Institute and Faculty of Actuaries

Nature at Risk, Models at Fault: Why Biodiversity Can't Wait

Report from the Investigations of the IFOA Biodiversity WP Scenarios Subcommittee

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Challenging, Complex, Necessary

Pathways to Sustainability

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Pathways to Sustainability

Executive Summary

The most fundamental headline outcome from the experts at our Biodiversity Scenarios workshop is that there is no use-case for Climate Scenarios that do not explicitly allow for and integrate biodiversity considerations and impacts[1]. This presents a direct challenge to the current NGFS, IEA, and similar scenarios and suggests they should not be the core basis of regulatory and disclosure efforts[2]. This does not mean climate scenarios should be abandoned, simply that these should now become at least "climate plus" (biodiversity) and then move to "climate and biodiversity" as soon as possible.

There are three intersecting realities that lead to this fundamental conclusion, with the corollary of three intersecting challenges that actuaries and the profession need to engage with, if we are to fulfil our core functions of adequately assessing pricing, reserving, and risk resilience for insurers and pension funds.

The three realities are: (1) the impact of biodiversity risks to UK economy and financial institutions are equal or greater than climate risks, (2) climate and biodiversity are intrinsically linked and mutually reinforcing and (3) the outcome of climate and biodiversity pathways are fundamental to understanding the potential state of our future economy and macro-economic impacts to financial institutions.

The three challenges to actuaries and the profession are (1) biodiversity scenario modelling faces data, technical and conceptual challenges, (2) actuaries will need to upskill in system thinking, complex risk modelling and narrative scenario development and (3) actuariues need to challenge regulators, existing practices and vested interest on the necessity of changing current climate scenario approaches so that these include biodiversity. To fail to address these, will be to fail to undertake the core actuarial functions and obligations expected of the profession.

In brief, integrating biodiversity into our climate scenarios is **Challenging, Complex, and Necessary.** The broader findings from our workshop and investigations outlined in this report can be summarised:

1. **Biodiversity is critical for climate risk analysis:** Biodiversity underpins ecosystem services essential to economic stability, health, food production, and climate regulation. Biodiversity loss poses systemic, long-term risks to society and the financial system. There is a material risk of biodiversity and nature-related macroeconomic impacts equalling the 2008 Global Financial Crisis, or even the COVID19 pandemic, within the next 10 years. Biodiversity risk is both inter-related with, and of an equivalent size to, climate risk. Thus, meaningful future scenarios need to incorporate the analysis of both climate and biodiversity pathways.
2. **Current climate scenarios have major gaps:** Widely-used climate scenarios (such as NGFS and IEA) rarely integrate detailed biodiversity impacts, creating significant blind spots for risk assessment, policy, and financial decision-making. Examples of assessment gaps in climate-only scenarios include food system impacts, land use tensions, ecosystem service collapse, pandemics and forced migration. Failure to incorporate biodiversity leads to misleading outputs and underestimation of both chronic and acute risks.

1 Biodiversity is defined as the variability among living organisms from all sources, while nature is broader and includes all features, forces and processes created at the same time as earth such as water, geology and climate. Within this paper, the scenario impact of both biodiversity and the broader element of nature are included together. For ease of reading, we have predominantly used 'biodiversity' as a proxy for 'biodiversity and nature-related' risks and impacts.

2 See also **IFoA Biodiversity Working Party**, 2025. *Climate scenarios "not fit for purpose" without biodiversity*. [online] Available at: https://blog.actuaries.org.uk/climate-scenarios-not-fit-for-purpose-without-biodiversity/ [Accessed 28 July 2025].

3. **Climate and biodiversity risks are deeply interlinked and mutually reinforcing:** Climate change accelerates biodiversity loss and vice versa. Biodiversity loss weakens natural climate regulation systems and lowers our resilience to severe weather and climate shocks. Biodiversity loss has the potential to turn natural greenhouse gas (GHG) sinks into sources of GHG emissions. These risks amplify each other through feedback loops, compounding threats to economies, societies, and financial markets that exceed individual risk assessments.

4. **Biodiversity scenario modelling faces technical and conceptual challenges**: Biodiversity risks and aligning to biodiversity objectives is made more difficult to model due to the absence of simple, universally accepted metrics. Existing models lack consensus on measurement, face severe data gaps, and struggle to capture non-linear, cascading, and tipping-point events. However, there are existing examples that have overcome these challenges using norms-based approaches (with alignment to Kunming-Montreal goals) and narrative-based approaches focused on extreme-but-plausible scenarios.

5. **Narrative approaches are essential:** Quantitative models alone are insufficient as they are unable to encompass outcomes that arise from factors outside of their data set and construction philosophy. Qualitative narratives are needed to communicate complexity, uncertainty, and the full range of plausible futures. Decision-makers, regulators and standard setters must become more comfortable with narrative-based scenarios to avoid “false precision” and better prepare for systemic risks.

6. **Requirements of actuaries and the actuarial profession:** Actuaries must systematically integrate biodiversity into all their climate scenario analysis to provide a more accurate, actionable foundation for risk management and policy. To support this the Profession must:

    a. ***Embrace systems-thinking and narrative approaches***, supporting continual scenario development to keep pace with evolving risks.

    b. ***Support upskilling of actuaries in systems thinking, complex risk analysis and narrative approaches****:* enabling actuaries to move beyond purely quantitative models, embedding this in the qualification syllabi and CPD expectations of certificated actuaries.

    c. ***Support policy advocacy and regulatory reform***: requiring the integration of biodiversity risk considerations into regulatory and disclosure frameworks, highlighting where commonly-used scenarios are not fit for purpose.

    d. ***Public-interest communication of limitations****:* engage in broader public-interest communication, to be transparent about gaps in current climate scenario approaches and especially the absence of detailed biodiversity elements. Also, to highlight the potential role of, and insights offered by, narrative scenarios and ensure the limitations and uncertainties of approaches are understood, especially the limitations of using quantitative models which may appear more precise.

    e. ***Advocate for the development of better data and metrics*** to improve quantification of biodiversity risks along with developing a better understanding of the macro-economic impacts. Better understanding of nature-specific metrics and topical understanding should be brought inside core Actuarial syllabi alongside equivalent skills for climate and sustainability.

7. **Challenging, Complex, Necessary:** Biodiversity’s inconvenient truth is that integrating biodiversity-related risks into climate scenario analysis is challenging and complex, but absolutely necessary**.** Existing examples show that these challenges can be overcome. The necessary next steps are to ensure this becomes universal practice, embedded into supervisory expectations alongside the upskilling of actuaries to enable them to develop narratives scenarios for complex, interconnected risks.

1 Introduction: the biodiversity scenario challenge, our research approach and the structure of this paper

1.1 Introduction

Biodiversity is a cornerstone of ecosystem health and resilience, providing many vital components of modern economies and food production. The stock of biodiversity, together with non-living assets of nature like water, air, minerals is often called 'natural capital' and the benefits derived from it within our economy called 'ecosystem services'.

Damage to ecosystem services can be caused by climate change. Climate change and nature risk are often two sides of the same coin, with the acute and chronic impacts of climate change exacerbating nature-related risks and pushing local nature tipping-points. For example, chronic drought, coupled with the effects of water resource overexploitation, could drive watershed collapse and freshwater fish extinction events[3]. Similarly, collapse of ecosystems such as rainforest, can reverse carbon sequestration to become a source of carbon emissions.

Current climate models used by policymakers and other decision-takers have relatively little detail on biodiversity. Depending on the use case, this can result in blind spots of significant importance, as model outputs will be misleading.

On 26th November 2024, twenty-five actuaries, scientists, policymakers, and insurer and pension fund representatives convened in London to share their understanding and perspectives on the importance of biodiversity in climate risk analysis.

1.2 Purpose of the Workshop

The workshop was set up to explore whether biodiversity was adequately considered by current approaches to climate change, as used in actuarial and other disciplines. It aimed to:

- Highlight the interplay between biodiversity and climate change risks, understanding how land use changes and ecosystem services directly affect economic stability and insurance risk assessment
- Identify gaps and challenges in existing climate scenarios in relation to biodiversity
- If needed, formulate actionable recommendations for better incorporating biodiversity into financial risk modelling and policy- and decision- making

1.3 Biodiversity and Climate Scenarios considered

At the time the workshop material was prepared, there were only a few choices to inform background research on biodiversity scenario analysis, or integrated climate-biodiversity scenario analysis. We thus selected three scenarios - two pioneers in the climate-nature scenario space plus the NGFS Climate scenarios, the latter being widely-used and known by financial institutions and their regulators:

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3 Ranger, N., Alvarez, J., Freeman, A., Harwood, T., Obersteiner, M., Paulus, E. & Sabuco, J., 2023. *The Green Scorpion: the Macro-Criticality of Nature for Finance – Foundations for scenario-based analysis of complex and cascading physical nature-related financial risks.* NGFS-Oxford Occasional Paper. [pdf] Available at: https://www.ngfs.net/sites/default/files/medias/documents/ngfs_occasional_paper_green-scorpion_macrocriticality_nature_for_finance.pdf [Accessed 28 July 2025]

1. **The NGFS climate scenarios** were chosen due to their sponsorship by a global group of Central Banks and supervisors, their prominent role in climate scenario literature, and their ubiquity in the financial space. These scenarios integrate climate risk, macroeconomic risk, and energy systems development and ambition over a series of stories about how the world could progress towards different levels of warming given different assumptions about society, energy use, and technological change.

   The NGFS scenarios are frequently used as a basis for financial stress testing, modelling and analysis especially for regulatory and financial sector disclosure purposes.

2. **The ECI/GFI UK Nature-Related Risks: UK Domestic and AMR-Health Scenarios** were UK Green Finance Institute (GFI) sponsored Environmental Change Institute (ECI) investigations to explore plausible, high-impact biodiversity risks for financial stress testing. Built from literature reviews and stakeholder input, these scenarios emphasize shocks that regulatory bodies may not be preparing for.

   The Domestic Nature Loss scenario models severe wildfires triggered by biodiversity loss, disrupting transport, increasing air pollution, and causing capital damage. The AMR-Health scenario models a rise in antimicrobial resistance, increasing disease spread and fatalities, especially affecting livestock and food security. Both were included for their emphasis on integrating biodiversity into financial risk assessments and capturing severe, systemic shocks.

3. **The Inevitable Policy Response (IPR) FPS+Nature:** IPR scenarios developed from annual high-conviction climate policy forecasts covering 21 countries and 10 policy areas across energy and land use. Its Forecast Policy Scenario (FPS) projects the macroeconomic impacts of these policies on sectors like energy, transport, and agriculture.

   Commissioned by the Principles of Responsible Investment (PRI) in 2023, IPR expanded its FPS scenario to ‘FPS+Nature’, integrating land use change as a key driver of biodiversity loss. This scenario highlights agriculture’s role in tropical deforestation, providing critical insights into nature-related impacts.

These scenarios offered significant material to compare and contrast to explore the pros and cons of different scenario modelling approaches, the limitations and strengths of different approaches, and the obvious and less-obvious opportunities for integration of biodiversity to build towards a coherent climate-nature scenario approach that takes into account scope and scale to inform actionable analysis. See Appendices B, C and D for more information about these climate and nature scenarios that were discussed over the course of the workshop session.

There are continual and growing efforts to develop these models. Direct comments and analysis on these models will become dated but the consideration of the construction challenges and insights will be applicable for far longer.

1.4 Structure and purpose of this paper

This paper summarises the outcomes of the workshop, structured around key thematic areas. It captures the perspectives of a diverse range of stakeholders, each with different expectations of biodiversity scenarios, informed by their experience with climate scenario development, application, or early-stage nature scenario development.

The paper begins with an overview of themes and findings, followed by conclusions and next steps. Threaded throughout the paper is the shared view that emerged among participants over the course of the workshop session: nature and climate cannot be addressed in isolation. While integrating both into a coherent modelling framework can be complex, doing so will dramatically improve the quality and relevance of the outputs from the models and better account for the impact of nature in financial decision making, enabling more resilient and better aligned actions and policies to be undertaken.

2. Why is biodiversity important?

Every breath we take, every bread we break, every thirst we slake, ... I'll be wanting you[4]

2.1 The criticality of biodiversity to our planet and our economy

Nature plays a critical role in providing food and feed, energy, medicines and genetic resources. Nature, through its ecological and evolutionary processes, sustains the quality of air, fresh water and soils on which humanity depends, distributes fresh water, regulates the climate, provides pollination and pest control and reduces the impact of natural hazards[5]. From this ecosystem services perspective, the World Economic Forum has stated that more than half of global gross domestic product (GDP) is moderately or highly dependent on nature and its services[6]. However, a simpler basis would merely observe that 100% of GDP depends on nature as humanity couldn't exist without food, air and fresh water.

Biodiversity is a cornerstone of ecosystem health and resilience, providing many vital components of modern economies and food production. Biodiversity loss and environmental degradation generates significant and long-term risks to society, the economy and therefore financial institutions. The impacts range from increasing the risk and impacts of pandemics, floods and droughts to undermining water quality and supplies, soil erosion, damaging agricultural production and risks to human health[7].

IPBES "The global assessment report on Biodiversity and Ecosystem services" (2019)[8] concludes that nature across most of the globe has now been significantly altered by multiple human drivers, with the great majority of indicators of ecosystem and biodiversity showing rapid decline. The report sets out the direct drivers of change in nature as: changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species and states that climate change is a direct driver and also increasingly exacerbating the impact of other drivers on nature and human well-being. It also defines the indirect drivers as underlying causes which are underpinned by societal values and behaviours that include production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance.

Nature related financial risk assessment is in its infancy and is not clear whether these risks are priced into financial markets. The risks and impacts have, at best, marginal allowance in the climate and sustainability scenarios used by financial institutions, potentially leaving the financial system exposed to systemic nature-related risks[9]. Current climate models used by policymakers and other decision-takers have relatively little allowance of biodiversity and nature-related impacts[10].

The ECI/GFI report identified that Nature-related risks may be as detrimental as climate risks to the UK Economy over the next ten years, reflecting a 2008-type (6% GDP) loss in their domestic scenario and a COVID level (12% GDP) loss in their AMR scenario[11].

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4 With apologies to Sting.

5 IPBES, 2019. Global Assessment Report on Biodiversity and Ecosystem Services: Summary for Policymakers. Bonn: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. [pdf] Available at: https://files.ipbes.net/ipbes-web-prod-public-files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf [Accessed 28 July 2025]. pXIV

6 Avery, H., Ranger, N., Oliver, T. et al., 2024. Assessing the Materiality of Nature-Related Financial Risks for the UK. London: Green Finance Institute. [pdf] Available at: https://www.greenfinanceinstitute.com/wp-content/uploads/2024/06/GFI-GREENING-FINANCE-FOR-NATURE-FINAL-FULL-REPORT-RDS4.pdf [Accessed 28 July 2025]. p6

7 Ibid p4

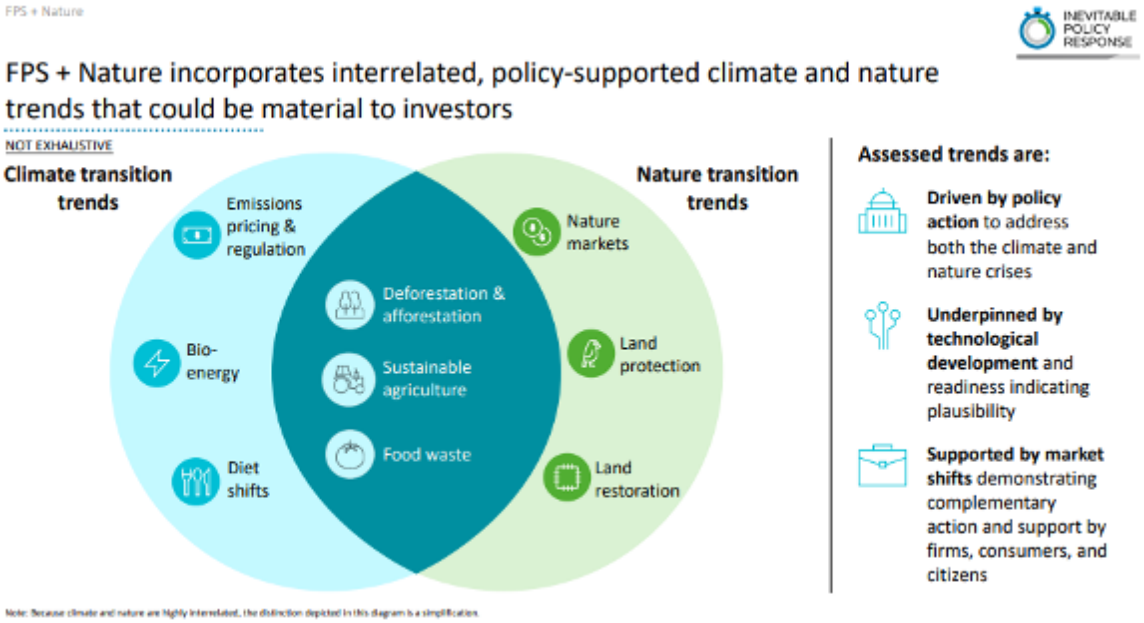
8 IPBES "The global assessment report on Biodiversity and Ecosystem services" 2019 pXVI, XVII

9 Ranger, N., Alvarez, J., Freeman, A., Harwood, T., Obersteiner, M., Paulus, E. & Sabuco, J., 2023. The Green Scorpion: the Macro-Criticality of Nature for Finance – Foundations for scenario-based analysis of complex and cascading physical nature-related financial risks. NGFS-Oxford Occasional Paper. [pdf] Available at: https://www.ngfs.net/sites/default/files/medias/documents/ngfs_occasional_paper_green-scorpion_macrocriticality_nature_for_finance.pdf [Accessed 28 July 2025 Page 6

10 Eg The gaps in the NGFS scenarios discussed in this paper.

11 Avery, H., Ranger, N., Oliver, T. et al., 2024. Assessing the Materiality of Nature-Related Financial Risks for the UK. London: Green Finance Institute. [pdf] Available at: https://www.greenfinanceinstitute.com/wp-content/uploads/2024/06/GFI-GREENING-FINANCE-FOR-NATURE-FINAL-FULL-REPORT-RDS4.pdf [Accessed 28 July 2025].

The IPR's FPS+Nature scenario explicitly sought to build on the existing FPS scenario to consider the impact of seeking to meet the broader (Kunming-Montreal) biodiversity goals alongside the Paris Climate goals. It identified 3 areas of nature-specific policy efforts (land protected, land restoration and development of nature markets) alongside 6 policy areas that intersect with climate (carbon pricing, bioenergy, diets, deforestation, sustainable agriculture and food waste)



It noted material shifts in existing pathways particularly regarding food including dietary shifts especially reducing red meat, constraints on the growth of bio-energy and tensions with demands for transition metals and minerals. And whilst co-ordinated biodiversity policy action by governments could halt and start reverse global biodiversity loss, climate-related policies alone would be unlikely to achieve this. (i.e. climate policies alone are not enough.)

A more general overview is given in "Biodiversity & Nature Related Risks for Actuaries: An Introduction", for the IFoA's Biodiversity policy. Further background information can be found on the IFoA's web site as well as a Primer written by one of this paper's co-authors[12].

12 Saye, L., 2023. Biodiversity & Nature-Related Risks for Actuaries: An Introduction. Institute and Faculty of Actuaries. [pdf] Available at: https://actuaries.org.uk/media/ascndk0h/biodiversity-and-nature-related-risks-for-actuaries-an-introduction.pdf [Accessed 28 July 2025] ; Milliman, 2024. Primer on biodiversity and nature-related risks, opportunities and regulation for those working in financial institutions. [online] Available at: https://www.milliman.com/en/insight/biodiversity-nature-related-risks-opportunities-regulation-financial-institutions [Accessed 28 July 2025].

3. Core challenges of modelling biodiversity, including an outline of current approaches to scenarios

3.1 A range of challenges

Climate and nature are interrelated concepts that require holistic treatment to accurately assess the scope and scale of nature and climate linked risks. Despite the importance of integrated climate and nature scenario representation, there are significant challenges to overcome to realise a more robust representation of climate and nature in scenario modelling. These challenges range from the technical to the philosophical and will require creativity and ingenuity to address in this critical period where action on the dual challenge of climate change and nature collapse is required to secure a future compatible with human life.

3.2 Uncertainty and knowledge gaps

Among of the core challenges in any modelling exercise, but especially in biodiversity scenario modelling, is recognising knowledge gaps and proactively managing uncertainty.

In contrast to climate change, where there are clear science-based metrics, and globally-agreed targets associated with these metrics (total emissions, aligned with 'well below' 2°C of warming in line with the Paris Agreement) - biodiversity lacks a closed set of clearly defined critical elements, making it difficult to measure and therefore, to model, biodiversity linked impacts accurately over time[13].

Biodiversity loss is complex and driven by a range of factors, including, but not limited to: habitat loss, species interactions and human interventions. Any scenario model will necessarily simplify the full range of potential drivers, let alone the full range of potential outcomes and interactions with climate. This complicates the dynamic relationships between what is known, what can be modelled, and the analytical power of those models given the basket of data points, assumptions, and inferences made based on existing knowledge, which is changing as the pace and scale of nature and climate collapse accelerates.

3.3 Importance of understanding model structures and scenario philosophies

Models are useful tools for interrogating the world as it is and exploring options for how the world could be different. Scenario analysis is a critical tool for understanding the impact of future pathways. The recent UK Centre of Greening Finance and Investment (CGFI) report, "A climate scenario taxonomy for the financial sector", provides a helpful overview of different model structures in climate-scenario modelling. It illustrates the breadth and series of decisions and assumptions underpinning published climate models.

Our review of the available biodiversity scenarios brought the model structure and scenario philosophies to the fore. We found that:

13 Millette, K. et al., 2022. Expert Input to the Post-2020 Global Biodiversity Framework: Transformative Actions on All Drivers of Biodiversity Loss are Urgently Required to Achieve the Global Goals by 2050. CBD Information Document CBD/WG2020/3/INF/11. [pdf] Available at: https://www.cbd.int/doc/c/16b6/e126/9d46160048cfcf74cadcf46d/wg2020-03-inf-11-en.pdf [Accessed 28 July 2025].

- There are many metrics for nature and biodiversity, which makes aligning on concepts related to measurement and monitoring extremely challenging.
- There is no common agreement on individual biodiversity measures, let alone how measures across regional ecosystems and biomes could be aggregated to different concepts to capture ideas about current and future-state nature and biodiversity[14].
- There are many providers in the financial services space that are seeking to capture nature via different metrics.

These different metrics and indicators for decision-making were widely discussed among the participants, as was the viability of connecting these metrics to forward-looking scenario analysis, and their current utility was found to be low. Moreover, while there are global high-level conservation targets in the Kunming-Montreal Global Biodiversity Framework, only 57 of the 196 signatories[15] have created National Biodiversity Strategies and Action Plans (NBSAPs), greatly limiting practical, local insights into how these will be achieved.

There are different practical and philosophical considerations to enable integrated climate-nature scenario analysis. The two published biodiversity scenarios took very different approaches. The ECI/GFI work on the materiality of nature risks developed five innovations to create a series of biodiversity scenarios aligned to financial service stress tests. The IPR FPS+Nature uses a normative approach – estimating the most likely policy interventions to achieve stated policy objectives. In contrast, the NGFS's climate scenarios predominantly use a shadow carbon price to reflect economic preferences and the economy's transition within a given carbon budget. This enables more granular calibrations on countries and industries, however, extending this to include biodiversity objectives alongside emissions may be more challenging than taking a different conceptual approach.

These reflections highlighted the tensions between creating useful narrative scenarios and practical Monte-Carlo-style scenario generators. The ECI/GFI work highlighted the challenges of discovering plausible narrative scenarios and translating the biodiversity impacts into economic and financial impacts.

The scenarios that were considered and discussed over the course of the workshop can be summarised by a consideration of their purpose, analytical approach taken, and the representation of nature within the scenario. See below a summary of the scenarios along these dimensions:

	Purpose	Analytical Approach	Representation of Nature
IPR FPS +Nature	**Inform** investment decisions based on forecasted likely policy outcomes	Normative forecast based on expert opinion ('norms based')	Policy focus + Biodiversity Intactness Index (BII)[16]
ECI/GFI	**Assess** materiality of nature risk to the UK	Cause and effect focus – *if this, then this, then this* - focusing on causal mechanisms rather than social/cultural change	GDP linked to nature (NiGEM modelling approach) – with identification of specific nature risks

14 There are ongoing efforts to provide guidance such as Align https://capitalscoalition.org/project/align/ and BISI https://resources.unep-wcmc.org/products/WCMC_RT284.

15 Secretariat of the Convention on Biological Diversity. (2025). Online Reporting Tool. Available at: https://ort.cbd.int/#0.4/0/0 (Accessed: 3 September 2025)

16 Natural History Museum, 2022. Biodiversity Intactness Index. [online] Available at: https://www.nhm.ac.uk/our-science/services/data/biodiversity-intactness-index.html [Accessed 28 July 2025].

NGFS	**Influence** central bank risk assessments and include explicit focus of climate on macroeconomic policy making	Scenario based approach based on mixture of SSP assumptions matched to climate outcomes	None – climate focus

3.4 Challenges and limitations of narrative approaches

Developing narrative approaches depends on complementing them with rigorous quantification. The narratives need to be translated into plausible assumptions about future rates of economic growth, warming trajectories, and future policy responses to climate and nature risk. From a design perspective, the level of detail or disaggregation available for quantification of a scenario influences its potential granularity, insights, and decision-making utility. There is a balance to be struck between the details in those designed for local (country/regional impacts) and the details that would apply at a global level.

Timescale is also critical. The ECI/CGI focuses on a 10-year horizon (2025-2035), which is likely to be the most influential from a financial services point of view. Narrative clarity on longer-term timescales becomes increasingly difficult and challenging to evidence. Although, both nature- and climate-related risks will continue to grow beyond the 10-year timeframe – almost certainly growing until we are both net-zero and nature-positive and have also undertaken suitable adaptation efforts.

3.5 Challenges of measuring and modelling biodiversity risks

Current approaches to modelling biodiversity risk face several challenges. Similar to climate scenarios, existing models often fail to fully capture the dynamics and complexity of nature risks. Whilst narrative scenarios can capture potential tipping points, such as the example of the ECI/GFI pandemic scenario, this is challenging within more quantitative forecast approaches.

Biodiversity measurement comes with additional challenges as we do not have an equivalent metric to carbon[17] for biodiversity loss. It is easier to measure greenhouse gas emissions released in the atmosphere than to wade in the rainforest and measure the nutrient load in the river, monitor every tree or measure the chemical content of the soil. The range of metrics available makes modelling and decision-making more challenging. The spatial nature of biodiversity adds further challenges, including the discrepancy between tackling local issues granularly and the global scale of action required to address the biodiversity crisis meaningfully.

Finally, it is difficult to articulate what success looks like. Unlike climate, where the elimination of net greenhouse gas emissions can be taken as a direct goal, the exact manner and measure of policy outcomes for biodiversity and nature is not clear[18]. At best, we may see an emergence of local strategies for the global policy goal, but this is neither imminent nor are its consequences easily apparent.

[17] "CO_2e" is typically taken as the universal carbon metric. It allows for the measurement of the emission of methane and other gases too Although it takes an averaging approach to the timescales the forcing effect applies in the atmosphere.

[18] This may also reflect that there can be different priorities and benefits that people prefer to derive from nature.

3.6 Examples of biodiversity considerations that may be missing in climate-only scenarios

Land use and food systems were two of the more significant gaps identified in current climate scenario modelling. Whilst some of the climate models allow for reducing deforestation, and some behavioural shifts, full impacts on the food system and agricultural shifts typically do not feature significantly in the models explored in the workshop session.

Combining insights from both the IPR FPS+Nature and the ECI/GFI scenarios, challenges and limitations of climate-only approaches include gaps in:

- The strains on the food system that will be caused by climate change, droughts, heatwaves, floods and supply chain disruption, alongside restrictions on deforestation and agricultural methods
- Balancing both chronic and acute impacts via macro-economic effects and the resulting increase in volatility of prices and economic activity
- The focus on intersectional needs including bio-energy limitations (when balanced by land, nature and food needs), sustainable agriculture, dietary shifts, actions on food supply chains and reducing waste, more explicit action on deforestation, land protection and restoration

Challenges in Defining and Measuring Biodiversity Metrics[19]

A significant challenge of measuring biodiversity risks and metrics is the hyper-local context necessary to accurately measure and understand nature poses challenges associated with them, for example, water stress may vary significantly by local regions. Global metrics don't capture this making it challenging to integrate biodiversity risk data (**dependencies, impacts, risks and opportunities)** into current models in ways that reflect the spatial heterogeneity of nature.

There have been attempts by different market actors to use different biodiversity metrics to connect biodiversity with decision making. For example, the Biodiversity Intactness Index (BII) - is a metric integrated into Bloomberg platforms to enable companies to understand their proximity to important ecosystems. But it's important to note that how this metric is integrated into valuation or financial decision-making is unclear. It is only one among hundreds, and whilst it is a useful indicator, the linkage to financial impacts or even what 'good' and 'bad' BII scores are, is unclear[20].

19 IFoA Biodiversity & Natural Capital Working Party, 2021. Introduction to biodiversity valuation tools. [pdf] London: Institute and Faculty of Actuaries. Available at: https://actuaries.org.uk/media/1u0po4xn/introduction-to-biodiversity-valuation-tools-april21.pdf [Accessed 28 July 2025].

20 Bloomberg L.P. "The Natural History Museum and Bloomberg Team Up to Make the Museum's Biodiversity Intactness Index Available to Financial Markets for the First Time." Bloomberg.com, 29 Nov. 2023, www.bloomberg.com/company/press/the-natural-history-museum-and-bloomberg-team-up-to-make-the-museums-biodiversity-intactness-index-available-to-financial-markets-for-the-first-time/. [Accessed 29 August 2025].

4. Workstream 1: Comparing and evaluating Biodiversity Scenarios Against Each Other

4.1 Workstream 1 summary

- Compared biodiversity-focused scenarios like IPR FPS+Nature (IPR) (norms-based) and ECI/GFI (ECI) (cause-effect driven): IPR focuses on achieving policy-driven outcomes to stimulate investment behaviour, whereas ECI emphasises causal mechanisms to understand systemic impacts
- Highlighted that IPR aligns well with regulatory goals but lacks granular guidance for risk preparation, while ECI provides detailed insights into cause-effect chains but is less applicable at the macroeconomic level
- Highlighted the absence of a "State of Nature" baseline in current models

4.2 Comparing biodiversity scenarios against each other

Biodiversity scenarios have struggled to reconcile short-term and long-term risk perspectives due to the design of models underlying these scenarios. Ecological shocks may compound or cascade over time, creating complex risk profiles that exceed the predictive capabilities of “roll-forward” integrated assessment models.

The two published scenarios, ECI and IPR, exhibit two alternate philosophies to address this challenge. Their key features are summarised below, and fuller details are provided in the appendix:

	ECI/GFI UK Nature-related risks	IPR FPS+Nature
Model Objective	Develop plausible but severe (1 in 100) biodiversity scenarios that can reflect macro-economic impacts on financial institutions	Model impact of plausible policy pathway that achieves both Paris-aligned Climate and Kunming-Montreal Global Biodiversity Framework (K-M) goals
Time horizon	Up to 2035	Up to 2050
Model approach	Causal relationships – *if this, then this, then this* - rather than external social/cultural change	Normative forecast based on expert opinion (‘norms based’)
Nature representations	GDP linked to nature (NiGEM modelling approach) – with identification of specific nature risks	Policy focus + Biodiversity intact index (BII)

Role of expert judgement	Developing and identification of clusters of risk from a risk inventory that reflect 1 in 100 likelihood and highlight financial institutions vulnerabilities. Scenario pruning and selection to develop these into thematic, plausible narratives	Selection of 10 policy areas across energy, land use and nature related that would be the most likely to be selected to achieve the Paris and K-M goals
Models used	Expert judgement was used to evaluate likelihoods and NiGEM models used to evaluate sector-specific and macroeconomic impacts	G-cubed econometric model used to combine outputs from TIAM-GRantham energy model with MAgPIE for land use and agriculture/environment impacts
Tipping points and non-linearities	Directly incorporated into scenario selection. Although each scenario represents one specific set of impacts and not a broader range	Generally not included implying a gradual, shock-resistant transition

4.3 Key strengths of different approaches

ECI provides a series of "severe but plausible" narrative shocks, grouped into three scenarios. It also includes a "pandemic" style scenario (AMR scenario) that may be particularly interesting to actuaries albeit they need to develop the liability impacts themselves. It illustrates the impacts of tipping points - and can be used as a starting point for different narratives and clusters of risks for bespoke scenarios.

IPR FPS+Nature provides a 'norm' based approach from which can be seen what would be needed to reach climate and biodiversity goals. It highlights some of the longer term sectorial and behavioural shifts that are likely to be needed for successful outcomes.

4.4 Key model limitations and challenges

ECI is focused on nature-based risks that have an economic impact on the UK. The scenarios have been selected to represent a range of illustrations across the three rather than the most plausible, or the single scenario that would be the most impactful. These focus on nature-related risks rather than taking account of other climate or geopolitical impacts that may compound the impacts. These are single scenarios, focussed on the next 10 years and not directly integrated into broader stochastic models.

IPR: FPS+Nature focuses on the nature risks that fitted into their existing framework rather than a fresh nature-focused transition risk framework, which might have captured compounding risk and risk accelerators. Future models may take a broader approach. From a stress scenario point of view, there is an implicit gradualism and lack of shocks and tipping points within the projections. It is reliant on the single, biodiversity intactness index, to measure biodiversity which in practice no single metric can cover.

5. Workstream 2: Comparing Biodiversity with Climate (only) scenarios

5.1 Workstream 2 Summary

- Explored how climate scenarios could be extended to better include biodiversity, emphasising the need for simplicity and actionable insights. It was also noted that biodiversity modelling requires more granularity in assumptions and modelling philosophies, and that establishing a widely-supported foundation for these will take significant time
- Provided example scenarios such as the potential collapse of pollinator species in key agricultural regions like California - this scenario would lead to dramatic reductions in crop yields, widespread food insecurity, and economic instability, triggering mass migrations and conflict over resources
- Highlighted that numbers and outcomes from quantitative models can only give a partial, not accurate, sense of the magnitude and type of scenarios we may face and thus prepare for. Qualitative narratives are essential to capture a fuller range of possibilities and understand their impacts

5.2 Moving from Climate to Biodiversity Modelling

5.2.1 Granularity and Complexity

A central theme was the difference in detail between climate and biodiversity modelling. Climate models often focus on broad trends in temperature, precipitation, and sea levels. Biodiversity modelling, however, requires finer resolution to capture the variety of species distributions and interactions, ecosystem condition, extent, and function, and how species respond to environmental changes.

This greater complexity presents a significant challenge. It may lead to a long period before we have widely accepted modelling approaches and philosophies, similar to the lengthy process of establishing climate change modelling standards. Although, recent reviews of the widely accepted climate models that suggest that confidence in them may be misplaced and should be reconsidered[21]. Such reconsiderations may lead to even longer period before there are widely accepted approaches to modelling biodiversity risks – although better approaches hold the potential to address the challenges for both climate and biodiversity modelling.

5.2.2 Limitations and Uncertainties in Modelling Biodiversity

Current models may be disconnected from ecological reality as they produce biodiversity likelihoods and outcomes based on assumptions and approaches that are hard to validate. They may also miss the full range of possible outcomes especially as ecosystems are increasingly moving past equilibrium

21 Trust, S., Joshi, S., Lenton, T. & Oliver, J., 2023. The Emperor's New Climate Scenarios: limitations and assumptions of commonly used climate-change scenarios in financial services. London: Institute and Faculty of Actuaries & University of Exeter. [pdf] Available at: https://actuaries.org.uk/media/qeydewmk/the-emperor-s-new-climate-scenarios.pdf [Accessed 28 July 2025].

states into nature-related tipping points. Consequently, policies and decisions based on them may misstate risks and impacts, potentially may promote decisions that inadvertently cause harm.

5.2.3 The Role of Narratives in Decision-Making

The value of qualitative scenarios was widely acknowledged. These can explore potential futures and inform policy decisions. The resulting narratives can more effectively communicate complex ecological dynamics and uncertainties, offering a more complete understanding of the consequences of biodiversity loss.

However, some decision-makers, especially in finance, are reluctant to act without quantitative assessments. Integrating model-derived scenarios into narratives may help bridge this gap and enhance the impact of qualitative assessments. The alternative is for decision-makers to be supported to become more comfortable with the visible subjectivity of narrative scenarios over the pretended objectivity of quantitative scenarios which is equally dependent on subjective inputs, judgements and limitations.

5.2.4 Feedback Loops and Human Systems

The discussions emphasised incorporating the effects of impacted biodiversity on human systems within models. Changes in biodiversity can affect human migration, energy use, and land use patterns. This creates feedback loops that can further worsen or lessen the impacts of climate change.

Biodiversity impacts can have critical financial impacts when they affect human systems. For example, a collapse in California's food production, due to drought or pollinator loss, could cause significant socio-economic disruption.

5.2.5 Financial and Regulatory Considerations, or Lack Thereof

To the extent regulatory requirements have included climate change scenarios, biodiversity is almost always absent. The focus is also typically, on the risks to financial institution’s financial resilience, with no account being taken of the risks to the biodiversity (and resulting benefits) supported by the institution. There are efforts, found within voluntary and mandatory reporting frameworks like TNFD and CSRD, to recognise the principle adverse impacts (PIA), but these are still developing.

As a result, financial decision-makers' current incentives are more often than not, short-term in nature and insufficiently related to climate and biodiversity. Large-scale capital reallocation towards solutions is therefore unlikely without further regulatory change. The plausibility or otherwise of meeting long-term biodiversity - and climate - goals should be considered in this context.

5.3 Considering Climate without Biodiversity, or Biodiversity without Climate, is inadequate

Given the challenges and systemic uncertainty associated with measuring and forecasting climate and biodiversity risk, it is perhaps not unsurprising that another key thematic area covered in Workstream 2 was the idea that climate change scenario analysis could be insufficient if this approach did not also adequately consider biodiversity.

According to recent publications, such as the Emperor's New Climate scenarios, widely available climate scenarios systematically underestimate risk given the inadequate treatment of tipping points and uncertainty. Climate and biodiversity risks are deeply interlinked. Climate change alters habitats and ecosystems, putting pressure on species and accelerating biodiversity loss. In turn, biodiversity loss weakens natural systems that regulate climate, like forests and oceans that absorb carbon. Together, these risks amplify one another and pose compounding threats to economies and societies. If these risks are not considered in a linked and systematic fashion in underlying scenario approaches, then it is unlikely we will have the insights necessary to address the risks posed by the dual challenges of climate breakdown and ecosystem collapse.

6. Workstream 3 insights: opening the box

6.1 Workstream 3 Summary

The third workstream had a wider scope, addressing key gaps in existing Biodiversity scenarios, a wish list for future scenarios, and related factors such as social issues. This open approach generated a broad range of ideas, and the key themes are summarized below:

- The necessity of cultural and societal shifts to enable meaningful biodiversity protection. Emphasis was placed on public engagement, institutional reforms, and integrating ecological values into policy and financial decision-making
- The need for targeted education initiatives and systemic thinking, metrics aligned with societal priorities, and narratives linking biodiversity health to economic and social well-being
- The importance of valuing ecosystem services beyond GDP-centric models, emphasising narrative-driven and localised data approaches to fully capture biodiversity scenarios and provide actionable insights

6.2 The target audience and the purpose of biodiversity scenarios

The discussion started with the two fundamental questions:

- Who is the target audience, whose perspective are these scenarios going to reflect? For instance, a localised flood risk is significant for individuals who live in the area, but this may not be material for the financial system
- What are we trying to achieve by coming up with Biodiversity scenarios and what decisions are these scenarios trying to support? Is this analysis a regulatory exercise or can biodiversity modelling affect key business and policy decisions?

Having the scenarios seen as solely part of a regulatory exercise might limit their applicability to individual firms and disengage executives.

The loss of biodiversity should therefore be seen in the context of events that have wider economic implications and can affect both businesses and individuals. We reframe scenarios by use-cases by adopting a narrative-based approach, which could help businesses to connect to the key concepts and outcomes of relevance, and use them for business decision-making.

We also lack a clear set of biodiversity strategies - only 57 of over 180 Nations completing their strategies (National Biodiversity Strategies and Actions Plans (NBSAPs)) to align with the Kunming-Montreal global biodiversity framework. If we have nation-by-nation strategies to meet the global framework then we can understand the required policy response at national and global scale. Although, even where NBSAPs exist more granularity and clarity is required to understand how businesses, and financial institutions, can best contribute to the goals.

One of the purposes for biodiversity scenarios can be generating the cultural change that has the potential to fundamentally change the investment system. This could happen when people who run the businesses, financial and public institutions realise the consequences of nature events on their

organisations.

Developing narratives, starting with the most impactful sectors, would initiate that understanding, then a mandate to develop into further analysis would follow. Explaining how individuals may respond to climate and nature crises with historical examples (e.g. migration) and the implications of these changes on economy, finance, politics and social life would help institutions relate and start thinking about the impacts on their businesses. When assessing likelihoods and pathways, the potential of cultural change - or the likelihood of the lack of change, is an important consideration on the plausibility of each path.

6.3 The ideal biodiversity model and the challenges

6.3.1 Which metrics to use?

In climate risk modelling, carbon equivalent emissions are widely accepted as a common metric. However, identifying an equivalent measure for nature-related risks is much more difficult. One possible approach is to assess different types of physical nature risks individually and select the most appropriate metric for each. These metrics can then inform the development of damage functions to support modelling.

For biodiversity, the concept of being “nature positive” may offer a parallel to terms like "carbon neutral" or "net zero" used in climate frameworks. At an aggregate level, it may be possible to define a global target for biodiversity that functions similarly to a carbon budget, providing a clear goal for progress and accountability.

6.3.2 Narratives

Narrative pathways are a useful way to explore nature-related risks by considering how companies depend on ecosystems, which physical risks could affect them, and what the resulting consequences might be. For example, improving supply chain resilience may protect individual firms but does not necessarily reflect broader systemic impacts on nature or society.

Nature transition risks do not always follow the same patterns as climate transitions. Examining regulations such as the plastics treaty or the 30 by 30 target from the Global Biodiversity Framework, along with the national strategies that support them, can help build a clearer picture. These efforts can also be aggregated to provide insights for investors and institutions.

Instead of trying to calculate precise values for nature-related impacts, it may be more practical to rate impacts as high, medium, or low using defined ranges and multiple scenarios. This approach could help in developing useful damage functions while reflecting uncertainty.

It is important to avoid the trap of analysis paralysis. Just as there is no perfect model for climate risk, there is unlikely to be a complete model for nature and biodiversity. What is needed is a coherent way to evaluate risks that supports real-world decisions. Narrative scenarios can help with this by offering structure and clarity, even when data is incomplete. Finance and policy decisions must be advanced based on the best available insights, not delayed in search of ideal models.

6.3.3 Timeframes

Companies, including financial service institutions, tend to focus on the impact on them in the short term. Although a move to long term risk management and goals are critical for nature risks, initial emphasis could be on short term manageable risks.

6.4 Other modelling considerations and challenges

Such was the wide-ranging nature of this workstream, it posed a series of questions that will require further investigation:

- Do we have the tools as actuaries to build models for these scenarios – non-linearity, chaos theory, causal maps?
- How can we address the challenge of valuing ecosystem services and building models? The aim is to assess the financial losses caused by nature risks (e.g. soil condition or crops) and get a global sense of these issues
- How can we develop our thinking about narrative (deterministic) or stochastic approaches at several levels (e.g. metrics, policy, etc.)?
- Does looking at the impact on countries need a different approach than assessing companies (though in theory the same approach can be used for a range of actors)?
- Can we work back from where we are trying to get to?
- How to overcome data availability challenges? *e.g. local scale of biodiversity- where we may not have sufficiently granular information required to make decisions. From a risk management perspective, it may be best to start by identifying and then managing high risk "hotspots", and building metrics and insights from there*

6.5 Societal shifts

The workstream also considered the ways in which the culture and incentive shifts could occur that could better support nature positive outcomes:

- Removing nature disruptive subsidies would free-up resources to finance nature solutions and these could be included into the models when assessing scenarios
- Strategies around insuring nature solutions could be developed
- Valuing the ecosystem services beyond GDP-centric metrics and aligning this with social priorities and narratives would enable linking biodiversity to economic and social well-being
- Focusing on actions that could lead to positive tipping points rather than focusing on risks only could be beneficial

7. The way ahead: an eyes-open approach to using biodiversity scenarios

7.1 The Einsteinian Razor

When faced with the challenges of understanding the impacts of the sustainability transition, actuaries must confront the "Einsteinian razor" of striving to reflect a simple reality without oversimplifying it. In grappling with the difficulties of climate scenarios, the necessity of including biodiversity appears to be a rather inconvenient truth. Yet, we recognise that it has a material impact; ignoring it would be tantamount to discarding the materiality of the global financial crisis or COVID events.

Thus, our first conclusion is that biodiversity impacts need to be considered, and where possible, actuaries should incorporate biodiversity into their climate scenario analysis. This provides some additional challenges. Where integrated approaches aren't available, actuaries need to be aware of the implications of the challenges and limitations in existing published scenarios.

7.2 Norms-base vs 'extreme-but-plausible' ideation

Workstream 1 identified two approaches to developing Biodiversity scenarios

a. **Norms-based Integrated Assessment Model (IAM) approaches.** An IAM is a modelling framework that seeks to integrate knowledge from climate science and economic theory into a single analytical system. It provides overarching approach to study the climate-economy interactions where the "norms-basis" are used to develop potential policy and behaviour shifts sufficient to align with international agreements

b. **Risk ideation on "extreme-but-plausible" shorter-term outcomes**, grounded in analysis of the financial consequences of impacts of plausible short-term risks occurring

The first challenge for norms-based approaches is the increasing reality-gap between the required policy actions aligned to climate and biodiversity goals and actual progress. GHG emissions have continued to rise since the Paris Agreement. Less than a third of the Kunming-Montreal Parties have completed a National Biodiversity Strategies and Action Plan (NBSAP)[22], let alone taken all the actions to enact them, or confirm in aggregate these plans will be sufficient to meet the agreed biodiversity goals.

7.3 The 'reality-gap' challenge for norms-based IAMs

The 'reality gap' challenge is before considering the broader challenges of this being one set of policy choices against a limitless array, and the broader IAM issues of projecting the economy over long time horizons when the equilibrium assumptions typically underpinning their models look unlikely to

22 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), no date. Open Response Tool Dashboard. [online] Available at: https://ort.cbd.int/dashboard#0.4/0/0 [Accessed 28 July 2025]

hold. Our investigations found value within these approaches but insights from them need to be framed in this broader context:

- They are unlikely to give a direct quantification of long-term (10, 20, 30+ years) economic and financial impacts that will actually unfold. What's more, the simplifications, lack of constraints and assumed efficiencies tend to underestimate the efforts required, albeit future innovations and exponential improvements provide potential for it to be less costly and easier.
- Notwithstanding these challenges, these models are useful outlines of the quantum of policy shifts and changes that would be required to meet goals. This can be helpful for policy advocacy and aligning internal actions and efforts to be consistent with goals. It forms a baseline against which actual progress and shifts can be measured
- They are also useful to consider potential limitations in climate-only models. They can help identify areas where policy approaches would have to be changed as well as new policies developed. This highlights particular tensions in agricultural food systems and diets, the use of biofuels and the substitution of natural products in construction. The impacts and tensions from mining sufficient natural commodities to meet new infrastructure and technology demands, whilst preserving natural habitats, and meeting growing water and food demands are often missing from longer-term models
- Whilst implicitly designing a smooth path, these integrated model pathways can be adapted to illustrate non-equilibrium aspects and in particular the financial and economic shocks of "sudden wake-up call" policy responses. This may illustrate the quantum of impact with the above caveats to be considered on its precision. In particular, it's important to consider these models as examples of potential pathways. If looking to mitigate the potential risks, it's critical to consider the array of similar policy pathways. Less thoughtful mitigations may not address vulnerabilities to other policy approaches; indeed, they risk magnifying vulnerabilities if these policy risks are not considered from a broad enough perspective.

7.4 The reality-gap challenges for narrative scenarios

The shorter-term narrative scenarios focused on "extreme-but-plausible" outcomes (b) that offer more direct quantification of short-term risks. The size of the challenge means they aren't a panacea:

- Subjectivity abounds in the selection of the scenarios, the understanding of likely risks, their quantification in direct and economic effects and then application to individual institutions
- Individual institutions will wish to consider specific events that reflect their own risks and vulnerabilities - reducing the relevance of "off-the-shelf" scenarios and making cross-industry comparisons far harder
- Actual events and impacts will almost certainly be different, and the best of any severe scenario that occurs is that it will reflect different combinations of events that had already been considered

7.5 Eyes-open: none of this is easy

The difference between scenarios and future events has two direct implications. Firstly, any mitigation or risk management actions need to be considered in a broad context of "similar type" situations rather than tied to solely mitigate the specific scenario. Secondly, there needs to be an ongoing dynamic process to consider broader waterfront of potential scenarios and ways different combinations of events could occur. Ideally, institutions would have a structured way to consider how different vulnerabilities and risks interact with their business and capital models. They will then be in a position to explore and risk-manage or risk-accept scenarios that focus on their vulnerabilities.

There are now published, leverageable economic biodiversity models and scenarios under which we can make progress in understanding risks and financial outcomes. This is not yet at the sophistication level of climate scenario modelling but has passed a tipping point on materiality and potential modelling adjustments to mean it should always be considered.

7.6 If we had a magic wand…

We should not be naive in considering the gaps and shortfalls in current modelling that would face significant effort and development to overcome. One way to reflect on the gaps is to ask, "if we had a magic wand what we would include in complete biodiversity modelling?"

Magic Wand aspect	Why important and why challenging
Robust metrics	Lack of clear metrics on biodiversity, nature abundance - or even what measurements are most critical from an ecosphere and societal point of view
Clear baseline	Lack of clear metrics means also the lack of a clear baseline. And what does it mean for this to evolve naturally? What allowance should be made for climate changes, and for example, conditions under which invasive species might be tolerated or even encouraged?
Downscaling	Criticality of locality to biodiversity. Whilst GHG emissions are largely indifferent to location released, locality of impacts is critical for biodiversity. So asset location and business activities need to be set within the context and impact of the locality they are in
Non-fungibility and gaps to natural capital	Whilst carbon emissions are largely location-indifferent and thus can be captured as a number, nature is not fungible. Disclosures and natural capital approaches that translate into financial quantities imply a fungibility that nature doesn't have
Understanding and managing transition risks	Lack of NBSAPs make it difficult to form a view of global intentions and pathways. This creates gaps in understanding potential shifts and transitions and even whether positively intentioned efforts align to likely policies. Lack of global approach makes shadow pricing difficult even if it could be accurately represented. This makes it more difficult to integrate into climate models which have used shadow carbon price as their core driver of the economic transition
Pricing and integration of nature's regulatory and maintenance services	Current economic models presume these exist and continue. Modelling, especially more stressed scenarios, would need to include potential impairments and losses
Integration of Global System Tipping points	We're approaching 16 global biodiversity system tipping points[23]. This will have material, irreversible consequences, but inherently unpredictable in occurrence and timelines
Local tipping points	Local tipping points act in addition to global - and similar challenges of knowing when the thresholds for these tipping points are close or being breached
'Domino' impacts	How climate or other tipping points may interact increasing the chance of triggering adjacent tipping points in a "domino" effect
Avoid unintended consequences of modelling and optimisations	Fundamentally, any modelling approach will remain limited. A magic wand would prevent us from over-relying and over optimising on the results from our modelling

23 University of Exeter, 2023. Global Tipping Points Report. [online] Exeter: Global Systems Institute. Available at: https://global-tipping-points.org/ [Accessed 28 July 2025].

8. Future Milestones and Next Steps

8.1 Barriers to Increased Engagement

Whilst not a direct objective of the workshop, some core barriers to the integration of Biodiversity scenarios emerged, including:

- **Communication Gaps:** Financial institutions often struggle to relate biodiversity risks to their immediate concerns.
- **Short-termism:** Investment decision-makers' horizons frequently overlook long-term biodiversity tipping points.
- **Regulatory Barriers:** Lack of standardised biodiversity risk disclosures hampers progress.
- **Skillsets and belief in quantification:** There is a need to upskill in complex risk modelling and narrative scenario development which are relatively new to actuarial profession and financial industry more generally.
  There also needs to be a mindset shift away from presuming that only quantified risks can be material. We need to separate identification of risk materiality from its quantification – and integrating risks into our materiality assessments whether or not the risks fits within the model quantification.
  Finally, we need to embrace narrative approaches and building resilience to risks, such as biodiversity, which we cannot precisely quantify.

8.2 Proposed Next Steps and Recommendations

Actuaries must systematically integrate biodiversity into all their climate scenario analysis to provide a more accurate, actionable foundation for risk management and policy. To support these efforts, actuaries in collaboration with the profession, industry and academics should support:

- **Scenario Development:** Creating multi-faceted scenarios integrating biodiversity into financial risk analysis with particular attention to Biodiversity-specific elements such as localised data, tipping points, and resilience metrics. Further work is also required on the connections between biodiversity risks and the financial and macroeconomic impacts.
- **Greater data collection and better risk assessment tools and metrics:** building robust datasets and refining biodiversity risk assessment tools to support risk assessment and scenario development.
- **Increase stakeholder engagement:** engaging regulators, financial institutions, and scientists to align goals and incentives.
- **Promote cross-sector collaboration:** Foster partnerships between actuaries, scientists, policymakers and supervisory authorities.
- **Enhance communication tools:** Develop narratives and visual aids to simplify biodiversity complexities for decision-makers.

To specifically support actuaries in their work, the Actuarial Profession should:

a. ***Embrace systems-thinking and narrative approaches***, supporting continual scenario development to keep pace with evolving risks.

b. ***Support upskilling of actuaries in systems thinking, complex risk analysis and narrative approaches****:* enabling actuaries to move beyond purely quantitative models, embedding this in the qualification syllabi and CPD expectations of certificated actuaries.

c. ***Support policy advocacy and regulatory reform***: requiring the integration of biodiversity risk considerations into regulatory and disclosure frameworks, highlighting where commonly-used scenarios are not fit for purpose.

d. ***Public-interest communication of limitations****:* engage in broader public-interest communication, to be transparent about gaps in current climate scenario approaches and especially the absence of detailed biodiversity elements. Also, to highlight the potential role of, and insights offered by, narrative scenarios and ensure the limitations and uncertainties of approaches are understood, especially the limitations of using quantitative models which may appear more precise.

e. ***Advocate for the development of better data and metrics*** to improve quantification of biodiversity risks along with developing a better understanding of the macro-economic impacts. Better understanding of nature-specific metrics and topical understanding should be brought inside core Actuarial syllabi alongside equivalent skills for climate and sustainability.

9. Conclusion

The insights from this workshop highlighted that current climate models do not form a suitable basis for projections as they fail to suitably integrate the biodiversity-climate change feedback loop on modelled outcomes. This creates a blind spot for users of climate models, as biodiversity impacts have significant real-world effects on the key outcomes important to users of climate models, including land use, economic metrics, and human movements and wellbeing.

Challenging, Complex, Necessary

What3words allocates 'Challenging, Complex, Necessary' to rural Oklahoma, just Southeast of Oklahoma City - in the heart of the oil-rich plains, tornado-alley (the most tornadoes per square mile in the world) and in the "Sooner state". "Sooners" were those who illegally entered during the 1889 Land Rush before the official noon start, hiding in ditches and emerging to claim the best plot. The modern rehabilitation and celebration of "sooners" sits in contrast with the exploitiveness of their actions: the exploitation of the land, their fellow citizens, and the rule of law.

Crucially, the land rush fundamentally overrode the existing rights of indigenous peoples and the nature and wildlife already on the land. Such a combination of climate, industrial resources and poor heritage stewardship reflects some of the complexity and challenges of transitioning to a nature-inclusive economy and the necessity of integrating biodiversity into all our future scenarios.

Just because something is complex doesn't mean that these risks and challenges do not exist. In this paper, we have sought to show there are practical approaches that can be used to develop necessary adjustments and meaningful insights. It is certainly challenging - and will continue to evolve. But we hope this paper provides not only ways forward for developing and applying biodiversity scenarios but also illuminates how the existing work in this space has been helpful for understanding the gaps in climate modelling. We also have outlined ways to understand and use the current biodiversity scenarios, understanding these are, and almost certainly will always be, incomplete.

In summary

Actuaries will need to upskill their capabilities and approaches. They should increase their awareness of the array of modelling approaches and structures, become more fluent with narrative scenarios, and better able to match model approaches to the questions under investigation.

The workshop highlighted the need for greater engagement with narrative approaches, to embrace the complexity of risks and develop a better understanding of their direct impacts, the potential volatility spikes, feedback loops, and broader tipping points. The complexity and interconnections mean that actuaries – and indeed, decision makers more broadly - will need to embrace a broader array of systems-thinking and complex risk analysis tools to understand, navigate and quantify these risks. There is both a need and an opportunity for actuaries and the profession to develop and advocate these skills and approaches.

This paper has been written to summarise the current state of biodiversity scenarios and, more particularly, show how progress can be made. Integrating biodiversity into our scenarios is **challenging, complex, necessary.**

Appendix A: Pre-reading for Workshop attendees

INTRODUCTION TO CLIMATE AND BIODIVERSITY SCENARIO SUMMARIES

For this workshop, we have prepared brief summaries of five scenarios. These should be considered illustrative rather than definitive for the purposes of the workshop. In particular, their relative strengths and weaknesses are areas we hope to explore during the workshop.

The scenarios we have considered are:

Two NGFS (Network for Greening the Financial System) Scenarios

1. Below 2°C
2. Current policy scenarios

Two ECI/GFI Nature Scenarios

3. UK Domestic Scenario
4. AMR Pandemic Scenario

An IPR Scenario

5. IPR FPS+Nature Scenario

Participants are encouraged to use their knowledge to identify potential strengths and weaknesses of these scenarios. Even if an aspect is unclear or absent from the scenarios, feel free to raise it for discussion. We will investigate these areas further and note their importance.

Optional Extra Reading

Whilst these scenario summaries are the only requested reading for the workshop, those interested may wish to read our two earlier blogs:

- Nature-related risks as detrimental as climate risks: Call to action for actuaries
- Environmental risks and biodiversity tipping points

And for a more general overview, the Introduction to Biodiversity for Actuaries and our policy briefing written for the IFoA's Biodiversity policy launch last year:

- Biodiversity and nature-related risks for actuaries: an introduction
- Policy briefing on biodiversity risk and uncertainty

The CGFI paper on Climate Scenario Taxonomies was published after we started work on our summaries, so its framework hasn't been included but may also be of interest:

- https://www.cgfi.ac.uk/2024/10/a-climate-scenario-taxonomy-for-the-financial-sector/

Finally, there are also links to the underlying sources and reports at the end of each scenario. There is also a list of papers that were included in the Risk Alert. These are for reference only and not required reading. [A copy of the IFOA Climate Scenarios Risk Alert was also attached.]

Appendix B: NGFS Climate Scenarios (v5 - November 2024)

Below 2°C and Current Policies Scenarios

B.1 Introduction

The seven NGFS climate scenarios[24] are characterised by varying levels of physical and transition risks, driven by the technological advancements and policy ambition, timing and coordination assumed in each.

They fall into four broad categories – orderly transition, disorderly transition, hot house world, and too little, too late – with transmission channels transmitting climate risks to the economy and financial system:

Scenario categories

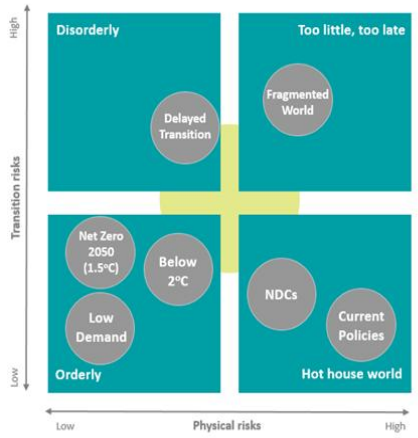


Figure 4. The NGFS scenario framework in Phase V

Transmission channels (climate risks to financial risks)[25]

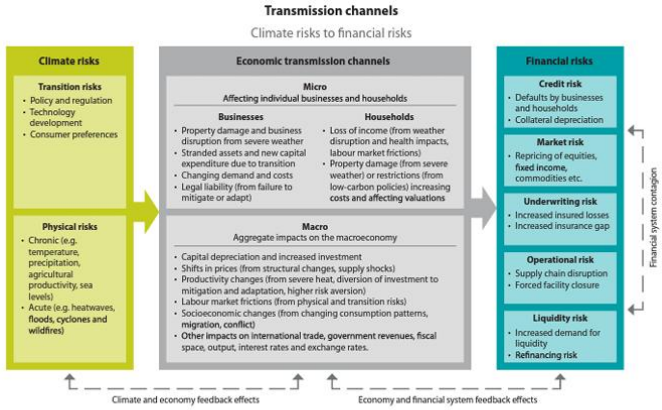


Figure 5. Transmission channels: climate risks to financial risks. Source: NGFS (2022)

The 'Below 2°C' (B2) and 'Current Policies' (CP) NGFS scenarios differ in their key drivers, resulting in different categorisations and projected outcomes:

Scenario	Category	Peak warming by 2100	Physical risk	Transition risk	Policy reaction	Regional policy variation	Technology change	Carbon dioxide removal
Current Policies	**Hot house world**	2.9°C	High	Low	None - current policies	Low	Slow change	Low use
Below 2°C	**Orderly transition**	1.8°C 67% probability	Low-Med	Low-Med	Immediate and smooth	Low	Moderate change	Medium use

24 p17-23, Network for Greening the Financial System (NGFS), 2024. NGFS Climate Scenarios Technical Documentation: Version 5.0 (November 2024). [pdf] Available at: https://www.ngfs.net/system/files/2025-01/NGFS%20Climate%20Scenarios%20Technical%20Documentation.pdf [Accessed 28 July 2025].

25 Ibid.pp.24-26.

B.2 Narrative Overview

INTEGRATED MODELLING APPROACH

For NGFS scenarios including B2 and CP, a combination of models is used to capture climate, macroeconomic, and financial contingencies:

Physical risk models[26] to reflect climate changes in both climate and economic indicators.

Transition risk models to derive the impacts of policy ambitions on the energy sector, emissions, and land use. They include three Integrated Assessment Models (IAMs), specifically **REMINDMAgPIE**, **GCAM** and **MESSAGEix-GLOBIOM.**

Macro-economic model NiGEM to help understand how transition and physical risks impact fundamental macro-financial indicators.

The models used for the NGFS scenarios all have in common a similar modular structure and assumption set, based on the Shared Socio-economic Pathway 2 (SSP2), using harmonised population and economic development trajectories.

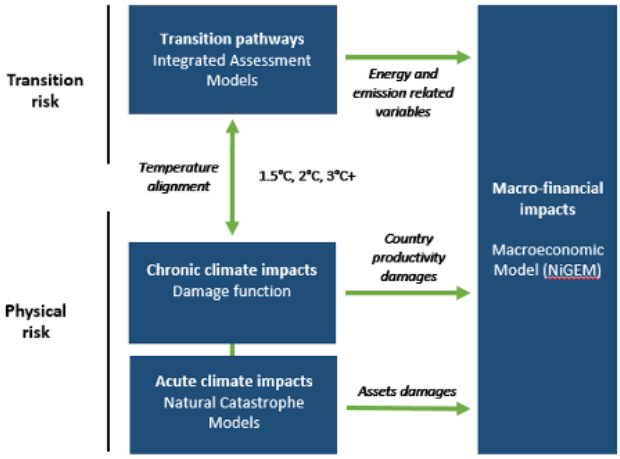


Figure 6. Interactions between the three model categories in the NGFS framework

Likewise, the modelling framework underpinning the IAMs is one of 'general equilibrium' economic model[27] which is based on assumptions such as markets are perfectly competitive, and participants have perfect knowledge, and they optimise behaviour. As a result, the pathways are optimised, e.g. the best way for us to go from present day to net zero.

1. CLIMATE AND ECONOMIC SYSTEM REPRESENTATION

Climate impacts are modelled as 'chronic' and 'acute' physical risks:

- Chronic risk modelling[28] quantifies the effects of changes in climate-related variables (temperature change, annual precipitation, number of wet days, extreme daily rainfall) on

26 Include all models that are participating in the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) 8 and CLIMADA9. Potsdam Institute for Climate Impact Research (PIK) et al., 2025. *ISIMIP (Inter-Sectoral Impact Model Intercomparison Project) data portal*. [online] Available at: https://www.isimip.org/ [Accessed 28 July 2025]; ETH Zurich, 2025. CLIMADA—open-source climate adaptation model. [online] Available at: https://climada.ethz.ch/ [Accessed 28 July 2025].

27 GCAM uses Partial Equilibrium Model. Joint Global Change Research Institute, 2024. *Global Change Analysis Model (GCAM) documentation: Partial-equilibrium energy–land–water system model.* [online] Available at: https://github.com/JGCRI/gcam-core [Accessed 28 July

28 Ibid.p.102.

economic output by using a damage function. The damage function[29] used for the 2024 release of NGFS scenarios projects much higher losses than the previous damage function and captures losses up to 10 years after the initial shock. However, the damage function:

  - does not capture sea level rise, ocean acidification
  - has no allowance for tipping points, such as the AMOC collapse, ice sheet loss, Amazon rainforest dieback, all of which are climatic events with potentially catastrophic impacts
  - does not capture nature-related risks (e.g. biodiversity loss) and non-market risks (e.g. human health impacts) are not explicitly covered
  - fails to account for climate-induced societal impacts such as conflict and migration
  - Chronic physical risks have long term effects; the new damage function captures the persistence effects of climate change up to ten years after the initial impact, and not beyond projection period.
  - While damage projections are now much higher, a global economic recession caused by climate change is not foreseen, even in the worst-case scenario.
- Acute physical climate risk[30] assessments focus on extreme weather events like floods, heatwaves, tropical cyclones, and droughts and their potential increase for a given temperature pathway. Natural catastrophe models used for acute risk are based on extreme events, exposure (i.e. objects exposed to damage such as assets, infrastructures) and vulnerability (i.e. assessing the degree of damage).
- With the use of the more comprehensive damage function, there is a risk of acute risks being implicitly factored in within chronic risks, the NGFS would no longer represent total physical risk damage as the sum of damage function projections and hazard-specific models.
- The NIGEM econometric model uses energy-related and carbon tax inputs from the IAMs and to generate macro-economic series (e.g. inflation, unemployment and house prices) used in financial modelling and analysis.
- The main driver of transition risk is a carbon price – a proxy for all carbon related policies.
- Ecosystem service losses are not directly modelled. Biodiversity is vital to several such services, including natural carbon sinks, pollination, and water purification, which impact net emissions and agriculture.

2. POLICY AND GOVERNANCE FRAMEWORK, ENERGY AND TECHNOLOGY TRANSITIONS

The REMIND-MAgPIE[31] framework is used to explore sustainability-related questions in research and policy, eg: the impact of policy proposals intended to preventing / mitigating climate change, the technologies to use, and the consequences for economic development, air pollution, and land use.

The link to MAGICC[32] model enables analysing the interactions between agriculture, land-use, greenhouse gas emissions, and climate change.

For below 2°C Scenario policy reactions are assumed to be immediate and smooth, with moderate technology change and low variation between regional policies.

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29 Network for Greening the Financial System (NGFS), 2024. Damage functions, NGFS scenarios, and the economic commitment of climate change: An explanatory note. [pdf] Available at: https://www.ngfs.net/sites/default/files/media/2024/11/05/ngfs_scenarios_explanatory_note_on_damage_functions.pdf [Accessed 28 July 2025].

30 Ibid.p.111.

31 Ibid.p.42.

32 MAGICC (Model for the Assessment of Greenhouse Gas Induced Climate Change). This is a climate model, which accounts for changes in climate-related variables like global surface mean temperature.

For Current Policies Scenario it is assumed that there will be no policy reaction, with slow change in technology and low variation between regional policies.

3. SOCIOECONOMIC AND BEHAVIOURAL DYNAMICS (AMOUNT AND KEY FEATURES INCLUDING DIET)

All NGFS scenarios draw their key socio-economic drivers (such as harmonised population and economic developments) from SSP2, which is neither optimistic nor very pessimistic.

The scenarios do not model or directly allow for climate displacement, migration or conflicts. These alter land-use, agriculture, emissions, and biodiversity through displaced humans' actions.

4. INTEGRATED ASSESSMENT OF SUSTAINABLE DEVELOPMENT (NATURE CONSERVATION, BROADER SDGS)

The NGFS scenarios can aid policymakers and other relevant stakeholders evaluate the effectiveness and efficiency of different policy interventions and identify optimal pathways for achieving sustainable development goals.

Chronic physical risk assessments do not include biodiversity and ecosystem impacts.

B.3 Summary of critical analysis/limitations

- Tipping points are not represented in the NGFS Scenarios.
- Biodiversity and ecosystem impacts are not directly captured in chronic physical risk assessments.
- Ecosystem service loss is not directly modelled.
- Human movements caused by climate change are not well represented. Enhancing this may:
  - improve modelling of SDG goal achievement
  - increase usefulness for policy research through better reflecting evolving population-related parameters and resulting impacts over projection timeframes.
- Population migration, biodiversity loss, and climate change all impact each other in feedback loops. In reality these impacts can happen quite rapidly, affecting land use, emissions, agriculture, population locations and density, and economies.
  - Incorporating these feedback loops by dynamic changes to model parameters over projected timeframes may provide useful insight and realism for policies and planning.
- Even with the much more severe damage, the scenarios do not depict de-growth or catastrophic developments. Nor does it closely consider a global financial crisis.
- Economic theory: The modelling framework underpinning the IAMs is one of the 'general equilibrium' economic models, which is based on assumptions such as perfect competition and that participants have perfect knowledge to act. However, this is at odds with empirical evidence from the economy.
  - Furthermore, the transition will require an economy that looks very different to the one we have now. It will not be an economy that is reverting to our current equilibrium.
- Impacts of scenarios are expressed relative to a hypothetical baseline scenario without climate change which makes it difficult to validate.
- NGFS scenarios take a long-term perspective [although since the workshop they have also] developed some short-term NGFS scenarios.

There are extensive further details on the NGFS scenarios, starting at the NGFS Scenarios Portal, https://www.ngfs.net/ngfs-scenarios-portal/.

Appendix C: ECI/GFI UK NATURE-RELATED RISKS

'UK Domestic' and 'AMR-Pandemic' Scenarios(April 2024)

C.1 Introduction

This note is based on the 'Assessing the materiality of nature-related risks for the UK' *report*

The report introduces six innovations to assess the materiality of nature-related financial risks to the UK, with 1, 3, 4 and 5 in the graph below being specifically relevant to scenario development:

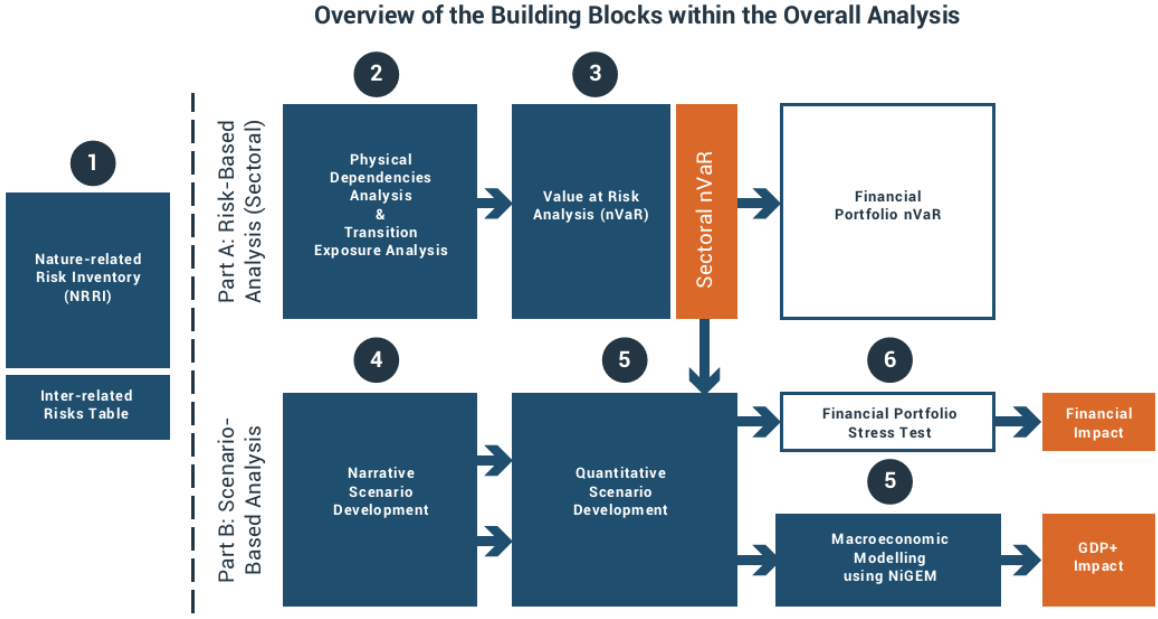


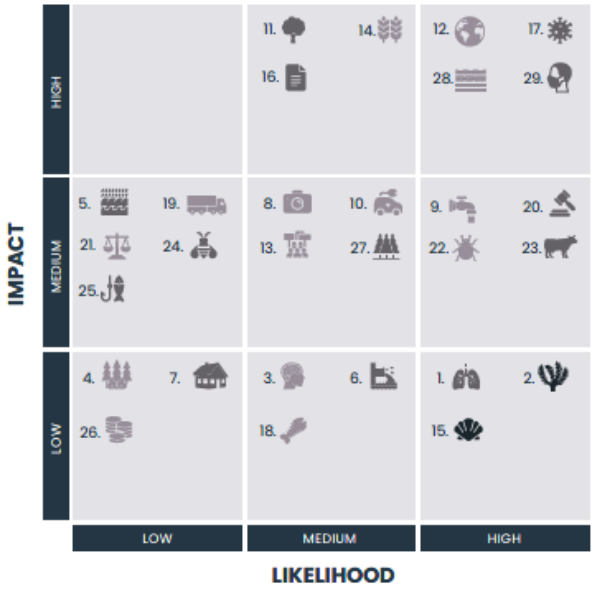
Figure 2: Flow of methodological components of the project.

Building on a literature review and stakeholder discussions, the key criteria for scenario development include: a focus on plausible yet extreme material financial impacts (following IMF guidance for stress-testing) and the inclusion of shocks which could impact the financial system in unexpected ways (where these risks may be overlooked by Central Banks and Supervisors).

All scenarios share a common structure: scenarios are specified over 2023 – 2050 (with a 10-year window of interest between 2025-2035) for the financial scenario analysis application; up to 5 chronic impacts that run continuously from 2023-2050; and two acute impacts that occur in the centre of the window of interest around 2030, designed to represent an event with (very roughly) ~ 1 in 100 annual probability.

These scenarios were developed as part of the Integrating Nature-Climate Scenarios & Analytics for Financial Decision-Making (INCAF) project and are based upon expert consultations and literature reviews conducted over more than eight months (2023-24). The scenario development process comprises five steps, detailed below for the **'Domestic'** and '**Health (AMR-Pandemic)'** scenarios:

The UK nature-related risk inventory (UK-NRRI), step 1 in the figure above and depicted in the figure below), underpins the scenario development:



Mainly Domestic

1. Air pollution from wildfires
2. Algal blooms in water ecosystems
3. Biodiversity access and mental health
4. Direct damage from wildfire
5. Flooding due to deforestation and soil damage
6. Freshwater pollution
7. Housing asset risks due to policy and legal changes
8. Risks to tourism from nature damage
9. Water shortages impact energy and agriculture

Mainly International

10. Critical resource supply chain disruption
11. Deforestation and ecosystem tipping points
12. Global food security repercussions
13. Global food supply chain interruption from biodiversity and climate policy misalignment
14. Multiple breadbasket failure
15. Ocean acidification

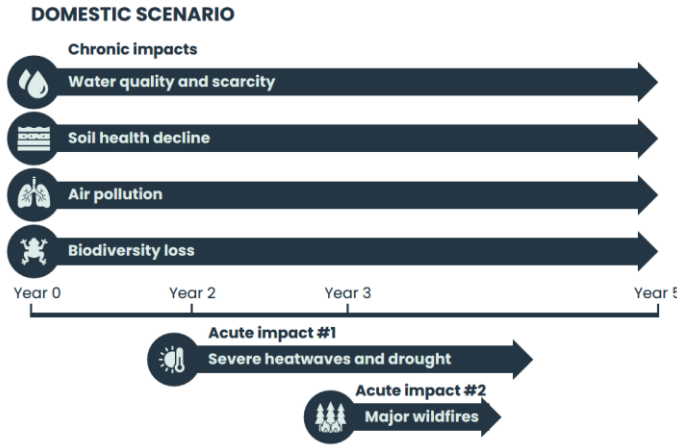
Domestic and International

16. Acceleration of strict net zero and nature protection policies
17. Anti-microbial resistance
18. Aquaculture major pest or pathogen outbreak
19. Business impacts due to UK-only biodiversity policies
20. Corporate litigation cases
21. Government litigation cases
22. Grain crops pest / pathogen outbreak
23. Livestock disease
24. Loss of pollination service
25. North Sea fishery collapse
26. Reputational risk, stranded assets and fund withdrawal
27. Sitka spruce pest outbreak
28. Soil health decline
29. Zoonotic disease

Figure 1.3: The estimated likelihood and impact of NATURE-RELATED RISKS to the UK economy and financial system up to 2050. Scores were derived from an expert elicitation process with mean scores shown (also see Table 1.1). Confidence in scores is indicated by the colour of the risk symbol with darker shading indicating higher confidence. Risks numbered 7, 13, 16, 19 & 26 are transition risks, 20-21 are litigation risks, all others are physical risks.

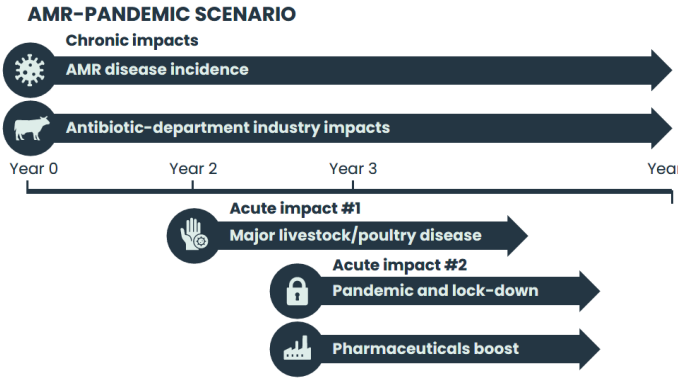
C.2 Narrative overview

Following step 4, the figures below show the 'Domestic' and 'Health (AMR-pandemic)' scenario schematics:



Chronic impacts: resulting from a long-term baseline decline in environmental quality including water quality and quantity, soil health, air quality and biodiversity loss in the UK.

Acute impacts: In 2030, an acute event of extended heatwaves and droughts further exacerbates health impacts from air pollution, reduces agricultural productivity and water availability in the UK. In 2031, an acute event of major wildfires occurs in the UK leading to major impacts on air pollution, disruption of transport and capital damage.



Chronic impacts: including a rise in AMR leading to a global increase in infectious diseases which spread more easily and are more difficult to treat, resulting in significant increases in morbidity and fatalities. This is accompanied by widespread antibiotic-dependent industry impacts, primarily affecting the agricultural sector, which is globally reliant on antibiotics through their use in intensive livestock farming, in addition to broader economic impacts such as a decline in labour availability and productivity (with a concomitant impact on global trade) and increased public health expenditure.

Acute impacts: taking the form of the emergence of a major disease which causes a reduction in poultry and livestock production (accompanied by the widespread collapse of agricultural SMEs), which then transfers into human populations, causing a global human pandemic on a similar scale or greater to that of Covid-19, with comparable economic impacts and a slower pace of recovery due to compounded effects (albeit a boost to certain sectors such as the pharmaceutical industry). The stacked components of impacts for the scenarios are included below:

'Domestic' chronic	'Domestic' acute	'Health' chronic	'Health' acute
Water quality and scarcity impacts on agriculture and energy generation	Amplified impacts of water and air related to heatwave and wildfire	Labour force impacts of higher mortality and morbidity	Major livestock and poultry disease outbreaks lead to fall in trade shares
Soil health decline impacts agriculture	Labour impacts increase due to heat and air pollution from wildfire	Increased public expenditure on public health to combat disease	AMR-driven pandemic leads to economic shutdown a la Covid reducing productivity and household consumption and increasing non-commodity prices
Agricultural supply shock impacts prices	Amplified agricultural supply shock	Fall in export shared of advanced economies due to production decline	
Increases in health expenditure due to air pollution and loss of recreation	Water constraints lead to price shock and public expenditure		
Labour productivity impacts of pollution and biodiversity loss	Increased risk premia due to disasters		

NOTE: Except where stated otherwise, the rest of this note is applicable to both scenarios.

1. CLIMATE & ECONOMIC SYSTEM REPRESENTATION

This is based on the “Too Little, Too Late” world (2°C vs pre-industrial of warming by 2050).

The quantitative scenario modelling was done using the NiGEM model, in close collaboration with the National Institute of Social and Economic Research (NIESR). The translation of the qualitative scenarios into a set of quantitative inputs into the NiGEM has two components: the sector-specific impact pathways and the secondary macroeconomic impact assumptions.

2. POLICY AND GOVERNANCE FRAMEWORK, ENERGY AND TECHNOLOGY TRANSITIONS

Whilst Global Biodiversity Framework is agreed, progress on protection and restoration is slowed by a continued failure to address the key underlying socioeconomic drivers of the erosion of natural capital and biodiversity and aggravating impact from climate change.

Thus, physical risks from climate change and biodiversity are very high whilst transition risks are low.

3. SOCIOECONOMIC AND BEHAVIOURAL DYNAMICS (AMOUNT AND KEY FEATURES INCLUDING DIET)

The outcomes of the scenarios demonstrate that nature-related risks can impact metrics of wider macroeconomic performance, including interest rates, unemployment, prices, public-sector finances, inflation and the current account balance.

4. INTEGRATED ASSESSMENT OF SUSTAINABLE DEVELOPMENT (NATURE CONSERVATION, BROADER SDGS)

The study recognised limitations of its modelling, especially across several systemic risks(see note below).

C.3 Summary of critical analysis/limitations

- Current output and data seem to be restricted to key items in the report rather than a usable data set, necessitating adaptation and custom coding for each specific application.
- The approach introduces a broader array of innovations and developments to create these scenarios. These overcome some of the core issues in data gaps and IAM modelling but generate challenges and limitations in their own right.
- Limitations of the innovations include novelty (a lack of extensive testing), the overcoming of nature-related risk data and analysis gaps, reliance on expert judgement and in particular, in the pruning and prioritisation of financially analysable scenarios.
- Scenarios are chosen based on criteria of “plausible yet extreme” financial impacts and unexpected systemic impacts, aiming for diversity across the three main scenarios rather than focusing solely on most-likely or norm-based outcomes[33].
- A single set of climate scenarios has been used with limited consideration of transition risks and a primary focus on projections up to 2035, relying on NiGEM for economic forecasting.
- No significant investigation of societal behavioural shifts which may mitigate impacts.

33 By design, the study was focused on explorative and not normative scenarios “developing an approach to design scenarios relevant for macro-prudential and micro-prudential policymaking on nature-related risks”. Following a literature review, its central design principle is consistent with IMF (2019): scenarios for bank stress testing should be “forward-looking, severe, consistent, and robust trajectories for a comprehensive set of macro-financial variables that react following the materialization of shocks… Scenario design starts with a narrative about how the realization of tail risks could interact with financial vulnerabilities to generate severe but plausible macro-financial impact”.
Adrian, T., 2019. Stress-testing for the transition to a low-carbon economy. Speech, Joint Workshop by the IMF and De Nederlandsche Bank on Stress-Testing for Climate-Related Risks, Washington DC, 10 April 2019. [online] Washington DC: International Monetary Fund. Available at: https://www.imf.org/en/News/Articles/2019/04/10/sp04102019-stress-testing-for-the-transition-to-a-low-carbon-economy [Accessed 28 July 2025].

- No allowance for broader chronic impacts, especially those from an international perspective – fisheries, pollinators, breadbasket failures, and geopolitical instability (these are included in the study's "International" scenario).
- No direct allowance for climate/biosphere tipping points outside UK analysis (SPG, AMOC etc) nor societal tipping point such as mass-migration albeit supporting evidence includes references to migration and Amazon dieback. AMR pandemic, and other stresses are considered separately in the UK domestic and international scenarios.
- The study goes further than previous studies in incorporating compounding, cascading impacts of nature and climate change. However, it recognises it is not possible to anticipate and incorporate all the risks especially indirect pathways involving social, cultural or political processes. It give examples of potential underestimation of systemic risks including Agricultural SMEs, NHS overwhelmed, tourism and housing impacts, mental health impacts, domestic/international civil unrest, nor flood/weather insurance impacts.
- There didn't seem to be a significant discussion on land-use change, with tensions between food systems and nature restoration efforts.

These scenario summaries are derived from Green Finance Institute (2024) 'Assessing the materiality of nature-related financial risks for the UK', available at: https://hive.greenfinanceinstitute.com/gfihive/insight/assessing-the-materiality-of-nature-related-financial-risks-for-the-uk/

Appendix D: Inevitable Policy Response

Forecast Policy Scenario + Nature (FPS+Nature)

D.1 Introduction

The Inevitable Policy Response (IPR), commissioned in 2018 by the Principles of Responsible Investment (PRI), is a climate forecasting consortium focused on developing realistic, conviction-based forecasts as to the speed and scale of the transition to net zero.

IPR produces an annual Climate Policy Forecast covering +300 high-conviction policy forecasts across 21 countries and 10 policy areas across energy and land use, which are reviewed on a quarterly basis. Policy forecasts are fed into a fully integrated climate and nature scenario model that elicits the impact of the forecasted policies on the energy, land use, and nature systems up to 2050, tracing detailed effects on the macroeconomy and emitting sectors like energy, transport and agriculture. This scenario, or IPR's Forecast Policy Scenario (FPS), based on a high-conviction policy-based forecast and not a temperature-optimised hypothetical, forecasts peak temperatures of 1.7-1.8°C around 2050.

In 2023, FPS expanded to FPS+Nature, integrating nature-related policies, with a focus on land use change, a primary driver of nature loss. This "beta" scenario underscores agriculture's significant role in tropical deforestation, influencing land conversion impacts.

Out of scope:

- FPS+Nature does not capture nature physical risk such as loss of ecosystem services e.g. pollination, changes in soil quality.
- Nor does it capture policies regulating marine and freshwater, pollutants in agriculture and invasive species.
- Acute physical risk is held constant (no change from historic impact of extreme weather on crop yields).

D.2 Key features

Narrative Overview

The FPS scenario leverages an integrated modelling framework which draws on models which have been extensively used to study global decarbonisation:

Model	Description	Key Features
G-Cubed	A macroeconomics intertemporal general equilibrium model of the global economy. The version used for the IPR project, G-Cubed, has been developed at the Australian national University	It includes the monetary side of the economy, allowing simulations of exchange rates, nominal interest rates, and financial flows over time across regions The model incorporates features of neo-Keynesian models allowing for short-term wage rigidities

TIAM-Grantham	A version of the ESTAP-TIAM model, a global energy system model developed by the Energy Technology Systems Analysis Programme (ESTAP). The version used for the IPR project is run by Imperial College London	The TIAM-Grantham model covers the full energy chain from extraction of energy resources (e.g. coal mining) through conversion (e.g. electricity generation or oil refining) and to final use to provide an 'energy service' to the end-user (e.g. heating or lighting in a building; mobility etc,)
MAgPIE	The Model of Agricultural Production and its Impact on the Environment (MAgPIE) is a global land use allocation model. It has been developed by the Potsdam Institute for Climate Impact Research [model diagram below]	MAgPIE is a spatially explicit partial equilibrium model, in which food demand is estimated using population, GDP, dietary assumptions, and demand elasticities from the GTAP database. The model then determines the least cost way to meet that food demand, while accounting for biophysical constraints including those on land and water, as well as potential crop yields. Biophysical limits are estimated in LPJmL, a separate PIK model that translates climate projections from global climate models into physical constraints relevant for agriculture[34].

Source: page 114, The Inevitable Policy Response: Forecast Policy Scenario (FPS)

Broadly, the approach integrates region-specific changes in commodity prices and provides geographically granular value drivers that consider both nature and climate impacts on commodities up to 2050. The MAgPIE model, starting from a 1995 base year, calibrates inputs like population density, GDP, food energy demand, and production costs. It accounts for biophysical constraints on land, climate, soil properties, freshwater access, and crop yields through data from the GTAP database. The model finds a least-cost pathway to meet food demand based on these constraints, using outputs from LPJmL to incorporate climate projections and physical limits for agriculture. While it's optimised for efficiency, this approach implies a gradual, shock-resistant transition, lacking abrupt changes or shocks.

1. Climate system representation

The FPS+Nature scenario builds upon the IPR's forecast which is described as IPR's most likely scenario.

- Acute physical risk is held constant (no change from historic impact of extreme weather on crop yields).
- It does not estimate nature-related physical risk such as loss of ecosystem services e.g. pollination, changes in soil quality.
- When considering impacts that are captured in the MAgPIE model, the approach captures some dynamics of chronic (climatic) physical risk including changes in average temperatures and average precipitation via the LPJmL dynamic global vegetation model.

The FPS+Nature scenario evaluates biodiversity/nature loss according to the Biodiversity Intactness Index (BII) metric, which assesses the average abundance of native terrestrial species in comparison to their abundance in the absence of pronounced human impact.

34 **Principles for Responsible Investment (PRI)**, 2021. *Inevitable Policy Response: Scenario Models*. [pdf] Available at: https://www.unpri.org/download?ac=16122 [Accessed 28 July 2025].

2. Policy and governance framework, energy and technology transition

The Policy and Governance Framework for FPS+Nature emphasises targeted policies that serve the dual aim of reducing biodiversity loss, and often reducing or offsetting carbon emissions. These policies focus on the land use sector, the largest contributor to global biodiversity decline.

Policies are split into key nature policy areas such as protected areas, land restoration, nature markets (e.g. voluntary biodiversity credits), climate policy (building on FPS), and interrelated impacts. These policies are extensions of identified policies within a handful of geographies, to more markets and in some cases with greater policy ambition as nature linked policies are expected to develop and mature over time.

The Energy and Technology Transition within FPS+Nature, modelled by ESTAP-TIAM, supports a shift toward clean energy technologies while supporting sustainable land use. Key elements include:

- Bioenergy development: Support for second-generation bioenergy though R&D and regulations to advance decarbonisation
- Full Energy Chain Coverage: ESTA-TIAM models everything from resource extraction to end user energy services, therefore each step of the energy value chain can be modelled and understood relative to biodiversity and climate targets
- Economic Viability: Integration with G-Cubed macroeconomic forecasts ensures consistency between economic activity/investment with energy extraction and demand over time.

3. Socioeconomic and behavioural dynamics

In the FPS+Nature scenario, socioeconomic and behavioural dynamics shift due to policies that influence consumer and firm behaviour. The G-Cubed model represents households and firms with two agent types: forward-looking and rule-based. Households balance lifetime budgets, optimizing savings and spending, while firms make long-term investment decisions. Policy incentives, such as taxes on high-impact goods or subsidies for sustainable practices, influence these agents differently, encouraging shifts in behaviour with different impacts on climate, nature, and economic activity.

The MAgPIE model relies on a set of socioeconomic assumptions including trends in income, demographics as well as trade liberalisation and diet shifts[35]. These assumptions come from the effects of the chosen policies and their outcomes within the context of the G-Cubed model environment, in addition to starting assumptions around population and GDP growth based on official sources and national statistics[36].

4. Integrated assessment of sustainable development

The FPS+Nature scenario models market and policy trends across 18 global regions and countries, providing a comprehensive, regionalised view. While the model explicitly addresses different global regions, it does not directly incorporate specific regional development goals or trajectories beyond the policies implemented within each area. Some of these policies align with sustainable development goals, indirectly supporting their attainment. However, the scenario lacks explicit consideration of income distribution or equity-focused social policies within countries, which limits a full assessment of sustainable development impacts at the regional level.

35 Ibid, Page 7

36 Page 30, **National Institute of Economic and Social Research (NIESR)**, 2023. *NiGEM Model Manual*. [pdf] Available at: https://www.niesr.ac.uk/wp-content/uploads/2023/11/NiGEM-Manual-2023.pdf [Accessed 28 July 2025].

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