct measurement of progress towards environmental commitments under the German National Sustainability Strategy, whilst also helping guide conservation and land management efforts through habitat stratification (40). However, the indicator relies exclusively on birds as a proxy for broader biodiversity. This is based on the rationale that landscapes with correctly managed habitats are home to species as well as birds, and therefore the indicator will directly reflect other species trends in sustainable land use (39) – an assumption that may not hold for all taxa across all habitats.

Similar target-based methodologies exist within European environmental legislation. The EU Water Framework Directive employs Ecological Quality Ratios (EQRs) for fish and other biological quality elements. This involves the comparison of current conditions against a reference target representing undisturbed ecological status (41, 42). Similarly, the Marine Strategy Framework Directive sets threshold values for abundance and distribution of species including fish and marine birds, to determine if waters can achieve 'Good Environmental Status' (43).

These frameworks demonstrate a broader adoption of expert-defined target-based or reference condition approaches that, like Germany's indicator, measure progress against scientifically determined sustainability thresholds than simply documenting trend direction. Germany's biodiversity indicator may be more manageable and cost-effective than multi-taxa approaches for ongoing monitoring, however, the substantial upfront investment in expert knowledge to establish meaningful targets for each species should not be underestimated. This process requires deep understanding of species ecology, habitat requirements, and sustainable population levels.

Norway's Nature Index demonstrates how target-based approaches can be scaled to comprehensive ecosystem coverage whilst providing both disaggregated ecosystem-specific results and an integrated overall assessment. Developed in line with Norway's domestic and international commitments to protect nature, the index is approved by both the Ministry of Finance and Ministry of Environment as an indicator, serving as an important tool in Norwegian environmental management (44). The methodology uses a composite metric, where multiple indicators, most commonly occurrence and abundance, are scaled to fall between 0 and 1, where 0 represents absence or extinction, and 1 represents abundance corresponding to that in a natural environment with minimal human disturbance (45). The framework encompasses more than 300 biodiversity indicators across seven major ecosystem types including mountains, forests and ocean (44, 46).

Unlike Germany's bird-focused approach, Norway's indicators include abundance measures, occurrence data, functional indicators (predator-prey ratios, pollinator success), and structural measures (habitat connectivity, dead wood volume). Norway recognises that there is a bias towards certain taxonomic groups and subsequently opted to weight the index to avoid over-representation (44, 45). As well as the monitoring data, the index also incorporates model-based estimates and expert evaluations. The inclusion of expert evaluations is a key innovation, allowing the framework to assess biodiversity in data-rich and data-poor areas alike. Published every five years, the Nature Index provides ecosystem-specific assessments, directly informing policy. However, the five-year reporting cycle limits the ability to monitor short-term progress or rapidly adjust management actions based on indicator feedback. The complex methodology allows assessments to be made for areas and taxa with where empirical data is limited. Although this framework requires substantial resources and institutional commitment, the five-year reporting cycle makes the comprehensive approach more practically manageable than annual indicator requirements.

4.3.3. Systematic Monitoring: Switzerland

Switzerland's Biodiversity Monitoring program (BDM) demonstrates a comprehensive systematic approach to biodiversity monitoring that has integrated scientific data collection with policy-relevant indicators since 2001 (47). Five hundred 1km ^{2} locations are systematically surveyed across the entire country, where multi-taxa surveys of plants, birds, butterflies, bryophytes, aquatic invertebrates etc. are conducted using consistent methodology (Fig. 1). BDM data directly informs multiple official government biodiversity indicators, including the Swiss Bird Index, which tracks population abundance trends of 174 bird species, the Butterfly Index, which measures butterfly diversity, and comprehensive Red List assessments covering 10,844 species (approximately one-fifth of Switzerland's total species) across plants, animals, lichens and fungi, with habitat-specific breakdowns and trend analysis through a Red List Index (48).

This systematic, long-term data collection approach does not generate a single composite multi-taxa abundance indicator but instead produces a co-ordinated suite of targeted indicators that are tailored to the data available for different species groups and habitats. The approach enables detailed assessment of biodiversity patterns across different taxonomic groups and habitats, providing the granular information needed for targeted conservation planning and policy interventions (49).

Switzerland's systematic monitoring approach represents a gold standard for generating robust, policy-relevant biodiversity data without the methodological compromises inherent in combining ecologically diverse taxa into single abundance metrics. However, this approach lacks a single composite indicator that could facilitate direct comparison with other policy priorities or provide the simplified communication tool that single metrics like net zero targets offer for climate policy.

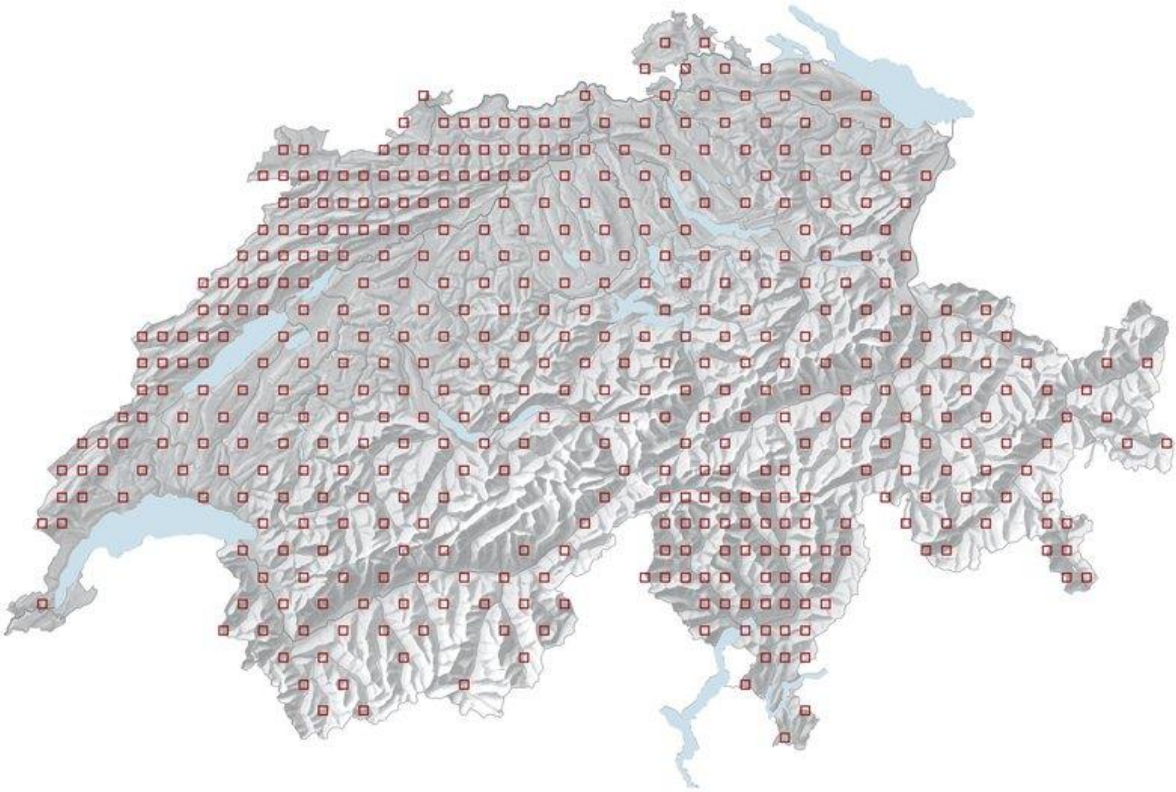

Figure 1: The gridded biodiversity monitoring framework across Switzerland (50). Each red square is 1 km x 1 km and a range of surveys are completed at each location.

4.3.4. Red List Approaches

Switzerland has developed a comprehensive Red List indicator that demonstrates how traditional Red List methodology can be adapted for broader biodiversity monitoring. Switzerland's approach covers 10,844 species (approximately one-fifth of the country's total species) across plants, animals, lichens and fungi, with habitat-specific assessments and trend analysis (49). Rather than focusing solely on threatened species as in traditional Red List applications, Switzerland's adaptation systematically evaluates a much broader range of taxa including common species, enabling assessment of overall biodiversity health rather than just extinction risk. The approach incorporates habitat-specific breakdowns that allow targeted conservation insights for different ecosystem types and uses trend analysis through a Red List Index to track changes over time (49). This systematic, comprehensive approach follows the globally standardized IUCN Red List methodology while extending its application beyond the typical focus on charismatic or threatened species.

Established in 1964, the Red List serves as the world's most comprehensive source on species conservation status, assessing over 172,000 species worldwide using standardized extinction risk criteria (51). Red List indicators have been widely incorporated into national biodiversity policies and environmental reporting frameworks across numerous countries and regions. The United Kingdom uses a Red List Index for England's native species (52), and a European wide Red List of Threatened Species helps guide conservation management across the EU's member states (53). Countries including South Africa (54), Finland (55), and Brazil (56), amongst others, use Red Lists for policy tracking.

The Red List Index importantly serves as an official indicator for UN Sustainable Development Goal 15 and was used for assessing progress towards the Convention on Biological Diversity's 2010 target and the 2020 Aichi Biodiversity Targets (57). However, Red List approaches face significant limitations for comprehensive biodiversity assessment. Red List criteria were designed with a primary focus on higher vertebrates which has in turn produced inconsistent and under-estimated threat and extinction assessments for other taxa (58). It is estimated that 0.5% of arthropod species and 4% of molluscs have been globally evaluated, revealing bias towards large species with wide distribution ranges and high dispersal abilities – essentially those which are easier to find (59).

Whilst providing valuable information on conservation priorities and extinction risk trends that align with international reporting requirements, without considerable adaptation (e.g. Switzerland), Red Lists often offer a narrow perspective focused on threatened species rather than overall ecosystem health or general abundance changes of common species.

4.4. Academic and Emerging Methodologies

Beyond established monitoring, reporting and indicator frameworks, academic research provides several emerging methodological approaches that offer potential for biodiversity assessment, particularly where data is limited, where understanding causal relationships between human activities and biodiversity change is needed and where future projections are desired.

Three key emerging approaches show promise for complementing traditional methods for indicators: spatiotemporal modelling for analysing biodiversity patterns across space and time; pressure-response frameworks for linking pressures and drivers to species change and scenario modelling for projecting biodiversity under different policy and environmental conditions.

Modern biodiversity modelling integrates these approaches through frameworks such as Essential Biodiversity Variables (EBVs) and pressure-response models like GLOBIO. EBVs provide standardised measurements of biological components, transforming raw, noisy biodiversity data into policy-relevant indicators. Data from multiple sources are harmonised and modelled with spatio-temporally consistent environmental data to create indicators covering six different classes, including on species populations and community composition (60). The EBV indicators create space-time-species cubes (Fig. 2), allowing for the assessment of multi-species distributions and abundances. The environmental data included such as climate, land cover and topography, help overcome data sparseness and bias present in typical biodiversity survey datasets and allow for predictions of species through space and time (61).

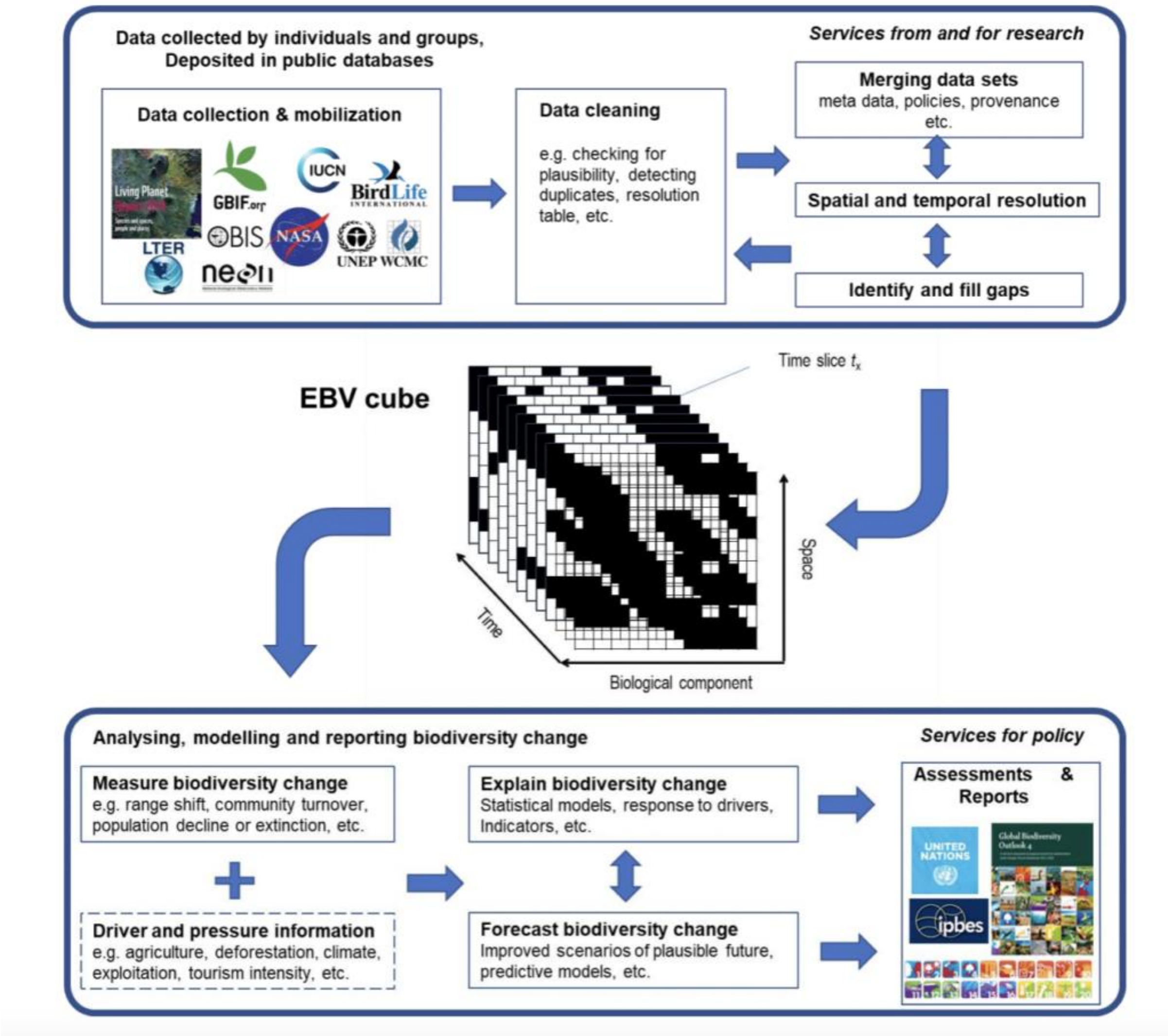

Figure 2: Essential Biodiversity Variables framework for transforming raw biodiversity data into policy-relevant indicators (62). The EBV framework creates standardized space-time-species cubes by integrating raw biodiversity data with environmental variables (climate, land cover, soil properties etc.) to overcome data sparseness and bias. This enables assessment of multi-species distributions and abundances across space and time, providing policy-relevant indicators for biodiversity change assessment.

Pressure-response modelling demonstrates how relationships between anthropogenic impacts and biodiversity change can be quantified and used to generate predictions at both large and small scales. This is exemplified by GLOBIO, which integrates human pressures including land use, habitat fragmentation, pollution and climate change to predict biodiversity intactness (measured as mean species abundance), establishing relationships between them (63). Such methodologies enable identification of which specific pressures contribute most to biodiversity loss, and coupling with spatially explicit modelling reveals the geographic patterns of biodiversity change and their underlying causes. GLOBIO's fine-resolution mapping facilitates targeted conservation interventions by identifying where biodiversity is most vulnerable to specific threats and which species are at greatest risk (63).

The integration of pressure-response relationship understanding with future spatio-temporal environmental data products enables forward looking projections essential for policy planning.

Predictive modelling can assess impacts of alternative scenarios and identify which conservation actions are most likely to and most effectively achieve biodiversity goals (64). GLOBIO, mentioned above, generates predictions for species abundances under varying climate and socioeconomic scenarios (63). Despite the advances in both modelling and environmental data, the application of predictive approaches remains underutilised in environmental policy – with all indicators discussed in this paper being inherently retrospective. A recent paper highlighted this gap, calling for the expansion of systematic predictive modelling in conservation biology, proposing a specific research program dedicated to co-ordinate global modelling efforts (65). These predictive frameworks have proven success in threatened species management (66) and in invasive species assessment (67), yet broader integration into both global and local policy has yet to be achieved (65).

A critical strength of these approaches is the capacity to quantify and communicate uncertainty, enabling robust decision making in practise. Models highlight data gaps and uncertainties which can help guide the design and implementation of future monitoring efforts (65). Statistical methodologies that can account for spatial, temporal and phylogenetic structures in biodiversity data can help smooth noisy trends and improve prediction accuracy, through minimising uncertainty (68). Uncertainty can be further reduced as more data is collected, creating a feedback loop of monitoring data and modelling to improve management and the generation of actionable insights (65). These uncertainty-quantified projections allow decision makers to understand confidence levels in different scenarios, and predictive indicators derived from these models can inform policy frameworks with forward-looking metrics rather than solely retrospective trends.

The approaches discussed here enable biodiversity predictions that can directly inform conservation management, resource allocation and trajectories towards important targets. As biodiversity data collection continues, and technology around current and future environmental and anthropogenic pressures data continues to develop, these methods offer increasingly powerful tools for producing evidence-based abundance indicators that guide proactive nature recovery planning to help halt and reverse biodiversity loss.

5. Options for Northern Ireland

Drawing on the international experience examined in *Section 4* and the stakeholder requirements and assessment criteria established in *Section 3*, this section presents six methodological approaches for developing species abundance indicators in Northern Ireland. Each option is assessed against the twelve criteria identified in *Section 3* (Table 2), considering both implementation factors and lessons learned from international applications.

The approaches range from adaptations of proven frameworks to innovative methodological developments, each with different trade-offs between for example comprehensiveness, feasibility, and policy relevance. While these options draw on implementations elsewhere, each would require adaptation to Northern Ireland's specific monitoring landscape and data availability. This assessment provides the evidence base for identifying the most appropriate options for Northern Ireland's biodiversity indicator development.

5.1. Adapted England Methodology: A Single Multi-Taxa Indicator

A potential option for Northern Ireland would be to adapt England’s multi-species indicator methodology, using the Freeman method (21), to combine individual species trends into a composite geometric mean index. Based on the State of Nature Northern Ireland 2023 report (19), this approach would work with significantly fewer species than England’s almost 1200. Instead, Northern Ireland would focus on well-monitored groups: 64 breeding bird species, 14 butterfly species, 36 wintering waterbirds, 6 bat species and any other taxonomic groups where sufficient data exists for trend calculation.

A constrained species list approach would be more robust than replicating England's exact list and would allow for methodological consistency with England's approach, facilitating understanding and integration within UK-wide reporting frameworks. Using the same statistical methodology would also benefit from the existing knowledge base and experience with the method. However, the different species compositions between England and Northern Ireland should be considered when making direct numerical comparisons, as the indices would reflect the particular ecological assemblages and pressures specific to each region. Additionally, a single indicator may be easier to understand for policymakers and for wider public reporting. However, it would still inherit England's fundamental methodological problems including excessive smoothing, retrospective only assessment capacity and unresolved statistical challenges of determining 'halt-and-reverse' of biodiversity decline. Further alterations such as weighting by species or stratifying by habitat could introduce more improvements to the existing methodology.

5.2. Living Planet Index Approach

Adopting the Living Planet Index (LPI) methodology would involve using a geometric mean of species population trends to create composite abundance indicators. Unlike England’s approach of double smoothing (23), the LPI methodology applies less intensive statistical smoothing, preserving the variability in the data while still providing robust trend information. Northern Ireland could stratify available species data (as discussed above (19)) by habitat (e.g. terrestrial, freshwater, marine) whilst maintain the ability to publish a single, easy to communicate, multi-taxa indicator with appropriate weighting between habitat types.

The LPI method offers a well-established, internationally recognised approach that avoids the excessive smoothing problems that render England's indicator unsuitable for confident detection of year-to-year change in biodiversity populations (9). It provides an easily communicated indicator that can work with existing data, offering greater flexibility in taxonomic composition and weighting. However, the LPI shares the retrospective limitations of other abundance indicators, unable to provide forward-looking projections or to link changes to drivers and pressures, both of which can be helpful for policy planning. The standard LPI method treats declines in abundant and rare species identically, which can potentially mask conservation priorities unless modified with appropriate weighting. It also remains dependent on sufficient time-series data - something which Northern Ireland has struggled with.

5.3. Red List Approach

A Red List approach would develop an indicator based on the IUCN methodology, tracking changes in species' extinction risk categories over time, rather than population abundance directly.

Northern Ireland could develop a Red List Index using existing all-Ireland assessments covering 2,508 species (19, 69), alongside creating Red List status assessments for additional common taxa beyond traditionally threatened species. This expanded approach, similar to Switzerland's Red List Index (48), could build on the trend data available from the State of Nature Northern Ireland 2023 report (19) as a foundation for determining conservation status categories. Northern Ireland could additionally develop habitat-specific disaggregations for targeted conservation insights. This approach would align with the globally standardised IUCN framework used for UN Sustainable Development Goal 15 reporting (70).

A Red List method offers the advantage of focusing directly on conservation priorities and extinction risk trends, providing clear policy relevance for nature recovery programs and protected area management. It would integrate well with international reporting requirements and offers habitat stratification capabilities for ecosystem-specific assessment. However, Red List approaches require intensive expert evaluation of multiple criteria including population size, geographic ranges and pressures on each species, making this process more resource-intensive than automated statical processing of monitoring data.

Like other approaches, Red Lists remain retrospective and assessing halt-and-reverse targets would require species to improve enough to move down threat categories, a process that could take decades rather than the annual detection needed for environmental improvement plan reporting.

5.4. Representative Taxa / Expert-Defined Target-based Approach

Following Germany's target-based method (39, 40), this approach would measure distance from sustainability targets rather than trend direction for a select number of species or taxa. An expert panel would set species-specific abundance targets representing levels achievable under sustainable land-use conditions, with progress expressed as a percentage of target achievement. Northern Ireland could focus on well-monitored taxa such as the 64 breeding bird species mentioned in the State of Nature Report (19) and break this down by habitat type (e.g. farmland, woodlands, wetlands), with species weighted by distance from favourable conservation status to prioritise conservation efforts.

This option offers clear advantages in providing directly actionable, species-specific conservation priorities by focusing on taxa where sufficient monitoring data and expertise already exist. A target-based framework enables measurement of progress towards goals, rather than simply documenting a decline, potentially offering more insights than trend only-approaches. The methodology integrates well with habitat-based conservation strategies and could provide clear accountability for land management decisions, and importantly links land-use with species abundance, a well-established driver of biodiversity decline (71). However, this requires substantial upfront investment in expert knowledge to establishing meaningful targets for each species, requiring a deep understanding of species ecology and population levels. Importantly, focusing on one representative taxa group may not capture broader biodiversity trends – although, more could be included as data collection improves. This approach also diverges from stakeholder preferences for a comprehensive suite of indicators covering multiple aspects of biodiversity change.

5.5. Suite of Indicators

A suite of indicators covering different aspects of biodiversity change could follow models like Scotland's domain-specific indicators (terrestrial abundance, occupancy, marine (25)) or Switzerland's comprehensive targeted indicators for different taxa, habitats and data types (48). Northern Ireland could build upon existing State of Nature reporting (19) to create separate abundance indicator (birds, butterflies, bats), distribution indicators (plants, invertebrates) and functional indicators (pollinator success, habitat connectivity) as data availability allows. This approach would maximise use of available monitoring data whilst maintaining transparency about taxonomic and habitat-specific variation.

A suite of indicators offers significant advantages in making optimal use of existing data without forcing compromises inherent in combining diverse taxa into single composite metrics. The approach aligns with stakeholder preferences for comprehensive biodiversity assessment, provides flexibility to start with available data and scale up over time as monitoring capacity develops. It may also enable habitat-specific conversation insights that can inform targeted interventions. However, multiple indicators present communication challenges for policymakers and the public, making it difficult to provide simple statements about overall nature health or set unified targets for a halt-and-reverse assessment. This complexity may have consequences for prioritising nature recovery more broadly, as it is easier to drive political action and public understanding around a single clear target for example net zero than around a suite of diverse targets. It would also require substantial ongoing resources to maintain multiple indicator systems and co-ordination across different data providers, though the scalable natures allows for a phased implementation aligned with capacity and policy or conservation priorities.

5.6. Pressure-Abundance Framework

A pressure-abundance framework would model species abundance as a function of environmental drivers and pressures, following emerging approaches previously discussed, the framework would integrate Northern Ireland's biodiversity monitoring data with spatially explicit environmental datasets including land cover, climate and other pressures to establish pressure-abundance relationships.

Statistical approaches could range from more accessible linear models to sophisticated Bayesian hierarchical frameworks that can separate observation error from true biodiversity change whilst also incorporating expert knowledge and uncertainty quantification (72, 73). This methodology enables forward-looking projections and scenario analysis and can provide probabilistic target assessment such as '60% confidence that species abundance decline is halted' instead of simplistic retrospective trend reporting. However, while probabilistic assessments offer valuable scientific insights, they may be incompatible with the binary requirements of statutory targets, which typically require definitive determination of whether legal obligations have been met or breached.

This approach offers unique advantages in providing policy relevant insights by identifying which pressures drive biodiversity decline and enabling 'what if' scenario analysis for different management interventions. The framework can support spatially explicit conservation planning and would represent genuine innovation as one of the first operational pressure-response abundance indicator systems adopted into policy. Importantly, the forward-looking capabilities provided are essential for proactive conservation planning and can utilise broader UK or all-Ireland datasets for species and environmental data to improve predictive power of models.

However, the approach faces significant implementation challenges including substantial data requirements for both species and environmental variables, high technical expertise demands for model development and validation, and potentially long development timelines. Additionally, the uncertainty quantification that make this approach scientifically robust may create challenges for establishing clear statutory targets that require unambiguous pass/fail determinations. The complexity of establishing robust pressure-abundance relationships and computational intensity may also limit immediate feasibility, though the framework's flexibility allows for phased development starting with simpler models and expanding sophistication over time.

5.7. Combined and Adaptive Approaches

The six methodological options presented are not mutually exclusive and could be combined or adapted based on Northern Ireland's specific data resources, policy priorities, and implementation timelines. For example, an England-based approach could incorporate habitat stratification from the LPI methodology, Red List assessments could focus on priority taxa with sufficient data, or pressure-response frameworks could be developed initially for single well-monitored taxonomic groups like birds before expanding to multi-taxa applications. A phased implementation might begin with a simple abundance indicator for available data while simultaneously researching and developing more sophisticated approaches as monitoring capacity and technical expertise develop. The choice between single composite indicators, habitat-stratified approaches, or comprehensive suites would require careful consideration of available data quality and quantity, technical resources, policy communication needs, and realistic development timelines. Ultimately, the most appropriate approach for Northern Ireland will depend on balancing methodological ambition with practical constraints, ensuring that indicator choice aligns with both scientific robustness, stakeholder priorities and policy implementation capacity.

6. Indicator Options Assessment and Recommendations

6.1. Indicator Options Assessment

To evaluate the six methodological options systematically, each approach has been assessed against the 12 criteria identified in Section 3, using a traffic light (Red, Amber, Green) scoring system. Green indicates the option performs well against the criterion with minimal concerns, Amber suggests moderate performance with some limitations or trade-offs, and Red identifies significant challenges or poor alignment with the requirement. This assessment is presented in Figure 3.

6.2 Key Findings and Trade-offs

The RAG assessment demonstrates that no single methodological approach performs optimally across all criteria, reflecting the inherent complexity of developing biodiversity indicators. This finding is consistent with international case studies (*Section 4*.3), where countries have adopted markedly different indicator approaches based on their specific data landscapes, policy priorities and resource constraints.

The assessment reveals several fundamental trade-offs that characterise biodiversity indicator development. A clear tension exists between feasibility and innovation: straightforward approaches like the Living Planet Index could be implemented immediately using existing data but offer limited policy innovation. Conversely, sophisticated pressure-response frameworks provide transformative advantages through scenario modelling yet require substantial technical expertise and development timelines that may exceed immediate policy needs. Communication clarity also conflicts with comprehensive assessment - single composite indicators offer easily understood policy messages and can drive action (such as net zero targets) but contradict stakeholder preferences for a suite to capture biodiversity complexity.

Two approaches emerge as less suitable for Northern Ireland's requirements. The Red List approach operates on 5–10-year reassessment cycles that fundamentally misalign with EIP annual reporting requirements. The England-based approach, though immediately feasible, inherits documented limitations that create challenges for any future potential legal target assessment, particularly the annual halt-and-reverse evaluation requirements.

Figure 3: Assessment of six methodological approaches against twelve evaluation criteria using traffic light scoring (Green = performs well; Amber = moderate performance; Red = significant challenges). Methods were identified from international case studies (*Section 4*) and discussed in *Section 5*, with criteria derived from OEP funded UKCEH stakeholder consultation (13) (criteria 1-8) plus additional technical requirements (criteria 9-12, *Section 3*)

6.3. Recommendations

The remaining four options demonstrate similar overall performance, indicating that optimal choice depends on which criteria are prioritised and on available resources. Based on this assessment and international experience, the recommended approach is a suite of biodiversity indicators that initially focuses on well-monitored taxonomic groups whilst building capacity for innovative frameworks where data permits.

This strategy enables immediate policy delivery through existing State of Nature trend data (birds, butterflies, bats) (19) whilst creating pathways toward more sophisticated assessment capabilities. Resource availability fundamentally shapes implementation: low-resource scenarios enable rapid adoption using existing data, whilst medium investment allows suite development incorporating distribution indicators. This phased approach acknowledges that indicator development must begin immediately using available data, rather than waiting for perfect methodological solutions, whilst building toward the comprehensive assessment framework needed for long-term conservation planning.

7. Conclusion

This analysis demonstrates that Northern Ireland faces fundamental trade-offs between methodological sophistication, policy relevance, and practical implementation constraints in developing biodiversity indicators, with no single approach performing optimally across all criteria. The assessment reveals that successful indicator development depends not on identifying perfect solutions, but on selecting approaches whose limitations align with available resources and priorities. Drawing from international experience and stakeholder consultation, this paper recommends implementing a suite of biodiversity indicators that begins immediately with well-monitored taxonomic groups e.g. birds, butterflies, and bats, whilst building analytical capacity toward innovative pressure-response frameworks that can provide the forward-looking assessment capabilities essential for effective conservation planning.

Northern Ireland stands at a critical juncture for biodiversity monitoring and nature recovery, where delayed action risks further environmental degradation whilst waiting for ideal technical solutions that may never materialise. The Environment Act 2021 creates legal requirements for annual biodiversity reporting (Schedule 2) (3) that necessitate effective indicator frameworks, and the draft Nature Recovery Strategy (7) establishes ambitious future visions that require frameworks to guide evidence-based conservation interventions. The recommended phased implementation pathway enables Northern Ireland to meet immediate policy obligations using existing monitoring infrastructure whilst progressively developing the innovative assessment capabilities needed to address one of the most pressing environmental challenges of our time. Northern Ireland has committed to halting and reversing biodiversity decline through its policy frameworks, and ensuring this commitment is measurable requires implementing robust biodiversity indicators that can evolve with institutional capacity and guide Northern Ireland toward demonstrable nature recovery.

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