



# Act now, save later

## Scenarios of the economic consequences of (in)action on biodiversity in Scotland

Alys Daniels-Creasey<sup>1</sup>, Marc Metzger<sup>1</sup>, Julia Clough<sup>2</sup> and Bruce Wilson<sup>2</sup>

1. Centre for Sustainable Forests and Landscapes, The University of Edinburgh
2. Scottish Wildlife Trust



THE UNIVERSITY  
*of* EDINBURGH

# Report overview and acknowledgements

This report explores two possible futures for Scotland following different pathways of (in)action on biodiversity, based on information discussed within a scenario workshop with stakeholders working in the fields of economics, biodiversity and wider environmental issues. While the report does not provide an economic analysis, the scenarios derived from the workshop and further evidence gathered through desk-based research build a picture of the economic consequences of biodiversity loss for Scotland.

**Part 1** outlines the two potential futures for Scotland which arose from the scenario workshop. Background information, including research methodology and information on drivers of biodiversity loss, impacts and costs of such losses, can be found in **Part 2**. For the full-length scenario narratives, please see **Part 3**.

The underpinning research was carried out by Alys Daniels-Creasey as a 20-day Earth Fellowship through the Edinburgh Earth Initiative, supported by Marc Metzger, Julia Clough and Bruce Wilson and funded by the Scottish Wildlife Trust.

## Acknowledgements

This project would not have been possible without the enthusiastic participation of all workshop attendees; many thanks for their time and valuable contributions to this work.

## Suggested citation

Daniels-Creasey A., Metzger M., Clough J, and Wilson B., 2024. Act now, save later: Scenarios of the economic consequences of (in)action on biodiversity in Scotland. CSFL report, The University of Edinburgh. <http://dx.doi.org/10.7488/era/5061>

## Table of Contents

Foreword .....	4
<b>Part 1: The economic consequences of (in)action on biodiversity for Scotland's future ..</b>	<b>6</b>
1.1 Definitions and scenarios .....	7
1.2 Exploring the scenarios .....	9
1.3 Economic consequences snapshots .....	12
1.4 What does this mean for Scotland? .....	20
1.5 Lessons learned .....	25
<b>Part 2: Background and methodology .....</b>	<b>26</b>
2.1 Project context.....	27
2.2 Defining biodiversity .....	28
2.3 Biodiversity loss .....	30
2.4 Impacts of biodiversity loss .....	32
2.5 Methodology .....	36
<b>Part 3: Narratives of the future.....</b>	<b>39</b>
3.1 Narratives of the future .....	40
References .....	44
Appendix 1: Workshop prompts.....	52
Appendix 2: Workshop materials from each group .....	55

## List of Figures and Tables

Table 1: Comparing scenarios .....	11
Table 2: Summary of economic snapshots.....	19
Figure 1: Ecosystem services land wheel .....	29
Figure 2: IPBES drivers of biodiversity loss .....	30
Figure 3: The role of biodiversity in global change .....	32
Figure 4: The interconnection of global risks .....	33
Table 3: Estimated economic costs related to ecosystem services .....	34
Figure 5: What are scenarios? .....	37

## Foreword

It's 2045; what can you see, hear, feel? Maybe you're somewhere in the Highlands, breathing in the earthy dampness of nearby peatland. Perhaps you're in the buzz of a crowd in one of Scotland's cities, waiting in the shade of a tree for a bus. Or maybe you're looking out to sea from one of the islands, feeling the wind burn your cheeks and watching seabirds divebomb for fish. Wherever you are, your present experiences have been partially decided by those in the past...

It's 2024; Scotland's future isn't set. Much of what we will see across rural and urban landscapes in two decades' time (and beyond) relies on what actions we might, or might not, take now for biodiversity. Like the rest of the world, Scotland depends on its biodiversity: nature is our life support system. From the pollinators that ensure productive crop yields, to the healthy riverbanks that protect us from flooding, protecting and restoring biodiversity is vital to ensure future generations can thrive, not just survive.

Environmentalists often stress urgency, and rightly so; without immediate action, we risk reaching irreversible ecological and climate tipping points. Yet environmental arguments alone have fallen short of generating the action needed. Could greater awareness of the social and economic impacts of biodiversity loss prompt wider demands for action across society?

We hope this report highlights that action to recover biodiversity has far-reaching benefits beyond the initial intervention, that the positive effects of investing in nature *now* multiply the benefits over time. From the Scottish Wildlife Trust's perspective, this report adds three key points to the debate around the cost of inaction:

1. **Interconnectedness** - biodiversity is crucial for social, economic and environmental stability; all are deeply interlinked. Complex and entangled with all other aspects of life, its decline will affect us all and must be addressed collaboratively. People from all sectors and communities are affected, and a diversity of voices need to be included.
2. **Resilience** - early action enhances resilience, supporting food security, health and economic stability. While consideration of the economic and political costs and benefits inevitably dominate these discussions, a much larger backdrop of the social, health and environmental impact is in play.
3. **Momentum** - acting now on biodiversity initiates a positive feedback loop, amplifying economic and social benefits while unlocking future opportunities for growth. By acting promptly, we minimise long-term costs and preserve the ability to make decisions later. The earlier we act, the greater our capacity to shape a sustainable and resilient future.

Put simply, taking action now is more cost-effective, straightforward and impactful, enabling us to thrive in the future rather than merely struggle to survive.

# Act now, save later

Why investment in nature makes economic sense

## Without investment

## With investment



**Flooding and extreme heat**  
make life difficult for people in towns and cities.



Nature-based solutions are creating **safer and healthier places** for people and wildlife to live.



People leave school **ill-equipped** to deal with our environmental challenges.




Good quality nature education means more people can pursue **green jobs**




Food prices are more **volatile** because of our reliance on imports from other countries.



**Food prices increase** because crops must be pollinated by hand.



Thriving and well-monitored insect populations continue to **pollinate crops** with minimum intervention required.



**Food prices are lower** and more stable.



There is a **huge decline in wildlife** such as Scotland's much-loved red squirrels.



Red squirrels, along with other native plants and animals, are **thriving**



Lack of contact with nature **increases physical and mental health issues** increasing costs to the NHS.



**Nature-rich urban greenspaces boost wellbeing** and provide highly cost-effective social, environmental and economic benefits.



Scotland's iconic whisky industry is hit by **drought events** reducing its economic and cultural significance.



Whisky remains a major export and tourist attraction, with **healthy pollinator populations** ensuring good barley production and **healthy river systems** providing good-quality water.



Degraded peatlands continue to emit carbon dioxide **making climate change worse**.



Restored peatlands **capture and store carbon** helping the fight against climate change.



Fewer tourists visit Scotland for its natural environment, putting **rural jobs at risk**



**Ecotourism** **increases**, providing jobs and a boost to rural communities.

## Part 1

# The economic consequences of (in)action on biodiversity for Scotland's future

*Part 1 outlines and explores the two potential futures for Scotland which arose from the scenario workshop. It also provides snapshots of the economic consequences of both scenarios.*

# 1.1 Definitions and scenarios

## Biodiversity: the foundation of life

Biodiversity refers to both the variety of life and the variety of functions that can be found within and across species and ecosystems (IPBES, 2019). Biodiversity is crucial for sustaining humanity's economic, cultural, spiritual and social wellbeing (Sumaila et al., 2017), and underpins many, if not all, of the benefits humans gain from nature – often called ecosystem services (NatureScot, 2023).

Renowned for its sheer number of species and complex patchwork of rich habitats, Scotland, like elsewhere, is facing devastating biodiversity decline (NatureScot, 2023; State of Nature, 2023). Facing a future of potentially devastating biodiversity loss, the nation has difficult cost-benefit decisions to make regarding (in)action on biodiversity. We are at a crossroads: we can decide to take action on biodiversity loss now, or delay action in the hope we can address the consequences of biodiversity loss later. These pathways will result in very different environmental, social and economic futures.

## Scotland's future: two scenarios

By 2045, under a **delayed-action scenario** in which no further significant actions, policies or funding are dedicated to halting/reversing biodiversity loss, Scotland could look rather different to today. Having suffered two further decades of environmental decline, Scotland is likely to be struggling: the economy is declining; there are uncertainties around food production and prices are rising; rural areas face depopulation; social inequalities are worsening; and Scotland's reputation as a potential environmental leader is damaged.

Alternatively, Scotland could follow a **taking-action scenario**, in which there is not just a strategy to stop biodiversity loss, but new actions, policies and funding to enable significant leaps in making such strategy a delivered reality. By 2045, Scotland could be on a path to nature recovery, supporting the rest of society to thrive. In this scenario, as a nation, Scotland accommodates actors and industries that understand, value and respect the importance of biodiversity. It upholds a sustainable economy operating within the bounds of a healthy environment, and offers viable economic and environmental futures for all communities.

Comparing these scenarios, it is tricky to provide a full picture, as biodiversity loss is so all-encompassing and complex, and the economy is entwined with all parts of life. But we provide economic snapshots to illustrate some of the more tangible consequences, from the impacts faced by the whisky and ecotourism industries to the knock-on effects seen within essential and public services, such as food production and the NHS.

## What does this mean for Scotland?

We identified five key messages from the scenarios and snapshots within this report:

1. Biodiversity is complex and entangled with all other aspects of life; its decline will affect us all and must be addressed.
2. Immediate action is needed: it will cost much less than if we wait and keeps future options open.
3. Consideration of the economic costs and benefits is imperative within these discussions, but social, political, and environmental aspects must not be sidelined; holistic thinking is necessary.
4. Justice must be central when choosing pathways forward and innovating solutions, considering all people in all contexts.
5. All sectors and actors have a part to play in imagining the future we want to see – ongoing, inclusive collaboration is needed to ensure actions remain relevant and grounded.

As an expansive topic that can be approached in many ways, on many scales and via many perspectives, it is impossible for this report to cover all aspects of biodiversity loss and dissect the many related societal implications in any great depth within the constraints of a 20-day project. Yet, our work demonstrates how creative, collaborative, bigger-picture forward thinking can enrich discussions about Scotland's future. The hope is that this brings attention to the swathes of literature, reports, evidence and experiences which speak to the urgent need for actions that address biodiversity loss both globally and in Scotland, and touch on the concerns that waiting too long to act will cost us; not just in terms of accumulating greater environmental damage and decline, which will need to be faced, but financially too.



## 1.2 Exploring the scenarios

The choices we make now will impact the future of the country. There are many factors that will play into what this future may look like, meaning a whole range of outcomes is possible. To simplify things, this report aims to bring creative, bigger-picture thinking to two possible futures: delaying action, and taking action, on biodiversity loss.

### Delayed-action scenario

*Policies and action to restore biodiversity are not a priority for the Scottish Government, no further significant policies and actions are implemented, and public sector funding for nature remains at current levels.*

Nature is struggling and, because everything relies on it, many other aspects of society are struggling too. The economy is declining, and the nation is scrambling to fund innovations which replace the things that nature used to do for us. Certain industries are being hit particularly hard: the lack of pollinators is wreaking havoc on the agricultural sector and a degraded environment has put off potential tourists. Rural and island communities face continued depopulation as opportunities diminish, whilst urban areas are increasingly ill-equipped for flooding and extreme heat events. All sorts of inequalities are worsening, and the population is growing increasingly anxious about the uncertain future ahead. Scotland's reputation as a breathtaking landscape and potential to be a global leader on biodiversity has been lost.

### Taking-action scenario

*A Scotland in which policy and actions to restore biodiversity are a Scottish Government priority, new significant policies and actions are implemented, and public sector funding for nature is increased.*

Nature is recovering, which is helping many other parts of society to thrive. All sectors, industries, and individuals understand the importance of biodiversity, and their actions reflect this. Scotland's economic success is no longer measured by GDP but by how well a healthy economy can exist within a healthy environment. We live in a food secure nation underpinned by sustainable practices. Rural and urban communities alike have viable economic and environmental futures with nature-based solutions in place to boost climate resilience, opportunities for community-led ecotourism flourishing, and holistic decisions being made around multi-purpose land use changes. Inequality gaps are lessening; a Just Transition is in full swing.

## Comparing the scenarios

	<b>Delayed-action scenario</b>	<b>Taking-action scenario</b>
<b>Economy</b>	Nature cannot be relied on as before to support a robust economy; job losses, declining investments, and losses of certain exports and industries are hitting hard. More money is needed to fund innovations to replace things nature used to do for us. Insurance costs are higher as claims are more likely. Rural economies are suffering from lost opportunities.	The success of the economy is no longer measured by GDP but by how well a healthy economy is functioning within the bounds of a healthy environment. Nature is not seen as an infinite resource and the true value of nature is reflected in new regulations, subsidies, taxations, policies, and economic decisions.
<b>Politics</b>	Scotland's reputation is damaged: the country is no longer seen as an attractive tourist destination and is not recognised as a global leader championing biodiversity and the climate. Social inequalities are exacerbated as impacts are felt unequally and political instability is growing.	Scotland can be proud of its biodiversity actions and benefits from an international reputation boost as others look to the nation as a positive example. Social inequalities have reduced as people have access to viable economic and environmental futures and feel some stability.
<b>Health + social aspects</b>	The burden on the NHS is huge, as costs associated with treating physical and mental wellbeing soar. Access to green space is limited. Anxiety amongst the population about our collective future is swelling. In everyday life, people are facing higher costs for food, insurance, health-related issues, and more.	All people feel more connected to nature, regardless of whether they live in the city or countryside. The mental and physical wellbeing of the nation is improving as a result; NHS costs have decreased.
<b>Environment</b>	The quality of water, soil, air and other ecological systems has declined; many habitats have suffered further degradation. Nature is less resilient to extreme weather and climate change events.	Scotland is no longer one of the most nature-depleted countries in the world. Habitats have been restored and are bursting with rich wildlife. This bolstered environment is more resilient to climate change and more able to support life to thrive.
<b>Species</b>	Many species have disappeared, or are endangered, and there is an increase in invasive species causing issues for climate regulation, disease control, agriculture, and beyond. A lack of monitoring means we are unable to prioritise preventative actions and must rely on responsive actions which cost more or come too late.	Species' numbers have stabilised and, in some cases where populations were dangerously low before, have started to increase again. Invasive species are effectively controlled and managed, with good surveillance data available to make informed decisions around what proactive, preventative measures to take.
<b>Agriculture</b>	This hugely significant industry has been hit hard: more pesticides and chemicals are needed to maintain yields as pollinators decline and damage from pests increases. Food costs are higher and we have to rely more on imports, making prices/availability vulnerable to externalities.	Sustainable practices are widespread with subsidies in place to support these. Pollinators are flourishing and Scotland is a food secure nation, less reliant on imports. Agricultural jobs are secure, and food prices are stable.

<b>Tourism</b>	Fewer people are keen to visit Scotland, as the draw of its natural environment has diminished. The opportunities to benefit from ecotourism have been lost and local economies are losing out.	People are drawn to the conserved and restored landscapes of Scotland known across the world for their rich habitats and biodiversity. New ecotourism opportunities have been developed, supporting local economies to thrive.
<b>Rural and island communities</b>	These communities face continued depopulation as economic options become limited and opportunities for ecotourism were never seized.	Employment opportunities are plentiful in rural and island areas and people are choosing to stay in, or move to, these places. A community-led ecotourism industry thrives, and supports local economies.
<b>Urban communities</b>	City infrastructure is not able to deal with increased flooding and heat events.	Nature-based infrastructure in cities is well-equipped to cope with extremes in weather and climate change events.

*Table 1: Comparing scenarios*

## 1.3 Economic consequences snapshots

The economic consequences of biodiversity loss are wide and far reaching. To illustrate this array, this section of the report provides just a handful of snapshots of industries and aspects of society that face financial costs in relation to biodiversity (in)action. These snapshots are developed from examples offered by workshop participants and have been expanded here through desk-based research.

### Scotch whisky: an industry drying up?

The whisky industry is not just an important piece of Scottish cultural heritage (National Trust for Scotland, 2024), but creates notable revenue for the country, estimated in 2022 at £7.1 billion in gross value added to the UK economy annually (Scotch Whisky Association, 2024). It is seen as both a visitor attraction significant for encouraging tourism and a vehicle for job creation, with more than 10,000 people directly employed in the industry (Spracklen, 2014; Anstruther and Stewart, 2022). It is also a big export, adding over £5 billion per year to the UK economy and accounting for over one fifth of all exported UK food and drink (Anstruther and Stewart, 2022) and 74% of all such Scottish exports (Scotch Whisky Association, 2024).

To make whisky, you need cereal crops, yeast, and a good quantity and quality of water (Scotch Whisky Association, 2024; Visser-Quinn et al., 2021). Around 90% of barley requirements of the industry are sourced in Scotland (Scotch Whisky Association, 2024) and the whisky industry is one of the four main sectors (excluding public water supply) that uses water from Scottish rivers (mainly located in the Highlands) (Visser-Quinn et al., 2021). As such, biodiversity loss impacts to the provisioning of both barley and water in Scotland (e.g. through reduced crop yields, unpredictable weather, polluted waterways, etc.) have the potential to be detrimental to the whisky industry and could cost the economy dearly. Impacts of climate change on the Scotch whisky industry have been detailed recently (Roberts and Maslin, 2021), such as drought events halting production, although the impacts of biodiversity loss more directly are less reported. What is abundantly clear, though, is that ensuring reliable crop yields and high-quality water supplies are essential activities in protecting the multi-billion-pound Scotch whisky industry – and conserving biodiversity is key to these activities, through the protection of pollinators and waterways.

### Fighting the current: invasive riparian plant species

Watercourses are a fundamental feature of Scotland's landscape, culture, and society, playing a key role in supporting the economic, environmental, and recreational wealth and health of the nation through providing food and water, corridors between habitats for biodiversity, a site for outdoor activities, a source for industries and tourism, and a draw for artistic inspiration, among other things (Horrill, Oliver and Partridge, 2019). However, some of these benefits can become inhibited by the risk of invasive alien plant species and be costly to deal with due to: direct

management costs associated with prevention, control, research, and publicity; direct production losses due to decreased yields, increased pest damage, reduced recreational activity and increased erosion; and indirect costs linked to losses to other sectors like higher prices and increased flooding (Williams et al., 2010). In 2010, the total annual costs of invasive non-native species to biodiversity in Scotland were estimated at £5.8 million (*ibid.*).

Watercourses are a particularly vulnerable habitat to the spread and damage of invasive plant species as they can crowd riverbanks and alter wider habitat health and functioning by limiting the growth of native plants and contributing to erosion, among other impacts (Scottish Invasive Species Initiative, 2024; Horrill, Oliver and Partridge, 2019; Williams et al., 2010). Giant hogweed, Japanese knotweed, and Himalayan balsam are all marked as high-impact species for waterbodies and/or biodiversity, with the latter species found by one study engaged with 10 river trusts attempting to treat plant invasions to be the most challenging infestation to deal with (Horrill, Oliver and Partridge, 2019). Over a decade ago, the annual cost of controlling Japanese knotweed in riparian habitats in Scotland was approximated at £1.7 million (Williams et al., 2010).

The establishment of various initiatives to fight invasive species in the late 2000s and the commitment to “*Implement the Scottish Plan for INNS Surveillance, Prevention and Control*” in the draft Strategic Framework for Biodiversity indicates the state-level recognition that this is a major threat to aspects of the country’s ecological and socioeconomic wellbeing, with management actions already being taken to address various alien plants. Whilst the costs associated with this are sizeable, the possible future impacts of riparian zones being overtaken by alien plant species are potentially even pricier. Action costs related to researching, controlling, and eradicating invasions must be considered against inaction costs associated with losing native species, habitat reconfigurations, bank erosion, flooding, and knock-on effects of changed water characteristics like temperature, which can impact fish stocks. Further, the control of invasive alien species in Scotland is often reliant on short-term or project-specific funding which results in start-stop cycles and the need to repeatedly funnel money into start-up costs; this way of managing funding is more costly, both financially and in terms of maintaining capacity and credibility, than maintaining funding for the recurrent costs of ongoing projects (Horrill, Oliver and Partridge, 2019). This highlights an important interaction between decision-making and finances – costs for biodiversity (in)action are not only determined by what activities are done (or not) and when, but by how they are managed effectively.

## **Squirrel success: investing in endangered species**

Grey squirrels, introduced to the UK in the late 19<sup>th</sup> and early 20<sup>th</sup> Century, outcompete native red squirrels for the same habitat requirements in much of the country and can asymptotically host a virus that is deadly to their red counterparts, leading to devastating declines in populations (Williams et al., 2010; State of Nature, 2023). Further, grey squirrels can damage wood production, causing upwards of £1 million of economic loss to forestry annually in Scotland (Richardson et al., 2021) and it is likely that this number would be far higher if it we did not have active grey squirrel

management programmes in place across Scotland the cost would likely be far higher (Scottish Wildlife Trust, 2023).

Actions have been taken to control grey squirrel population numbers which, of course, also costs money: over a decade ago, the annual cost of grey squirrel control was estimated at £235,400 a year in Scotland (Williams et al., 2010) whilst more recent case studies by the Royal Forestry Society in 2018 estimate costs of between £49 and £58 per hectare per year to control grey squirrels via traps (Richardson et al., 2021). Yet, as is now a familiar story, it seems that early-stage intervention costs considerably less than late-stage intervention (Williams et al., 2010) and acting sooner rather than later will curb the extensive costs associated with grey squirrel woodland destruction. This highlights one example of how it is often worth investing in controlling problematic species and protecting endangered species earlier. Because of targeted efforts to protect red squirrels in Scotland, their populations have remained largely stable, offering glimpses of an ongoing success story due to proactive measures although actions must continue to maintain such gains (Tonkin, Hatcher and Tipple, 2023).

## **For peat's sake! Restoring a vital habitat**

Scottish peatlands are not just crucial to Scotland, covering more than 20% of the country (Nordbeck and Hogl, 2023), but they hold global significance; 13% of the world's blanket bog is located here (Artz and Chapman, 2016). Peatland habitats protect biodiversity, mitigate water supply issues and climate change, reduce flood risk and are vital carbon stores; yet, when degraded, peatlands *release* carbon and contribute to climate warming (Nordbeck and Hogl, 2023; RSPB, 2024; State of Nature, 2023). Being the first of the UK legislatures to publish a national peatland strategy in 2015, Scotland has taken a leading role in restoration, with more than 10,000 hectares of damaged peatland restored over the last year and a government pledge of £250 million over 10 years to support these actions (Nordbeck and Hogl, 2023; Scottish Government, 2024a).

Whilst restoration costs vary across sites and peat types, Glenk et al. (2022) provide some insight via a mean estimate of £1712 per hectare, using data from reports of actually incurred costs. This suggests it is no cheap and easy task to scale such projects nationwide, yet such costs may be minimal in comparison to the potential price tag attached to addressing all the issues, big and small, connected to delaying action and allowing further degradation. Short-term inaction related to carbon sequestration efforts will result in a need for larger greenhouse gas removal actions in the longer term, which will cost even more money, as well as present itself as an opportunity cost, as further degradation may render habitats irreversibly damaged (Glenk et al., 2021). Thus, prompt action is preferable (Nugent et al., 2019; Moxey and Morling, 2018); there is evidence that this is an attitude present amongst the public, perhaps due to the recognition that earlier intervention will bring substantial welfare gains and secure healthy habitats for future generations (Glenk et al., 2021). This snapshot clearly illustrates the importance of considering the accumulation and compounding of various increased and opportunity costs over time to be able to make well-informed decisions regarding action.

## Ecotourism: a land of opportunity?

Ecotourism, as opposed to tourism more generally, emphasises responsible and sustainable travel practices which support local people and offer opportunities for people to engage with, and learn about, the environment (The International Ecotourism Society, 2024). The Scotland Visitor Survey 2023 found that 70% of visitors chose Scotland for its scenery and landscape, plus 27% mentioned the opportunity to take part in outdoor activities as part of their motivation to visit (Visit Scotland, 2024), illustrating the current key role and future potential for the ecotourism industry in Scotland. Of the £4 billion spent on tourism in Scotland a year, nearly 40% of this is due to nature-based tourism, and it is an industry supporting around 39,000 jobs (NatureScot, 2024b).

Yet, ecotourism will not be viable in a nature-depleted landscape which may put off, rather than attract, potential visitors. Thus, halting and reversing biodiversity decline is vital if an ecotourism industry is to thrive. Further, just as a biodiverse environment can support opportunities for ecotourism, ecotourism can support the conservation of biodiversity, by engaging people with nature in a way that increases support for conservation and involves visitors in sustainable practices and/or restoration activities (Peake et al., 2009; Fennell, 2014; Stronza, 2019). This demonstrates both the financial and ecological benefits that a healthy ecotourism industry could continue to bring to a biodiverse Scotland.

## Losing pollinators: a buzz of concern

Much of our agriculture, and the environment in general, relies on pollinators to be able to flourish. The integral nature of pollinators to the success of plant growth hints at their economic importance, from ensuring crop production and good yields to supporting the continued survival of varied plant life constituting the wild landscapes we enjoy; wild pollinators also offer insurance value if managed pollinators are impacted by pests (Scottish Natural Heritage, 2017; Vanbergen et al., 2014). Indeed, pollinators are worth millions of pounds to UK agriculture (State of Nature, 2023) with one figure estimating total crop sales value directly arising from pollination services in 2009 at £510 million a year (Breeze, Roberts and Potts, 2012).

Despite their clear merit to both socioeconomic and ecological systems, pollinators are declining globally, due to factors such as climate warming and land use intensity (Murphy et al., 2022; Chapin III et al., 2000; Millard et al., 2021). This presents a huge threat to global food systems (Murphy et al., 2022) and, potentially, huge costs too. In the UK, an outdated figure hints at one price tag attached to the decline in pollinators: replacing bee pollination services with hand pollination could cost farmers around £1.8 billion a year in labour and pollen alone (Breeze, Roberts and Potts, 2012). To avoid this, action can be taken to strengthen pollinator networks, review biosecurity measures for imported bees to reduce risks to native populations, and develop effective monitoring strategies (Scottish Natural Heritage, 2017). It seems such actions can be well worth the money, with one study contending that pollinator monitoring more than pays for itself, saving at least £1.50 on data collection per £1 paid (Breeze et al., 2020). This spotlight on

pollinators provides just one example of how ecosystem services can do a remarkable job of not just generating financial value through supporting crop sales, for example, but also *saving* money. Evidently, conserving biodiversity to maintain such ecosystem services can be viewed as both ecologically crucial and cash well spent.

## **A breath of fresh air: nature access and health in urban areas**

Urban areas are important, but often overlooked, places for conservation activities to occur; encouraging healthy nature in cities and towns is vital for creating joined-up habitats, supporting environmental education, mitigating environmental changes, providing ecosystem services, improving physical and mental wellbeing of residents and visitors through human-nature interactions, and combating the negative impacts caused by urbanisation to biodiversity (Dearborn and Kark, 2010; Snep and Clergeau, 2012; Baka and Mabon, 2022). Covering 54% of urban land area in Scotland, greenspaces also offer economic benefits, for example by making areas more appealing as a place to live and work and attracting inward investment (Greenspace Scotland, 2018). A Social Return on Investment assessment of Edinburgh's parks found that every £1 invested in these greenspaces generated a return of around £12 in social, environmental, and economic benefits; the £9.6 million invested by the Council in parks produced benefits worth £114 million (Edinburgh Council, 2015).

However, benefits such as these may not be felt equally: a study focusing on Glasgow showed that more disadvantaged areas have lower-quality greenspaces, including lower perceived greenness and biodiversity (Baka and Mabon, 2022). As such, they hypothesised that more deprived areas may be less able to provide neighbourhoods with both health benefits like space to exercise and build social connectivity, and ecological resilience benefits like heat mitigation and flood risk reduction. This demonstrates how issues around biodiversity will not be experienced in the same way by all people; social inequalities must be considered when thinking about environmental concerns, actions, and investments (Kubiszewski et al., 2023). Investing in high-quality, equitably-dispersed greenspace in urban areas seems like a positive way to fulfil multiple societal and biodiversity targets at once.

## **An education sector turning the page on biodiversity attitudes?**

A big benefit arising from funding better greenspaces in urban areas, is the ability for local children and tourists alike to become more educated about the role of nature. Because of such investments, Edinburgh Council (2015) estimates that schooling institutions in the city can provide outdoor educational experiences worth just under £1 million, whilst the awareness gained by visitors can be valued at just under £5 million. Across Scotland, further educational actions are being discussed, or are already in progress – namely, transforming the curriculum to embed sustainability and biodiversity learning into all education stages (White et al., 2023; Pakeman et al., 2023). Whilst there will be costs associated with enacting these changes, the focus on shaping



attitudes points towards the role holistic, sociocultural considerations can play in addressing biodiversity loss, and may not incur such steep costs in comparison to other biodiversity actions.

Evidently, the education sector has a key role to play in addressing biodiversity loss: as Scotland adopts new strategies to combat biodiversity decline, there will be demand for people to learn new skills and take on new roles, otherwise conceptualised as green jobs (Cardenas Rubio, Warhurst and Anderson, 2022). Demand for green jobs across Scotland is growing, across professional and skilled trade occupations, and process, plant and machine operative roles (*ibid.*). Skills planning is necessary to make sure positive efforts are not hindered by labour and skill shortages (Pakeman et al., 2023), ensuring Scotland can make the most of a promising opportunity for the economy to hold a greener focus. With evidence that green jobs are better paid than their non-green counterparts, there may also be personal economic benefits associated with such a career shift (Cardenas Rubio, Warhurst and Anderson, 2022).

## Reflecting on these economic snapshots

These snapshots do not provide the full picture of biodiversity decline and all its environmental, social, and economic consequences; rather, this section provides a colourful illustration of the variety of ways in which aspects of biodiversity contribute to the Scottish economy, and how declines in species, ecosystem services, and habitats can impact the nation's financial wellbeing. The snapshots provide a rich expanse of lessons:

1. Many aspects of society both benefit from biodiversity and can be a benefit for biodiversity.
2. Various Scottish sectors and areas of life offer biodiversity success stories which we can both champion and learn from.
3. Earlier interventions are often more desirable and effective than later interventions; taking action, rather than delaying action, can often save money going forwards.
4. Long-term success is not just about putting money towards funding an action, but ensuring effective decision-making is in place to make the most of that funding available.
5. Not all actions are costly; sometimes the amount of money spent does not correlate with the amount of positive impact generated from an action. There are steps we can take which do not have to break the bank.
6. Socioeconomic inequalities can lead to people having different experiences of both the benefits of biodiversity and the impacts of its decline; these should both be considered when deciding what actions to fund and take, or not.

There are many other aspects of biodiversity and its economic relevance that could be mentioned here, perhaps take a moment to think: what other areas of biodiversity decline have an economic impact in Scotland, be it species' changes, shifts in ecosystem services, or habitat losses? What is the cost of delaying, or taking, action for each of these?

## Economic snapshots overview

Snapshot focus	Current picture	Delayed-action scenario	Taking-action scenario
Whisky industry	Whisky contributes over £7 billion to the UK economy a year via tourism, exports, and job creation. Barley and a good quality/quantity of water is needed to produce this major, economically-influential Scottish product. Biodiversity loss can contribute to unreliable crop yields, for example, which alongside climate change events such as drought may put whisky's future in contention.	The whisky industry is starting to struggle, with frequent pauses to wait out drought events that force production to temporarily halt. As such, the whisky industry's contribution to the economy through exports is somewhat declining and losing its economic and cultural significance.	Whilst some of the major impacts to the whisky industry are caused by climate change rather than biodiversity loss, conserving biodiversity is, in turn, supporting a more resilient landscape. The production of barley is ensured through the adequate protection of pollinators. As such, whisky continues to be a major export and pull for tourists, remaining a cultural icon for Scotland.
Invasive riparian plant species control	Watercourses are particularly vulnerable habitats to the spread and damage of invasive alien plant species such as Japanese knotweed, Giant hogweed, and Himalayan balsam. These cause all sorts of problems for waterways, from overshadowing native flora to bank erosion, costing millions a year.	The costs of ongoing management are high, and creeping up year on year as larger interventions are avoided. Small-scale projects battle invasions with some success, but start-stop cycles in funding and organisation lead to resurgences of invasive species and increased costs. Ongoing ineffective funding management is costing Scotland dearly.	The costs of ongoing management are still present, with some higher costs initially as control activities are increased. However, there are fewer start-up costs and less disruptions caused by start-stop cycles, meaning actions are more effective and less costly in the long term.
Squirrel control	Grey squirrels outcompete native red squirrels for the same habitat requirements and asymptotically carry a disease which is deadly to reds; greys can also cause significant destruction to woodlands.	Without investment in controlling grey squirrels, populations of red squirrels have massively declined. The forestry sector faces continual economic impacts, due to the £1 million in damage done each year.	Grey squirrel populations are under control and are not spreading to new areas. Native red squirrel populations are healthy. The forestry sector has less expenses as it is not having to combat grey squirrel damage.
Peatland restoration	Holding both national and global significance, Scotland's peatlands are a vital carbon store. Yet, currently, this habitat is largely degraded and therefore leaking carbon.	Limited peatland restoration action has taken place so far, meaning most peatlands are still actively degrading. As such, inaction in the short term has led to the need for even larger greenhouse gas removals now, and we are facing a much larger task with costlier price tags.	Peatland restoration costs have been high so far, as large interventions have been implemented to try to reverse degradation as quickly as possible. Yet, costs look set to fall in the future as less restoration work will be needed.
Ecotourism opportunities	Many visitors come to Scotland for its natural beauty and to take part in outdoor activities; this shows the promise of a	Natural environments across Scotland have lost some of the beauty and charm that attracts visitors, shrinking the tourism industry and	Tourists are attracted by the natural beauty of healthy landscapes and there are many opportunities being developed to benefit local

	blossoming ecotourism industry based on engaging with nature.	impacting local economies negatively. An opportunity cost has become apparent, as some options for advancing ecotourism are now out of reach.	economies through ecotourism activities; when visiting Scotland, there is a palpable emphasis on connecting with, and giving back to, nature.
Loss of pollinators	Globally, pollinator populations are declining; this could have a knock-on effect for many industries and sectors, such as agriculture in Scotland.	Actions have not been taken to support pollinators in Scotland; therefore, the agricultural sector is struggling to source the labour and funding needed to be able to hand pollinate crops and keep up with production requirements. This is costing upwards of £1 billion a year, compared with the free services of pollinators lost.	Pollinator networks have been established and populations are thriving, meaning crops continue to be pollinated without much intervention required. There is adequate monitoring in place, to know where to effectively act and when to support pollinators; whilst this is a financial cost, it more than pays for itself in the data gained.
Nature access in urban areas	Being able to access high-quality greenspace is beneficial for both physical and mental health. In urban areas, this can support people to nurture a connection with, and understanding of, nature too.	Urban greenspaces have been overlooked and underfunded; as a result, people in cities feel disconnected from nature and are less invested in supporting biodiversity measures. There have been opportunities missed in terms of holistically supporting people's wellbeing through nature access.	Sufficient funding has been allocated for improving and expanding high-quality greenspaces in urban areas. Every £1 invested in city parks is returning £12 of social, environmental, and economic benefits.
Education and reskilling	The education sector is working to incorporate more sustainability and biodiversity knowledge into the curriculum. There is requirement for more green jobs going forward, which will need some reskilling of the labour market.	People are leaving the education system not understanding the importance of biodiversity as it is missing from the curriculum. Fewer people are motivated to train in green jobs and there is a labour and skills shortage as a result, leaving the nation unable to address certain environmental challenges.	Those studying at all stages, from primary to higher education, are learning about the importance of biodiversity and the impacts of its decline. Students are experiencing more outdoors education which is aiding their connection with nature. More people have access to training for green jobs and feel motivated to work in this field, filling the new roles needed and earning a good wage.

*Table 2: Summary of economic snapshots*

## 1.4 What does this mean for Scotland?

As the workshop participants discussed the two scenarios and offered key examples, various high-level themes emerged, from discussions regarding the difficulty in conceptualising and compartmentalising ideas around biodiversity loss and the interconnectivity of issues, to the consensus that it will cost less to act sooner alongside an emphasis on non-economic aspects of the conversation. Reflections on these themes are documented in brief below.

### Conceptualising biodiversity loss

It is challenging to conceptualise, and isolate from each other, aspects of biodiversity loss. Within the first activity of the workshop, participants were asked to list 'key types of biodiversity loss' and then agree on five they would be pinning the rest of their discussions on, ranking these from 'most key' to 'least key'. This activity was intentionally constructed in a way that allowed participants to lead with their own interpretation of the scope, scale, and framing of the conceptualisation of biodiversity loss concerns, rather than have the organisers dictate these; we were as much interested in the agreed starting point of these discussions as the resulting conversations. Based on this exercise, biodiversity loss was framed in a variety of ways, which is helpful to relay here for the purposes of understanding what the consequences, economic costs, and scenarios discussed were based upon.

**Impacts to ecosystem services:** Some key types of biodiversity loss identified by groups could be classed as impacts to ecosystem services, including categories such as pollinators, soil health, and food security. Two groups positioned pollinators as most key, demonstrating how pressing this issue is felt to be by those working in biodiversity.

**Impacts to habitats and species:** Another common way participants talked about key types of biodiversity loss was through identifying habitats and specific impacts to these. Habitats mentioned include marine, upland, riparian, Atlantic rainforest, marshlands, coastal, and peatlands. Issues discussed in relation to this included loss of the habitat itself, reduced connectivity within and between habitats, habitat degradation, species loss, invasive species, and ecosystem resilience.

**Impactful activities:** A third categorisation of types of biodiversity loss identified by participants was activities that have a big impact on biodiversity. These ideas largely fell under conversations related to urban expansion or issues of land management and quality and land use intensity, as well as invasive non-native species and pollution

### It's cheaper to prevent biodiversity loss

The consensus in the workshop was that acting sooner rather than later was not just environmentally beneficial but economically sensible, echoing other research which suggests

biodiversity decline financially costs us, it costs less to take action, and the benefits of investing far outweigh the costs (Hanley and Perrings, 2019; Sumaila et al., 2017; Bullock et al., 2011; Bradbury et al., 2021; Isbell et al., 2022; Stern, 2007; Dasgupta, 2021; State of Nature; 2023). Generally, participants conveyed this widespread sentiment that it will cost less to take action than to delay action. Further, participants also noted how acting sooner can bring additional economic benefits, whilst delaying action can lead to missed opportunities or limited future options (Chapin III et al., 2000).

## **Biodiversity, society, the economy... it's all connected**

Participants stressed the interconnectedness of environmental, social, and economic issues, both within and between these different dimensions (i.e. the connections within environmental spheres, such as increased invasive species and decreased crop yields, and the connections between environmental and socioeconomic spheres, such as reduced crop yields and increased food prices). They explained how difficult it is to unpick and isolate issues of biodiversity loss in these conversations, whilst also exploring how shifts in any one aspect of biodiversity can lead to knock-on impacts and exacerbate further environmental (and other) issues. This interconnectivity also indicates why it is so tricky to visualise the details of future scenarios as they are influenced by lots of things, many of which are hard to fully understand the implications of and/or are vulnerable to being impacted by multiple other changes and conditions. The concept of interconnectedness was also incited to impart the importance of considering all ecosystems, inclusive of both terrestrial and marine. There is a need to remember all habitats and aspects of these, not just the ones that are most easily conceptualised through economic, or even market-based, thinking (such as carbon).

Interconnectedness is explored by others in the literature to acknowledge the links between different aspects of nature and society, stress the need to think beyond silos and boundaries, recognise ourselves as part of wider systems and consider these holistically, and shift towards frameworks which set social-ecological targets as opposed to isolated environmental aims (Pörtner et al., 2023; Blanc and Soini, 2015; McIntyre-Mills, 2018; Mehring et al., 2017; Reyers and Selig, 2020; Tisdell, 2009). In line with much of this work, participants expressed that acknowledging interconnections might be one step towards understanding the intricacies and relative influences of these issues.

## **The biodiversity loss issue is a justice issue**

Topics of inequality and justice arose repeatedly throughout the workshop, discussed primarily in terms of justice considerations and intergenerational concerns, mirroring work which identifies biodiversity decline as a justice issue (Pickering et al., 2022; Armstrong, 2024; Martin, 2020; Gupta et al., 2023). Participants expressed that a suite of social inequalities would be likely to increase, and inequality gaps likely to widen, due to the impacts of biodiversity loss. For example, increased food prices or healthcare costs will have a greater impact on those with less disposable income.

Further, those living in more climate-vulnerable locations will face more devastating impacts of extreme weather and climate change events without suitable nature-based infrastructure put in place. Whilst the causal relationships between biodiversity and inequalities remain contested in the literature, the social implications of any environmental (in)actions are crucial to consider if we are to improve both social and ecological outcomes (Kubiszewski et al., 2023).

Another justice concern raised related to the impacts on future generations, who will have to live with greater, compounded consequences of biodiversity decline and may have less options for solutions and pathways forward (Chan and Satterfield, 2007). Those in attendance at the workshop cited intergenerational justice concerns as a compelling reason to act sooner rather than later. In thinking through these concerns, participants indicated that increasing inequalities and injustices may put Scotland on a route towards greater political instability, with a general decreased level of life satisfaction among the population leading to social unrest. This alludes to an inequality-instability dialectic discussed by Diamond and Newman (2024) in relation to British politics; it also, once again, elucidates the importance of considering the interconnectedness of issues.

## **We must rethink our relationship with nature**

Through workshop discussions, participants called for a reconsideration of our societal relationship to nature, acknowledging that Scotland is exceeding its planetary boundaries – the safe operating space which will enable future populations to thrive (Pakeman et al., 2023). Going forward, we must consider the environment as central and essential for all life to thrive, finite in what it can provide, and a valued and respected aspect of life rather than simply a resource we can extract and capitalise upon. This requires us to rethink the structuring of our economy; indeed, economic growth is a key driver of biodiversity loss (IPBES, 2019).

Participants recognised that a tricky part of this shift in how we relate to nature, though, is considering how we can support industries and other areas of society to become more sustainable, focusing less on growth and more on sustainable livelihoods; in other words, perhaps, to think beyond GDP (Kubiszewski et al., 2013) and towards a wellbeing economy (Roy, 2021; Hayden and Dasilva, 2022; Figus et al., 2020). Key to this discussion is the concept of resilience, which arose time and again in the workshop, particularly in relation to communities having the capacity to address environmental issues. It is important to think about what we collectively want ‘being resilient’ to mean, in terms of (self-)organisation, agency, and (state) responsibility, and what this looks like in a reconfiguration of socio-nature relations (Revell and Dinnie, 2020).

## **What scale? And who leads?**

Participants identified that notions of scale are important when discussing the impacts of, and solutions for, biodiversity decline. International actors and actions can greatly implicate Scotland and vice versa, for example in terms of food production and exports. Similarly, national-level

decision-making directly impacts local issues, for example budget choices regarding nature restoration funds and local community capacity to lead on such activities. These different scales operate in relation with each other, and we should be explicit in identifying what scale we are considering at any one time and how decisions taken within that sphere will impact other aspects relevant at different scales. Dealing with multiple environmental and governance scales at once is challenging but vital when working to address biodiversity concerns and requires flexible, interdisciplinary, and communicative approaches (Paloniemi et al., 2012).

Questions of scale, decision-making, and impact relate to perceptions of leadership. Leadership has been identified as an integral component of solving collective conservation issues; positive leadership involves stakeholder engagement, trust, and vision among other attributes (Webb et al., 2021). Workshop participants felt Scotland has a chance to be a global leader in halting biodiversity loss and restoring nature by taking action sooner rather than later, thereby illustrating how nations in a similar socioeconomic position could do the same. Within Scotland, there is an imperative for the Government to take a lead in setting the biodiversity agenda and getting the nation on the pathway to action. Additionally, there is a need to recognise local communities, particularly those who may have particular knowledge of the land, sea, or sustainable practices, as already being leaders in climate and biodiversity action. These perspectives should be valued, respected, and considered; an abundance of literature advocates for the importance of recognising and including indigenous and local knowledges in conservation strategies (Gadgil, Berkes and Folke, 1993; Hill et al., 2020; Wheeler and Root-Bernstein, 2020; Brondízio et al., 2021; Williams, Silkutshwa and Shackleton, 2020; McElwee et al., 2020; Lam et al., 2020).

## Thinking beyond economic costs and benefits

As to be expected in a workshop bringing biodiversity experts together, the feeling in the room was of urgency and importance to address biodiversity loss for a multitude of reasons, including social, economic, and environmental realms. The economic focus in this report was identified by workshop participants as helpful for various practical and political reasons: it speaks the language of some decision-makers and makes complex, interconnected issues understandable and tangible within political arenas. It also focuses the conversation on what actions are possible or necessary sooner: if they are cheaper to address, or probable to be incredibly costly if not addressed soon, then these things may be more likely to get attention.

However, it is important to note that participants were passionate about the fact that the conversation should not be limited to economic bounds; indeed, biodiversity holds 'cultural, intellectual, aesthetic and spiritual values that are important to society' as well as economic impacts (Chapin III et al., 2000, p.239). Prioritising the economic aspects of biodiversity loss over everything else can be problematic, reductive, and missing vital indicators of value beyond finances. The Dasgupta Review (2021, p.47), among countless others, warns us that economic value does not necessarily equal worth, providing pollinators as a pertinent example: whilst their measurable services to GDP may seem negligible, hovering around 0.03%, without them we many aspects of society would be in trouble.

Prioritising economic understandings of the world also does not allow for the fact that many decision-makers think in non-economic ways too, and it is not always necessary to reinforce the rhetoric that those in positions of power can only think in pound signs. We must acknowledge that people draw on multiple values, economic or otherwise, when making decisions and that we should be encouraging our societal systems to maintain a recognition of factors beyond the financial, which can contribute to wellbeing, sustainability, and justice outcomes (IPBES, 2022). Whilst this report has attempted to attach price tags to many aspects of biodiversity loss, there have been many occasions for which this has been difficult or indeed, impossible. It is key to recognise the plethora of other values evident throughout the scenario descriptions and economic snapshots contained within this report.



## 1.5 Lessons learned

Whilst this report is scoping rather than detailed in its focus, the ambitious, bigger-picture thinking provided here highlights some key lessons for Scotland to consider:

1. Biodiversity is complex and entangled with all other aspects of life; its decline should concern us all and must be a central priority both now and in the future.
2. Immediate action is needed: it is likely to cost less than if we wait. This also enables us to keep our options for the future open and to avoid missing opportunities we might not have in a couple of decades time if a pathway of inaction is followed.
3. Economic costs and benefits are crucial to these discussions, but it is not the only vital aspect – biodiversity loss needs holistic and ambitious thinking that goes beyond the realms of any one discipline, sector, or set of actors. The social, political, and environmental must be considered alongside the economic, and the interactions between all of these are just as important to focus on as what is happening within each area.
4. Justice should be central when choosing pathways forward and innovating solutions – in line with Scotland’s route to a Just Transition, biodiversity action must consider all people in all contexts. No community should feel overburdened, underrepresented, or marginalised when delivering biodiversity actions.
5. All sectors and actors in diverse roles have a part to play in imagining the future we want to see – inclusive collaboration and discussion must continue to ensure actions remain relevant and grounded.

Attending to all these points is no easy feat; Scotland has its work cut out to be able to deliver an array of ambitious and just biodiversity actions which will put us on a pathway towards viable and sustainable socioeconomic and environmental futures for all communities, both in the present and going forward. Yet, despite its challenges, acting now will cost less – financially and otherwise. Further, being proactive rather than responsive will keep open options for future actions and avoid the regret of missed opportunities. If Scotland is to meaningfully contribute to biodiversity action on global, national, and local scales, the imperative is clear: we must act now.

## Part 2

# Background and methodology

*Part 2 provides the context behind the scenarios and snapshots discussed above, detailing: the importance of biodiversity and drivers behind its decline; the risks and economic costs associated with biodiversity loss; and the justification for, and explanation of, the combined methodological approach of scenario work and desk-based research used here.*

## 2.1 Project context

This report aimed to explore the consequences of biodiversity decline for Scotland and the potential associated economic impacts of delaying or taking action on such biodiversity loss. It asked two key questions:

- What could Scotland’s future look like under two potential scenarios of delaying or taking action?
- What are some of the consequences/impacts, and economic costs, associated with delaying or taking action to halt/reverse biodiversity loss in Scotland?

Through a combination of desk-based research and an environmental scenario workshop with experts and other stakeholders working in fields of economics, biodiversity, and wider environmental issues, this report offers a brief (non-exhaustive) overview of the array of impacts biodiversity decline is having, and will have, on Scotland and traces two possible scenarios for the nation’s future based on either delaying or taking action on biodiversity loss. This work was carried out in 9 hours a week over 5 months (March– August 2024) and was commissioned by the Scottish Wildlife Trust as part of a wider Nature-based Solutions work programme which is funded by the Esmée Fairbairn Foundation . The scenario workshop was held on 8 July 2024 with 19 participants in attendance (excluding the organisers). Additional input from individual members of the Scottish Forum on Natural Capital Steering Group helped inform the project.

## 2.2 Defining biodiversity

The concept of biodiversity, and its adjacent topics and relevant sectors, covers an enormity of ideas and concerns. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) highlights the need for a holistic understanding of biodiversity, emphasising the importance of both the variety of life and the variety of functions that can be found within and across species and ecosystems (IPBES, 2019). Variety of life encompasses variability among living organisms and ecosystems whilst variety of functions speaks to the differentiated roles that living organisms and ecosystems carry out, such as food production and climate regulation. This definition champions the importance of interactions, relationships, and processes that occur between different elements of a biodiverse environment and showcases the need to consider the world's nature as a complex totality.

### The importance of biodiversity

Globally, it has been recognised that biodiversity is important for humanity's economic, cultural, spiritual, and social wellbeing (Sumaila et al., 2017). Biodiversity underpins all the benefits humans gain from nature, often called ecosystem services (NatureScot, 2023). These foster life by regulating, supporting, and provisioning essential processes for human flourishing, from providing clean air, water, and medicine, to pollinating crops, controlling diseases, and managing floods, among a multitude of other things (*see Figure 1*). They also offer a broad range of cultural benefits, encompassing education, tourism, recreation, and more. This wide array of ecosystem services makes a substantial contribution to economies worldwide, including in the UK (Costanza et al., 2014; Bateman et al., 2011; Eftec, 2005).

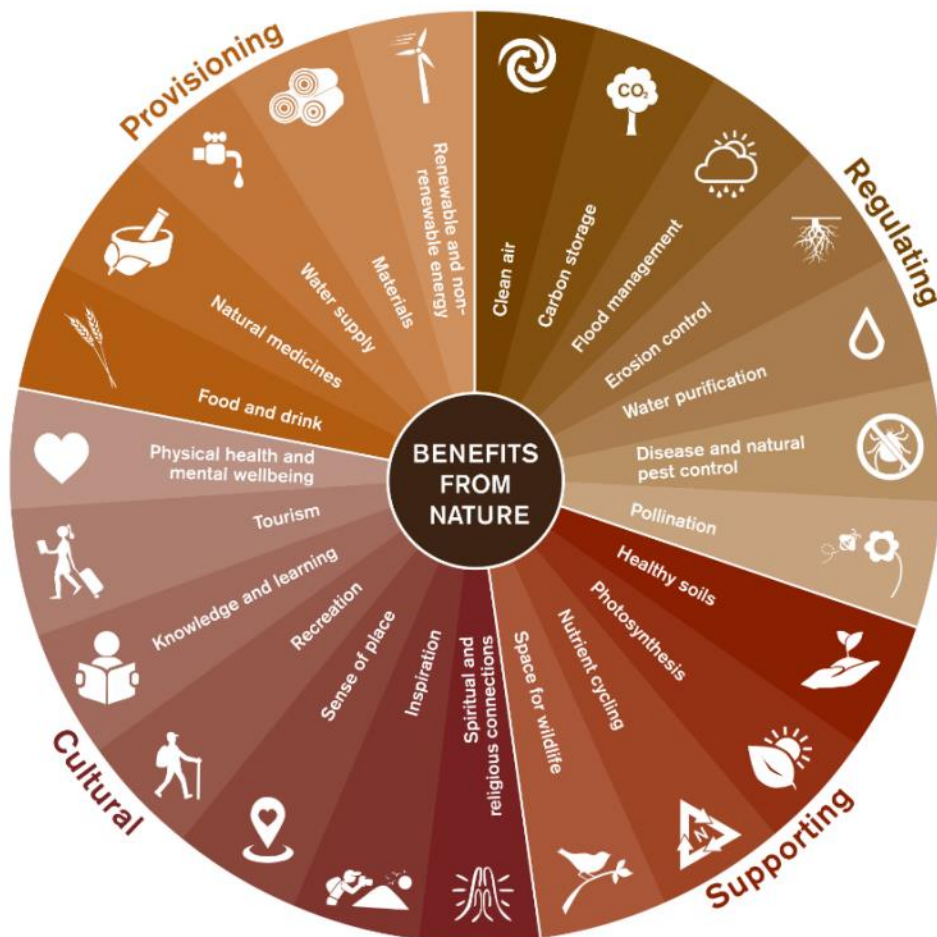


Figure 1: Ecosystem services land wheel (NatureScot, 2023)

## Biodiversity in Scotland

Scotland is renowned for its sheer number of species (approximately 90,000) and its complex patchwork of habitats that form rich and varied landscapes (NatureScot, 2023). Yet, Scotland is one of the most nature-depleted countries in the world and scores lower on the Biodiversity Intactness Index (which estimates the proportion of species still present in an area) than all other G7 countries (State of Nature, 2023).

Much like the rest of the world, biodiversity is crucial for sustaining life and livelihoods in Scotland, from providing physical goods we cannot live without, underpinning economic activities related to industry and tourism, and supporting the nation’s cultural heritage, to strengthening the health of the population, regulating the climate through nutrient cycling, and offering natural resilience to flooding and heat events (NatureScot, 2023; Scottish Government, 2024). Scottish habitats are also of international importance, with a significant amount of the world’s blanket bog located in Scotland and rich grassland, marine, peatland, montane, upland, and coastal environments providing homes for countless important and unique species (RSPB, 2024; NatureScot, 2023; State of Nature, 2023). As such, Scotland’s biodiversity is an important area of consideration for everyone residing in the country and beyond, not just environmentalists; impacts to biodiversity do, and will, affect everyone.

## 2.3 Biodiversity loss

Globally, it is evident that biodiversity loss is happening; not only this, but biodiversity is declining faster now than at any other point in human history (IPBES, 2019). Biodiversity experts approximated that 30% of species have been globally threatened or driven to extinction since 1500 (Isbell et al., 2022). Scotland is not an exception to such devastating global statistics. Focusing on three measures of biodiversity change – abundance, distribution, and extinction risk – the State of Nature (2023) report shows that Scotland has experienced an average 15% decline in species' abundance since 1994 and that 11% of species are now threatened. Alarming, to offer a specific key example, there has been a 49% decline in average abundance of Scottish seabirds since 1986 (this figure pre-dates the most recent avian influenza outbreak).

### Drivers of biodiversity loss

Multiple factors are driving biodiversity loss around the world; IPBES categorises the causes of biodiversity loss into five direct and two indirect drivers (see Figure 2). The five direct drivers are: changing use of land and sea; direct exploitation of organisms; climate change, pollution, and invasive non-native species. The two indirect drivers are people's disconnect with nature and the lack of value and importance placed on nature (NatureScot, 2023).

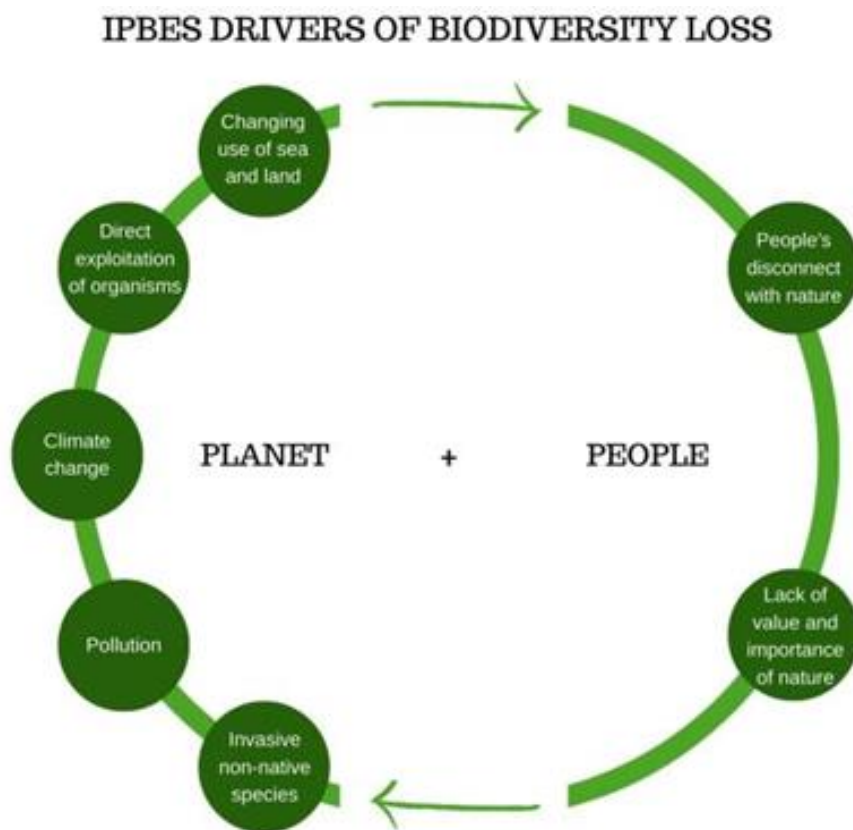


Figure 2: IPBES drivers of biodiversity loss (NatureScot, 2023)

Whilst Scotland faces the same climate and biodiversity problems as the rest of the world, there are key pressures related to Scotland's socio-political and environmental context that provide specific challenges of note. For example, the significant scale of peatland at risk of degradation, the management of uplands, changes to agricultural practices, habitat fragmentation and land use change, shifts in grazing levels, the multiple threats large seabird populations face, the persecution of birds of prey on land managed for grouse shooting, conflicts around protected species such as beavers, and difficulties monitoring biodiversity across remote, large land areas (RSPB, 2024; Coz and Young, 2020; State of Nature, 2023). Writing on the indirect drivers in the Scottish context, Pakeman et al. (2023) report that Scotland hosts a society with diverse, and sometimes conflicting, views about nature and pro-environmental behaviours, has a rural depopulation issue, and faces urbanisation pressures that may not be conducive with addressing biodiversity concerns.

## 2.4 Impacts of biodiversity loss

Biodiversity decline clearly impacts many aspects of nature and life: “ecosystem functioning and services often directly depend on biodiversity” (Isbell et al., 2014, p.119). Spatiotemporal changes in traits of species diversity (including species richness, evenness, and composition) can alter the vital processes ecosystems support and the benefits they are able to offer (Chapin III et al., 2000). For example, a decline in richness of specific fungi species can diminish plant production, or the introduction of new plants can inhibit the regeneration of some native species. Additionally, anthropogenic activities cause significant environmental and ecological changes which, via various mechanisms, contribute to changing biodiversity.

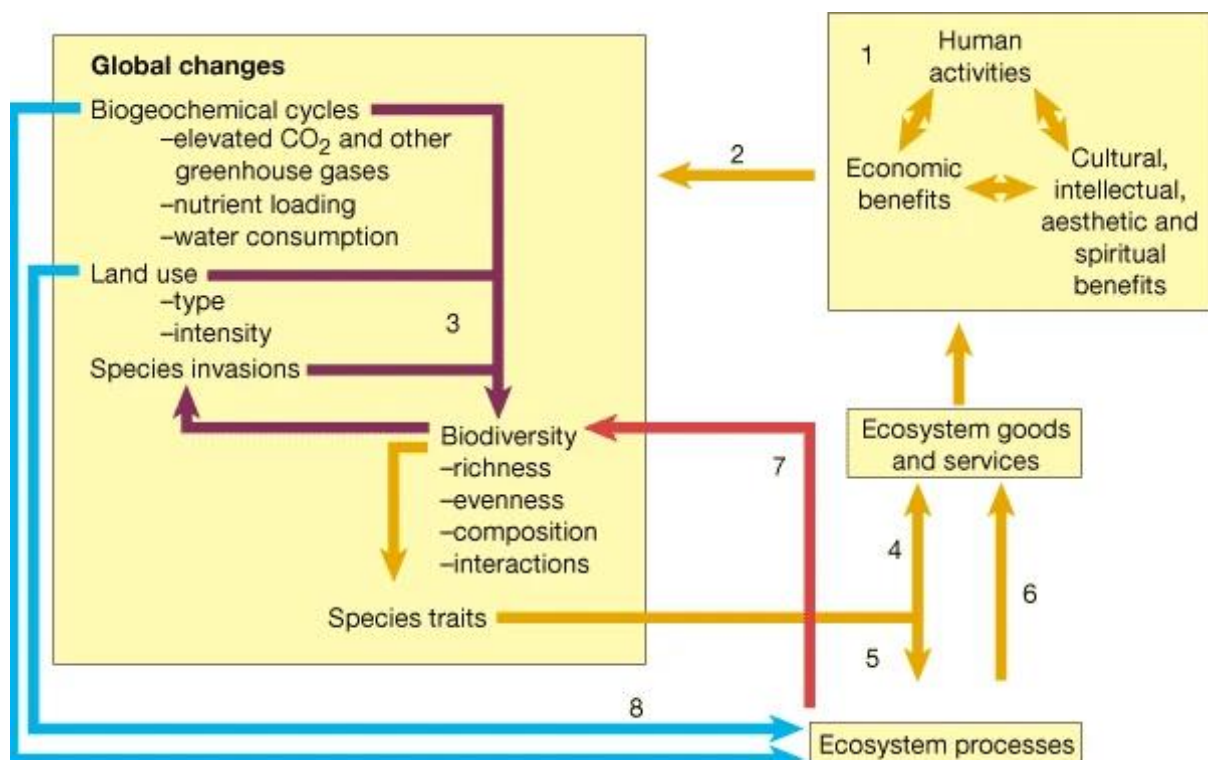


Figure 3: The role of biodiversity in global change (Chapin III et al., 2000, p.235)

To exacerbate issues further, changes to biodiversity can also alter an ecosystem’s resilience to environmental change: ‘diversity provides a general insurance policy that minimises the chance of large ecosystem changes in response to global environmental change’ (Chapin III et al., 2000, p.238). Areas with greater species richness have a greater chance that some of the species present will be resilient to change and help to maintain the current state of an ecosystem.

### The global risk of biodiversity loss

These changes present a huge global risk; indeed, biodiversity loss and ecosystem collapse has been identified as the fourth most severe long-term global risk (only ranked behind three other environmental factors) yet perceived to be one of the risks we are least prepared for (World Economic Forum, 2023). On the planetary scale, environmental risks are interlinked with other



major global risks, from the economic and geopolitical, to the societal and technological (see Figure 4).

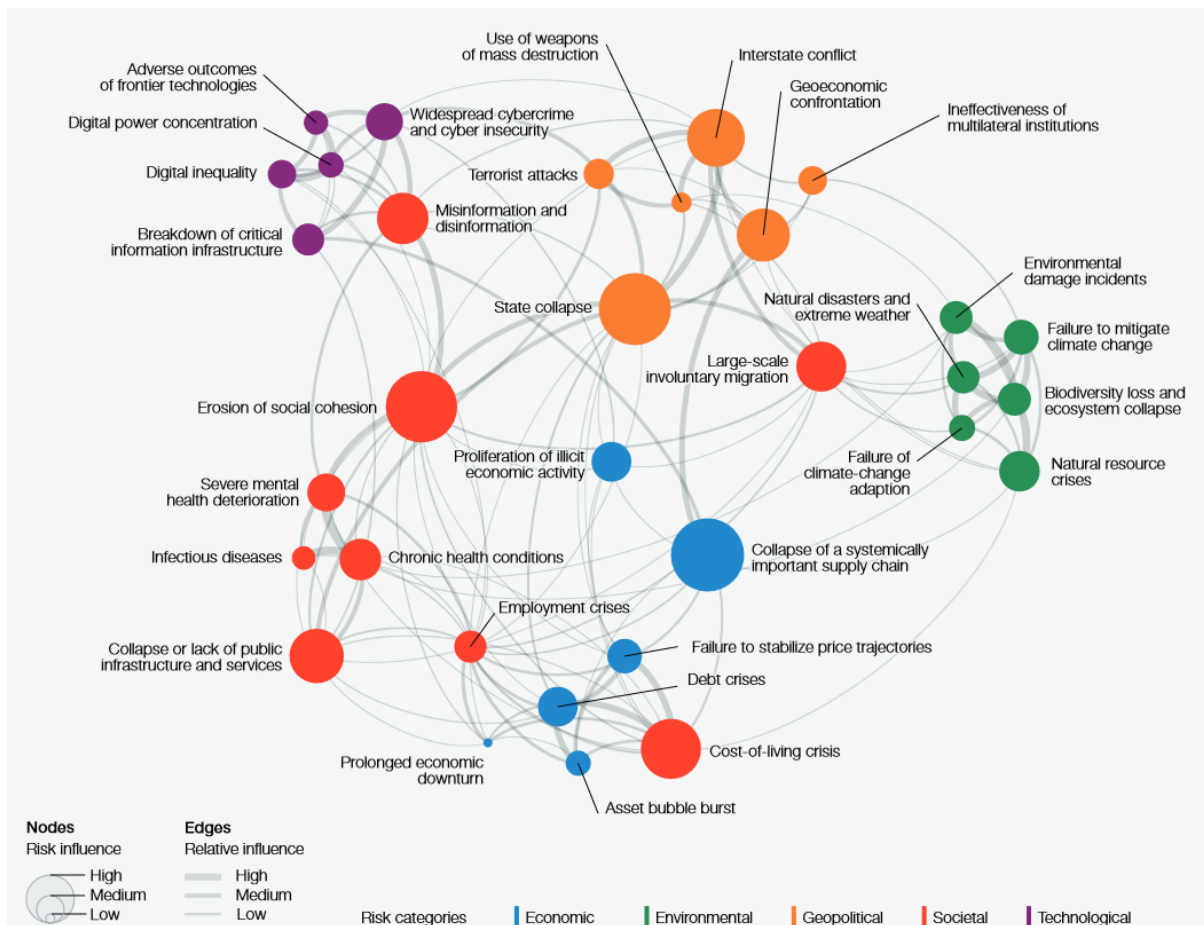


Figure 4: The interconnection of global risks (World Economic Forum, 2023)

Biodiversity loss is identified as having relative influence on the collapse of a systematically important supply chain, as well as directly influencing natural resource crises which feed into cost-of-living crises as well as supply chains, and environmental damage incidents which impact chronic health conditions. Risks faced include an increased occurrence of zoonotic diseases, a fall in crop yields and nutritional value, growing water stress which potentially leads to a greater occurrence of violent conflicts, the loss of livelihoods dependent on food systems and nature-based services like pollination, an increase in dramatic weather events, and sea-level rise and increased erosion due to degraded natural flood protections. Worryingly, biodiversity loss and ecosystem collapse were not positioned as a pressing concern over the short term, only rapidly accelerating to fourth place over a ten-year framing; this perhaps indicates why narratives calling for more immediate action, such as this report, are needed.

## Economic costs

Key to the economic discussion, the World Economic Forum (2023) writes ‘given that over half of the world's economic output is estimated to be moderately to highly dependent on nature, the

collapse of ecosystems will have far-reaching economic and societal consequences’ (p.31). Biodiversity decline impacts economies around the world, although it is tricky to put exact figures on the financial impact due to the interconnected nature of biodiversity and ecosystem services. However, one example suggests that global land use changes between 1997 and 2011 resulted in a loss of ecosystem services between \$4.3 and \$20.2 trillion per year, based on conservative estimates (Costanza et al., 2014). In the UK, more recently, an approximation suggests that deterioration of the environment is expected to cause a 12% loss to GDP, which is greater than the COVID-19 pandemic or the 2008 financial crisis (Green Finance Institute, 2024).

Assessing the economic costs of biodiversity loss on a global scale, Kumar, Shukla and Kailkhura (2024) identify several key ecosystem services that may present huge costs: pollination, water purification, climate regulation, soil fertility, and disease regulation (*see Table 3 for their estimated costs*).

Ecosystem service	Example	Estimated economic cost
Pollination	Declining populations of pollinators	\$235 to \$577 billion annually in global crop output
Water purification	Loss of wetlands and other natural filters	\$2.2 trillion annually for water treatment
Climate regulation	Deforestation and land-use changes	Up to \$3.3 trillion annually by 2030 for climate change
Soil fertility	Soil degradation and reduced agricultural productivity	\$300 billion annually
Disease regulation	Zoonotic disease epidemics	e.g. COVID-19 cost trillions of dollars

*Table 3: Estimated economic costs related to ecosystem services impacted by biodiversity loss (adapted from Kumar, Shukla and Kailkhura, 2024, p.33)*

Whilst this presents an initial look at some of the huge financial impacts humanity faces in relation to biodiversity decline, it is by no means the full picture. Regardless of exact figures, ‘impacts [of biodiversity loss] can be wide-ranging and costly’ (Chapin III et al., 2000, p.239) and the direct economic impacts of this decline are becoming more and more evident.

## The need to act

The fact that biodiversity is vital for sustaining humanity, paired with the knowledge that the world is suffering substantial biodiversity loss and impacts of this will be vast, has led to multiple international calls over the years for action to be taken to preserve and improve biodiversity (Sumaila et al., 2017). From the 2010 Biodiversity Target to the 2020 Aichi Targets, biodiversity has been on the global environmental agenda for a while. Yet so many of the targets set in the past have been missed by signatory countries; Scotland is not immune to this. The imperative is clear: globally, we need to act to stop the detrimental impacts of biodiversity decline (World Economic

Forum, 2023). What is less agreed upon, though, is what to financially prioritise, what we collectively want the future to look like, and how best we can go about realising this.

## **What about Scotland?**

Due to the complexity of biodiversity loss and all the ways this can impact the multitude of ecosystem services human's benefit from, as well as the various and interconnected scales these concerns can be investigated on and sectoral lenses they can be perceived through, it is perhaps impossible to provide a fully comprehensive picture of what all of this might mean for one country, like Scotland (Isbell et al., 2022). Even with a specific focus on the economics, it is hard to piece together a whole picture due to differences in data collection techniques, a lack of data, or data that relates to a singular site, for example. As such, to gain sight of the bigger picture for Scotland, it was beneficial to utilise creative, experience-based, collective thinking in the form of a scenario workshop. Such activities can operate outside the constraints of needing numerical data to be able to produce ideas about impacts and the future (Alcamo and Henrichs, 2008); this enabled us to smooth over gaps where robust research may not exist yet, but where those working in relevant fields may have ideas about what may lie ahead, and provide an overall idea of Scotland's possible future directions.

## 2.5 Methodology

To understand the potential consequences, impacts, and economic costs of addressing biodiversity loss in Scotland, and generate possible scenarios for the future, this research was conducted via both desk-based research and an environmental scenario workshop, both detailed below.

### Desk-based research

The desk-based research sought to understand the context of biodiversity decline in Scotland and its consequences and impacts, with a specific focus on economic costs associated with delaying or taking action. Information was gathered through a search for relevant academic and grey literature: articles and reports written about the Scottish context, and materials published in more recent years, were prioritised, although older documents or those with a wider national or global scope were not automatically discounted. This is because costs associated with biodiversity loss are broad-ranging and often there were no Scotland-specific materials available.

This desk-based research garnered a huge variety of evidence, with different scales of focus, methods applied, and conducted within various disciplines. As such, this report cannot comment on all of these; this is by no means a systematic or exhaustive review, rather it is an attempt to highlight some key concerns raised within the literature and consider how these might apply and relate to the Scottish context. It is important to note that the array of economic costs related to biodiversity loss are much further reaching than this research can possibly aim to report on.

### Scenario workshop

To strengthen and contextualise the evidence gathered via the desk-based research in Scotland's context, an environmental scenario workshop brought together biodiversity and/or economic experts and stakeholders working across various sectors in Scotland to consider the nation's future in light of what we already know about biodiversity loss and its economic costs. The primary question driving the scenario analysis segment of the research was: what will Scotland be like by 2045 following either a delayed-action or taking-action scenario?

Scenarios are 'images of the future' (IPCC, 2000, p.23) consisting of a set of 'if-then' constructions that explore the consequences of varying driving force assumptions (Alcamo and Henrichs, 2008) to 'foster anticipatory knowledge' (Iwaniec et al., 2020, p.1). Thus, scenario analysis involves 'building scenarios, comparing them, and evaluating their expected consequences' (Alcamo, 2008, p.3) providing 'an approach to thinking through plausible future developments and related uncertainties in a structured, yet creative manner' (Alcamo and Henrichs, 2008, p.15). On scales of certainty and complexity, scenarios sit somewhere between facts and speculations (*see Figure 5*) which offers a medium of investigation that is explorative, flexible, and creative, yet still grounded in disciplinary knowledge, be that economics, geography, or an alternative field (Alcamo, 2008).

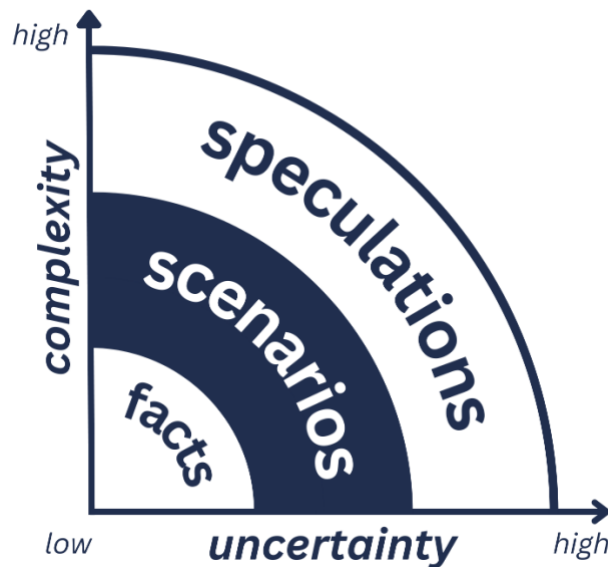


Figure 5: What are scenarios? (adapted from Zurek and Henrichs, 2007, cited in Alcamo and Henrichs, 2008, p.15)

Recognising that scenario analysis is ‘more a craft than a science’ (van de Heijden, 1996, cited in Alcamo, 2008, p.8), this report seeks to depict an admittedly partial but visceral image of two of Scotland’s potential socioeconomic-ecological futures. By facilitating participants who are highly experienced in their respective fields to generate these scenarios together, the report benefits from bigger-picture, inter-sectoral, creative thinking whilst ensuring suggestions are still based in experience and evidence. Further, following Alcamo and Henrichs (2008) guidelines for conducting environmental scenario analysis, which acknowledge there is no set way to do this kind of research, this report leans on a strategy-driven approach that prioritises the generation of clear and compelling scenarios which the wider public and other stakeholders beyond the scientific community can engage with.

The workshop was held at Edinburgh’s Climate Change Institute at the University of Edinburgh on 8<sup>th</sup> July 2024 and hosted 19 participants: 4 environmental advisors/consultants, 3 natural capital consultants/managers, 3 economists, 2 environmental policy advisors/officers, 1 environmental economist academic, 1 statistician, 1 financial analyst, 1 educator, 1 research and development scientist, 1 community support specialist, and 1 student. Participants were split between 4 tables, ensuring a mix of backgrounds at each and with no table hosting more than 1 person from a specific organisation. Participants remained in these same groups throughout the duration of the workshop and, in plenary, fed back to each other and engaged in a collective discussion regarding key concerns that crossed all groups.

At the start, it was necessary to establish a basic representation of the initial situation to ensure everyone was raising points relevant to the two distinct scenarios. This involved describing a simple narrative of biodiversity decline and the range of impacts this can have on ecosystem services worldwide to set the scene, and then outlining descriptions of what it would mean to follow either a delayed-action or taking-action scenario. Ideally, scenario workshops allot time to agree as a whole group on the scenario descriptions – in a time-limited workshop, though, doing

this in such a collective way was not possible. As such, participants were encouraged to work within the framing presented to them to try and ensure conversations were as productive and coherent as possible.

Workshop participants were primed for each scenario with a short list of principles of what was assumed to fall under a 'delayed-action' versus 'taking-action' scenario. A delayed-action scenario was presented as a Scotland in which policies and actions to restore biodiversity are not a government priority, no further significant policies and actions are implemented, and public sector funding for nature remains at current levels. A taking-action scenario, on the other hand, was presented as a Scotland in which policy and actions to restore biodiversity are a government priority, new significant policies and actions are implemented, and public sector funding for nature is increased.

For both scenarios, participants were prompted to think about the related economic, social, and environmental consequences/impacts, the economic costs of these consequences/impacts, and any examples or evidence to support these ideas. Additionally, for the taking-action scenario, participants were also asked to think about what actions would be required to reach this state. The two scenarios detailed in this report are a synthesis of ideas from all 4 groups. Many of the consequences, impacts, actions, examples, and costs that enrich the rest of the report are also taken from these group discussions, alongside information sourced from the desk-based research.

## **Method reflections**

Conducting the research through a scenario workshop with experts and stakeholders supported by desk-based findings enabled the project to cover a wide expanse of issues and ground these within the Scottish context without the luxury of time or a huge team working on the project. As such, those working in relevant roles helped guide the report towards relevant and timely conversations for contemporary Scotland. The hope is that this workshop also provided a space for participants to make connections with others who care about, and work on various aspects of, biodiversity; hopefully, this event contributed towards the strengthening of networks of those thinking through biodiversity loss in Scotland.

Through feedback forms, participants conveyed a key challenge of exploring biodiversity loss and possible futures through the format of a scenario workshop. They highlighted the difficulty in having to focus on isolated aspects of biodiversity loss when these are so entangled with each other, as well as other environmental, socio-political, economic, and further concerns. This mirrored the overall challenge identified in putting together this report – that biodiversity is a complex, interconnected, multi-scalar, international, inter-sectoral issue. For participants, this emerged in the need to keep zooming in and out on issues, and constantly having to think on different scales and through different lenses (whether that is habitat focus, ecosystem services focus, sector based...). This means that examples coming out of the workshop are not uniform or easily comparable or distinguishable. As such, decisions and compromises have had to be made in the reporting of this topic, for the purposes of practicality and clarity.

## Part 3

### Narratives of the future

*Part 3 contains the full-length narratives created from the contributions of workshop participants. It details what life in Scotland could be like under the two scenarios discussed in this report to provide a more in-depth picture of our potential futures following different pathways of (in)action.*

## 3.1 Narratives of the future

The full-length scenarios that were generated within the workshop are presented here, to demonstrate the richness contained within participants' discussions of future visions. All the ideas within these descriptions were points that were brought up and noted down by those at the workshop. Here, the ideas from all four groups have been combined into two cohesive narratives of the future.

### Delayed-action scenario

**It's 2045. Biodiversity has been politically sidelined for the last couple of decades and has not received much attention or funding.** Our natural resilience to climate change has worsened; without a healthy, biodiverse nature Scotland is struggling to be robust against extreme weather and pests. We've lost many of our treasured soil micronutrients and the quality of our famous Scottish water has declined. There's a continued focus on a small range of land management objectives, such as carbon sequestration, missing opportunities for more holistic thinking. Species and habitats unique to Scotland have disappeared or are disappearing rapidly. Instead, there are more invasive species: more giant hogweed crowding riverbanks, more pests destroying potato crops, and more mosquitoes at risk of spreading diseases we haven't seen before or prepared to protect ourselves against. The nature we have now is not what we're used to; how do we live with this new version of nature?

**The economy is declining as nature cannot be relied on in the same way as before for the resources and services it provides.** The loss and damage to economic growth and industries is substantial, with reduced trade competitiveness, job and income losses, lowered productivity, declines in investments into the economy, and loss of certain exports and industries (for example, meat, seafood, timber, and whisky). We are facing perpetually increasing costs and trade-offs and national debt is steadily increasing. To exacerbate this dire economic situation, **the nation is now scrambling to find money to fund innovations which replace the things that nature used to do for us**, such as nutrient and water cycling and air purification. Pesticides and chemicals are liberally applied to fields to desperately encourage yields we no longer seem able to achieve. The polluted rivers now carry agricultural run-off rather than fish; there are no salmon left to catch. No matter what we do, the 'solutions' end up creating further problems: how do we escape this cycle?

**Rural and island communities have suffered** continued rates of depopulation as economic opportunities become more and more limited; many people have lost their jobs and ability to earn an income doing what they were doing a few decades ago. **In urban areas, people struggle with flooding in the winter and extreme heat in the summer;** city infrastructure is not equipped to deal with either. All areas are suffering different sorts of cultural and heritage loss; what is our collective Scottish identity based on now?

**The tourism industry is also struggling;** the sights and activities that previously drew people into visiting a country renowned for its dramatic nature have diminished. The opportunities to benefit from ecotourism have been lost and local economies are worse off without being able to generate income from visitors. The options for attracting tourists are limited by hillsides overwhelmingly



covered in wind turbines and Sitka spruce; the 'wildness' that attracted people before is no longer there. In the eyes of potential visitors, has Scotland lost its magic?

It's not just its reputation amongst tourists that's been damaged; **Scotland, previously considered a potential leader on climate-related action, is now perceived as a major source of carbon emissions** due to its unaddressed degrading peatlands and a lack of industry shift to more sustainable practices. Our government is perceived to be ineffective. Fewer people are moving to Scotland from abroad each year, with **the country seen to be less desirable, less liveable, and offering less opportunity**; this will likely have knock-on effects in certain important industries which have high proportions of international workers. Scottish residents have lost hope that they will get to live in a stable, climate-resilient nation, and anxiety regarding the future swells.

But it's 2045 and the future is now. The consequences of inaction are not looming on the horizon anymore, they're here: **people's physical and mental wellbeing are suffering and NHS costs are soaring**. Access to greenspace is becoming increasingly difficult and urban populations are losing their connection to nature. Insurance costs are debilitating, for families and small businesses. Food costs are up as farmers struggle with declining crop yields year-on-year; the pollinators are just not there anymore! The nation relies more heavily on imports to plug the ever-growing production gaps, making us increasingly vulnerable to global shocks and externalities. More people are having to make tricky choices between which basics to buy... What can we go without?

**These devastating impacts are not being felt equally**. There are many instances of social inequality at play, for example those with less disposable income being hit by rising costs harder, and those who live in certain areas more likely to have their homes ruined by flooding. All these difficulties are contributing to **wide-ranging political instability and the future feels uncertain**. What would it have taken to not get to this place? How will future generations be impacted? What opportunities for nature restoration have we now missed? What could we have funded instead? **It's 2045; what regrets do we have?**

## Taking-action scenario

**It's 2045. Nature and the fundamental importance of biodiversity are considered in all decision-making processes; it is a top government and industry priority**. As a society, we understand that having a healthy and biodiverse environment underpins everything else. We recognise that nature is not an infinite resource and we have started to reflect better the true value of using nature in new regulations, subsidies, taxations, policies, and decisions; we recognise the real costs and benefits of all choices we make. All sectors understand their explicit connection to biodiversity loss and the potential downstream impacts of all activities undertaken; respect and accountability are woven into the deliberative fabric of society.

**Scotland has become a leading voice on biodiversity protection and the general population feels a national sense of empowerment and pride**. Scotland is playing its part in slowing down global emissions and ensuring the protection of biodiversity. People feel educated on biodiversity issues as notions of living within nature are embedded in all school curricula and there are mechanisms in place for communities to be heard on environmental issues.

**The economy has prioritised nature: measuring Scotland's success by its GDP is seen as outdated, and instead we look to how a healthy economy can exist within a healthy environment** and deem decisions and trajectories to be successful or not based on how they measure up to this expectation. Scotland's economy is more self-sufficient and deliberately designed to support regenerative production systems. These days, a big part of the economy is the requirement for sustainable, high-integrity, high-impact investments and markets that holistically consider and work to support the environment we all depend upon. Industries are all on board; they have made huge strides towards cooperating with an economic vision that respects biodiversity and nature as a whole.

**One transformed industry is the food sector:** sustainable farming and fishing practices are championed and well-supported by funding streams; local food production has increased with less concern regarding pests; there are higher levels of food sovereignty; and Scotland is a food secure nation.

**Rural and island populations are thriving.** They have viable economic and environmental futures, inspiring young people to move and take up new work opportunities and enabling communities to repopulate. Benefits have started to flow, from the provision of better local services and connections between different places, to the creation of more apprenticeships in nature-based livelihoods and the rise of a thriving, community-led ecotourism industry which supports the longevity of local economies and encourages visitors to engage with local heritage and nature restoration activities.

**Meanwhile, coastal communities are more resilient** to flooding risks and other climate events, with nature-based preventative measures firmly in place. Marine biodiversity is not sidelined, as discussions about biodiversity no longer focus overwhelmingly on terrestrial practices. With regularly updated marine and coastal monitoring and surveying, the **data is now coming in to assess the performance of habitats and species**. The same goes for data on land; carbon sequestration practices are becoming better understood and justly implemented. All mitigation and adaptation measures in place are properly implemented and adequately monitored, with responsive mechanisms in place.

**Local communities are supported to be stewards of the land they live on, with local knowledge respected and money provided to fund the realisation of local visions.** Nature can now support local populations as well as benefit national and international climate targets. Protecting historical and cultural heritage is seen to be integral to this process, with storytelling, identity, and contextual nuance championed. Further, **careful consideration is taken when deciding land use changes** – we recognise the need for land to be multi-functional and support sustainable long-term goals.

**People going about their everyday lives feel more connected to nature:** there are biodiverse blue-green spaces in cities, well-supported volunteering opportunities for restoring nature, and better rural-urban connectivity so people understand where their food comes from and how nature regulates liveable conditions. **Nature-based infrastructures support Scotland's resilience to climate change** and extreme weather conditions and better active travel and public transport

options have been implemented; as such, there is less of a burden on NHS services due to healthier populations not suffering from as many heat-related, pollution-exacerbated, or chronic illnesses. All of this, and more, means **life expectancy and mental wellbeing among the population have soared**; we have a fully realised wellbeing economy. **It's 2045; we are in the midst of achieving a Just Transition.**

## References

- Adade Williams, P., Sikutshwa, L. and Shackleton, S. (2020) 'Acknowledging Indigenous and Local Knowledge to Facilitate Collaboration in Landscape Approaches—Lessons from a Systematic Review', *Land*, 9(331), pp. 1–17. Available at: <https://doi.org/10.3390/land9090331>.
- Alcamo, J. (2008) 'Chapter One Introduction: the Case for Scenarios of the Environment', *Developments in Integrated Environmental Assessment*, 2, pp. 1–11. Available at: [https://doi.org/10.1016/S1574-101X\(08\)00401-8](https://doi.org/10.1016/S1574-101X(08)00401-8).
- Alcamo, J. and Henrichs, T. (2008) 'Chapter Two Towards Guidelines for Environmental Scenario Analysis', *Developments in Integrated Environmental Assessment*, 2, pp. 13–35. Available at: [https://doi.org/10.1016/S1574-101X\(08\)00402-X](https://doi.org/10.1016/S1574-101X(08)00402-X).
- Anstruther, A. and Stewart, G.G. (2022) 'Chapter 1 - An introduction to whisk(e)y and the development of Scotch whisky', *Whisky and Other Spirits (Third Edition)*. Edited by I. Russell, G.G. Stewart, and J. Kellershohn, pp. 1–6. Available at: <https://doi.org/10.1016/B978-0-12-822076-4.00032-2>.
- Armstrong, C. (2024) 'The biodiversity crisis and global justice: a research agenda', *Critical Review of International Social and Political Philosophy*, 0(0), pp. 1–20. Available at: <https://doi.org/10.1080/13698230.2024.2380218>.
- Artz, R. and Chapman, S. (2016) 'Peatlands', The James Hutton Institute, pp. 1-24. Available at: [https://www.hutton.ac.uk/sites/default/files/files/publications/Peatlands%20final\\_web\\_reduced%20size.pdf](https://www.hutton.ac.uk/sites/default/files/files/publications/Peatlands%20final_web_reduced%20size.pdf)
- Baka, A. and Mabon, L. (2022) 'Assessing equality in neighbourhood availability of quality greenspace in Glasgow, Scotland, United Kingdom', *Landscape Research*, 47(5), pp. 584–597. Available at: <https://doi.org/10.1080/01426397.2022.2051458>.
- Bateman, I. *et al.* (2011) 'Economic Values from Ecosystems', in *UK National Ecosystem Assessment: Technical Report*. Cambridge: United Nations Environment Programme World Conservation Monitoring Centre, pp. 1067–1152.
- Blanc, N. and Soini, K. (2015) 'Cultural and Biological Diversity: Interconnections in Ordinary Places', in C. De Beukelaer, M. Pyykkönen, and J.P. Singh (eds) *Globalization, Culture, and Development: The UNESCO Convention on Cultural Diversity*. London: Palgrave Macmillan UK, pp. 75–90. Available at: [https://doi.org/10.1057/9781137397638\\_6](https://doi.org/10.1057/9781137397638_6).
- Bradbury, R.B. *et al.* (2021) 'The economic consequences of conserving or restoring sites for nature', *Nature Sustainability*, 4(7), pp. 602–608. Available at: <https://doi.org/10.1038/s41893-021-00692-9>.
- Breeze, T.D. *et al.* (2020) 'Pollinator monitoring more than pays for itself', *Journal of Applied Ecology*, 58(1), pp. 44–57. Available at: <https://doi.org/10.1111/1365-2664.13755>.
- Breeze, T.D., Potts, S.G. and Roberts, S.P.M. (2012) *The Decline of England's Bees: Policy Review and Recommendations*. University of Reading, pp. 1–44.

- Brondízio, E.S. *et al.* (2021) 'Locally Based, Regionally Manifested, and Globally Relevant: Indigenous and Local Knowledge, Values, and Practices for Nature', *Annual Review of Environment and Resources*, 46, pp. 481–509. Available at: <https://doi.org/10.1146/annurev-environ-012220-012127>.
- Bullock, J.M. *et al.* (2011) 'Restoration of ecosystem services and biodiversity: conflicts and opportunities', *Trends in Ecology & Evolution*, 26(10), pp. 541–549. Available at: <https://doi.org/10.1016/j.tree.2011.06.011>.
- Cardenas Rubio, J., Warhurst, C. and Anderson, P. (2022) *Green Jobs in Scotland : An Inclusive Approach to Definition, Measurement and Analysis*. Warwick: University of Warwick, p. 55. Available at: [https://strathprints.strath.ac.uk/83080/1/Rubio\\_etal\\_2022\\_Green\\_jobs\\_in\\_scotland\\_an\\_inclusive\\_approach\\_to\\_definition\\_measurement\\_and\\_analysis.pdf](https://strathprints.strath.ac.uk/83080/1/Rubio_etal_2022_Green_jobs_in_scotland_an_inclusive_approach_to_definition_measurement_and_analysis.pdf).
- Chan, K.M.A. and Satterfield, T. (2013) 'Justice, equity, and biodiversity', *Encyclopedia of Biodiversity*, pp. 434–441.
- Chapin III, F.S. *et al.* (2000) 'Consequences of changing biodiversity', *Nature*, 405(6783), pp. 234–242. Available at: <https://doi.org/10.1038/35012241>.
- Costanza, R. *et al.* (2014) 'Changes in the global value of ecosystem services', *Global Environmental Change*, 26, pp. 152–158. Available at: <https://doi.org/10.1016/j.gloenvcha.2014.04.002>.
- Coz, D.M. and Young, J.C. (2020) 'Conflicts over wildlife conservation: Learning from the reintroduction of beavers in Scotland', *People and Nature*, 2(2), pp. 406–419. Available at: <https://doi.org/10.1002/pan3.10076>.
- Dasgupta, P. (2021) *The economics of biodiversity: the Dasgupta review: full report*. Updated: 18 February 2021. London: HM Treasury.
- Dearborn, D.C. and Kark, S. (2010) 'Motivations for Conserving Urban Biodiversity', *Conservation Biology*, 24(2), pp. 432–440. Available at: <https://doi.org/10.1111/j.1523-1739.2009.01328.x>.
- Decoupling Advisory Group (2020) *Building back better: Principles for sustainable resource use in a wellbeing economy*. Zero Waste Scotland. Available at: [https://pure.strath.ac.uk/ws/portalfiles/portal/122567846/Figus\\_etal\\_ZWS2020\\_Building\\_back\\_better\\_principles\\_sustainable\\_resource\\_use\\_wellbeing\\_economy.pdf](https://pure.strath.ac.uk/ws/portalfiles/portal/122567846/Figus_etal_ZWS2020_Building_back_better_principles_sustainable_resource_use_wellbeing_economy.pdf).
- Diamond, P. and Newman, J. (2024) 'Instability and inequality in the British state', *Parliamentary Affairs*, p. gsae023. Available at: <https://doi.org/10.1093/pa/gsae023>.
- Edinburgh Council (2015) *The value of City of Edinburgh Council's parks*. Edinburgh: Edinburgh Council, pp. 1–20. Available at: <https://www.edinburgh.gov.uk/downloads/file/24775/the-value-of-the-council-s-parks>.
- Eftec (2005) *The economic, social and ecological value of ecosystem services: A literature review*. London: Department for Environment, Food and Rural Affairs, p. 47. Available at:

<https://www.cbd.int/financial/values/unitedkingdom-valueliterature.pdf> (Accessed: 25 August 2024).

Gadgil, M., Berkes, F. and Folke, C. (2022) 'Indigenous knowledge for biodiversity conservation', in K.J. Fiorella et al. (eds) *Foundations of Socio-Environmental Research: Legacy Readings with Commentaries*. Cambridge: Cambridge University Press, pp. 506–511. Available at: <https://doi.org/10.1017/9781009177856.042>.

Glenk, K. et al. (2021) 'The opportunity cost of delaying climate action: Peatland restoration and resilience to climate change', *Global Environmental Change*, 70(102323), pp. 1–14. Available at: <https://doi.org/10.1016/j.gloenvcha.2021.102323>.

Glenk, K. et al. (2022) *The costs of peatland restoration revisited - March 2022 update on database based on the Peatland Action Programme in Scotland*. SEFARI.

Gordon, I. et al. (2010) 'International year of biodiversity: Missed targets and the need for better monitoring, real action and global policy', *Animal Conservation*, 13, pp. 113–114. Available at: <https://doi.org/10.1111/j.1469-1795.2010.00365.x>.

Green Finance Institute (2024) *Assessing the materiality of nature-related financial risks for the UK*. Reading: University of Reading, p. 135. Available at: <https://legacy.greenfinanceinstitute.com/wp-content/uploads/2024/04/GFI-UK-NATURE-RELATED-RISKS-FULL-REPORT.pdf> (Accessed: 25 August 2024).

Greenspace Scotland (2018) *The third state of Scotland's greenspace report*. Stirling: Greenspace Scotland, pp. 1–51. Available at: [https://drive.google.com/file/d/1aQLMu60G5WRi4QKBCuZJ92oT8eM2sxd3/view?usp=drive\\_open&usp=embed\\_facebook](https://drive.google.com/file/d/1aQLMu60G5WRi4QKBCuZJ92oT8eM2sxd3/view?usp=drive_open&usp=embed_facebook) (Accessed: 25 August 2024).

Gupta, J. et al. (2023) 'Earth system justice needed to identify and live within Earth system boundaries', *Nature Sustainability*, 6(6), pp. 630–638. Available at: <https://doi.org/10.1038/s41893-023-01064-1>.

Hanley, N. and Perrings, C. (2019) 'The Economic Value of Biodiversity', *Annual Review of Resource Economics*, 11, pp. 355–375. Available at: <https://doi.org/10.1146/annurev-resource-100518-093946>.

Hayden, A. and Dasilva, C. (2022) 'The wellbeing economy: Possibilities and limits in bringing sufficiency from the margins into the mainstream', *Frontiers in Sustainability*, 3, pp. 1–19. Available at: <https://doi.org/10.3389/frsus.2022.966876>.

Hill, R. et al. (2020) 'Working with Indigenous, local and scientific knowledge in assessments of nature and nature's linkages with people', *Current Opinion in Environmental Sustainability*, 43, pp. 8–20. Available at: <https://doi.org/10.1016/j.cosust.2019.12.006>.

Horrill, J.C., Oliver, M.K. and Stubbs Partridge, J. (2019) 'Lessons on effectiveness and long-term prevention from broad-scale control of invasive alien species in Scotland's rivers and lochs', in C.R.

Veitch et al. (eds) *Island invasives: scaling up to meet the challenge*. Dundee: Species Survival Commission, pp. 458–465.

IPBES (2019) *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES secretariat, pp. 1–1148. Available at: <https://doi.org/10.5281/zenodo.6417333>.

IPBES (2022) *Methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES secretariat, pp. 1–620. Available at: <https://doi.org/10.5281/zenodo.7687931>.

Isbell, F. et al. (2014) 'The biodiversity-dependent ecosystem service debt', *Ecology Letters*, 18(2), pp. 119–134. Available at: <https://doi.org/10.1111/ele.12393>.

Isbell, F. et al. (2023) 'Expert perspectives on global biodiversity loss and its drivers and impacts on people', *Frontiers in Ecology and the Environment*, 21(2), pp. 94–103. Available at: <https://doi.org/10.1002/fee.2536>.

Iwaniec, D. et al. (2020) 'The co-production of sustainable future scenarios', *Landscape and Urban Planning*, 197(103744), pp. 1–11. Available at: <https://doi.org/10.1016/j.landurbplan.2020.103744>.

Kubiszewski, I. et al. (2013) 'Beyond GDP: Measuring and achieving global genuine progress', *Ecological Economics*, 93, pp. 57–68. Available at: <https://doi.org/10.1016/j.ecolecon.2013.04.019>.

Kubiszewski, I. et al. (2023) 'The complex relationships between economic inequality and biodiversity: A scoping review', *The Anthropocene Review*, 11(1), pp. 49–66. Available at: <https://doi.org/10.1177/20530196231158080>.

Kumar, A., Shukla, A. and Kailkhura, S. (2024) 'Biodiversity loss and its economic costs: a global perspective', *Research Journal of Recent Sciences*, 13(1), pp. 1–7.

Lam, D. et al. (2020) 'Indigenous and local knowledge in sustainability transformations research: A literature review', *Ecology and Society*, 25(1), pp. 1–25. Available at: <https://doi.org/10.5751/ES-11305-250103>.

*Mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB* (2010). Geneva: UNEP, p. 39. Available at: <https://www.teebweb.org/wp-content/uploads/Study%20and%20Reports/Reports/Synthesis%20report/TEEB%20Synthesis%20Report%202010.pdf> (Accessed: 25 August 2024).

Martin, A. (2020) 'Biodiversity: Crisis, conflict and justice', in B. Coolsaet (ed.) *Environmental Justice*. Routledge.

Martino, S., Juarez-Bourke, A. and Miller, D. (2023) *The Environment Strategy for Scotland Driving the Transition to a Nature Positive Economy: A Synthesis of Policy Levers for Governments*. Aberdeen: James Hutton Institute, p. 95. Available at: <https://doi.org/10.5281/ZENODO.8128242>.

- McElwee, P. *et al.* (2020) 'Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment', *Journal of Applied Ecology*, 57(9), pp. 1666–1676. Available at: <https://doi.org/10.1111/1365-2664.13705>.
- McIntyre-Mills, J. (2018) 'Recognizing our hybridity and interconnectedness: Implications for social and environmental justice', *Current Sociology*, 66(6), pp. 886–910. Available at: <https://doi.org/10.1177/0011392117715898>.
- Mehring, M. *et al.* (2017) 'Halting biodiversity loss: how social–ecological biodiversity research makes a difference', *International Journal of Biodiversity Science, Ecosystem Services & Management*, 13(1), pp. 172–180. Available at: <https://doi.org/10.1080/21513732.2017.1289246>.
- Millard, J. *et al.* (2021) 'Global effects of land-use intensity on local pollinator biodiversity', *Nature Communications*, 12(2902), pp. 1–11. Available at: <https://doi.org/10.1038/s41467-021-23228-3>.
- Moxey, A. and Morling, P. (2018) *Funding for peatland restoration and management*. IUCN UK Peatland Programme, p. 33.
- Murphy, J.T. *et al.* (2022) 'Globalisation and pollinators: Pollinator declines are an economic threat to global food systems', *People and Nature*, 4(3), pp. 773–785. Available at: <https://doi.org/10.1002/pan3.10314>.
- Nakićenović, N. *et al.* (2000) *Special report on emissions scenarios: a special report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge: IPCC, p. 608.
- National Trust for Scotland (2024) *A guide to Scottish whisky*, National Trust for Scotland. Available at: <https://www.nts.org.uk/stories/a-guide-to-scottish-whisky> (Accessed: 28 August 2024).
- NatureScot (2023a) *Ecosystem services - nature's benefits*, NatureScot. Available at: <https://www.nature.scot/scotlands-biodiversity/scottish-biodiversity-strategy-and-cop15/ecosystem-approach/ecosystem-services-natures-benefits> (Accessed: 28 August 2024).
- NatureScot (2023b) *What is Biodiversity?*, NatureScot. Available at: <https://www.nature.scot/scotlands-biodiversity/what-biodiversity> (Accessed: 25 August 2024).
- NatureScot (2023c) *Key pressures on biodiversity*, NatureScot. Available at: <https://www.nature.scot/scotlands-biodiversity/key-pressures-biodiversity> (Accessed: 28 August 2024).
- NatureScot (2024) *Tourism*, NatureScot. Available at: <https://www.nature.scot/professional-advice/social-and-economic-benefits-nature/tourism> (Accessed: 25 August 2024).
- Nordbeck, R. and Høgl, K. (2023) 'National peatland strategies in Europe: current status, key themes, and challenges', *Regional Environmental Change*, 24(1), p. 5. Available at: <https://doi.org/10.1007/s10113-023-02166-4>.
- Nugent, K. *et al.* (2019) 'Prompt active restoration of peatlands substantially reduces climate impact', *Environmental Research Letters*, 14(124030), pp. 1-11.



- Pakeman, R.J. *et al.* (2023) *Understanding the Indirect Drivers of Biodiversity Loss in Scotland*. NatureScot. Available at: <https://www.nature.scot/doc/naturescot-research-report-1309-understanding-indirect-drivers-biodiversity-loss-scotland> (Accessed: 24 August 2024).
- Paloniemi, R. *et al.* (2012) 'Biodiversity conservation across scales: lessons from a science–policy dialogue', *Nature Conservation*, 2, pp. 7–19. Available at: <https://doi.org/10.3897/natureconservation.2.3144>.
- Peake, S., Innes, P. and Dyer, P. (2009) 'Ecotourism and conservation: factors influencing effective conservation messages', *Journal of Sustainable Tourism*, 17(1), pp. 107–127. Available at: <https://doi.org/10.1080/09669580802276000>.
- Pickering, J. *et al.* (2022) 'Rethinking and Upholding Justice and Equity in Transformative Biodiversity Governance', in I.J. Visseren-Hamakers and M.T.J. Kok (eds), pp. 155–178. Available at: <https://ueaeprints.uea.ac.uk/id/eprint/85334/> (Accessed: 24 August 2024).
- Pörtner, H.-O. *et al.* (2023) 'Overcoming the coupled climate and biodiversity crises and their societal impacts', *Science*, 380(6642), p. eabl4881. Available at: <https://doi.org/10.1126/science.abl4881>.
- Revell, P. and Dinnie, E. (2020) 'Community resilience and narratives of community empowerment in Scotland', *Community Development Journal*, 55(2), pp. 218–236. Available at: <https://doi.org/10.1093/cdj/bsy038>.
- Reyers, B. and Selig, E.R. (2020) 'Global targets that reveal the social–ecological interdependencies of sustainable development', *Nature Ecology & Evolution*, 4(8), pp. 1011–1019. Available at: <https://doi.org/10.1038/s41559-020-1230-6>.
- Richardson, W. *et al.* (2021) *An Analysis of the Cost of Grey Squirrel Damage to Woodland*. RDI Associates Ltd, p. 46. Available at: <https://rfs.org.uk/wp-content/uploads/2021/03/analysis-of-the-cost-of-grey-squirrel-damage-to-woodland-publication-copy-180121.pdf>.
- Roberts, C. and Maslin, M. (2021) *How might climate change impact Scotch Whisky production in the next 50-100 years?* UCL, p. 21. Available at: [https://fosm.de/wp-content/uploads/2021/10/How-might-climate-change-impact-Scotch-whisky-production-in-the-next-50-100-years\\_v2.pdf](https://fosm.de/wp-content/uploads/2021/10/How-might-climate-change-impact-Scotch-whisky-production-in-the-next-50-100-years_v2.pdf).
- Roy, M.J. (2021) 'Towards a "Wellbeing Economy": What Can We Learn from Social Enterprise?', in B. Gidron and A. Domaradzka (eds) *The New Social and Impact Economy: An International Perspective*. Cham: Springer International Publishing, pp. 269–284. Available at: [https://doi.org/10.1007/978-3-030-68295-8\\_13](https://doi.org/10.1007/978-3-030-68295-8_13).
- RSPB (2024) *Scotland: Our work to protect Scotland's wildlife*, RSPB. Available at: <https://www.rspb.org.uk/scotland> (Accessed: 25 August 2024).
- Rubio, J.C., Warhurst, C. and Anderson, P. (2022) *Green Jobs in Scotland : An Inclusive Approach to Definition, Measurement and Analysis*. Warwick: Warwick Institute for Employment Research, pp. 1–55. Available at:

[https://strathprints.strath.ac.uk/83080/1/Rubio etal 2022 Green jobs in scotland an inclusive approach to definition measurement and analysis.pdf](https://strathprints.strath.ac.uk/83080/1/Rubio%20etal%202022%20Green%20jobs%20in%20scotland%20an%20inclusive%20approach%20to%20definition%20measurement%20and%20analysis.pdf).

Scotch Whisky Association (2024) *Facts & Figures*, Scotch Whisky Association. Available at: <https://www.scotch-whisky.org.uk/insights/facts-figures/> (Accessed: 28 August 2024).

Scottish Government (2024a) *News - Record high peatland restoration*, Scottish Government. Available at: <https://www.gov.scot/news/record-high-peatland-restoration/> (Accessed: 25 August 2024).

Scottish Government (2024b) *Policy: Biodiversity*, Scottish Government. Available at: <https://www.gov.scot/policies/biodiversity/> (Accessed: 25 August 2024).

Scottish Invasive Species Initiative (2024) *Invasive Plant Project*, Scottish Invasive Species Initiative. Available at: <https://www.invasivespecies.scot/invasive-plant-project> (Accessed: 28 August 2024).

Scottish Natural Heritage (2017) *Pollinator Strategy for Scotland 2017-2027*. Scottish Natural Heritage, pp. 1–16.

Scottish Wildlife Trust (2023) *Ensuring a future for our iconic red squirrel*. Available at: <https://scottishwildlifetrust.org.uk/2023/05/ensuring-a-future-for-our-iconic-red-squirrel/> (Accessed 10 October 2024).

Snep, R.P.H. and Clergeau, P. (2020) 'Biodiversity in Cities, Reconnecting Humans with Nature', in V. Loftness (ed.) *Sustainable Built Environments*. New York, NY: Springer US, pp. 251–274. Available at: [https://doi.org/10.1007/978-1-0716-0684-1\\_296](https://doi.org/10.1007/978-1-0716-0684-1_296).

Spracklen, K. (2014) 'Bottling Scotland, drinking Scotland: Scotland's future, the whisky industry and leisure, tourism and public-health policy', *Journal of Policy Research in Tourism, Leisure and Events*, 6(2), pp. 135–152. Available at: <https://doi.org/10.1080/19407963.2014.911517>.

State of Nature (2023) *State of Nature*. State of Nature Partnership, pp. 1–108. Available at: [https://stateofnature.org.uk/wp-content/uploads/2023/09/TP25999-State-of-Nature-main-report\\_2023\\_FULL-DOC-v12.pdf](https://stateofnature.org.uk/wp-content/uploads/2023/09/TP25999-State-of-Nature-main-report_2023_FULL-DOC-v12.pdf) (Accessed: 25 August 2024).

Stern, N.H. (2007) *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

Sumaila, U.R. *et al.* (2017) 'Investments to reverse biodiversity loss are economically beneficial', *Current Opinion in Environmental Sustainability*, 29, pp. 82–88. Available at: <https://doi.org/10.1016/j.cosust.2018.01.007>.

The International Ecotourism Society (2024) *What Is Ecotourism*, The International Ecotourism Society. Available at: <https://ecotourism.org/what-is-ecotourism/> (Accessed: 28 August 2024).

Tisdell, C.A. (2009) 'Issues in Biodiversity Conservation Including the Role of Local Communities', *Environmental Conservation*, 22(3), pp. 216–222. Available at: <https://doi.org/10.1017/S0376892900010614>.

Tonkin, M., Hatcher, G. and Tipple, N. (2023) *Saving an icon: Final report from the developing community action phase of Saving Scotland's Red Squirrels*. Edinburgh: Saving Scotland's Red Squirrels, p. 119.

Vanbergen, A.J. *et al.* (2014) *Status and value of pollinators and pollination services*. UK Centre for Ecology and Hydrology. Department for Environment, Food and Rural Affairs, p. 53. Available at: <https://nora.nerc.ac.uk/id/eprint/505259/> (Accessed: 25 August 2024).

Visit Scotland (2024) *Why People Choose Scotland - Research & Insights*, Visit Scotland. Available at: <http://www.visitscotland.org/research-insights/about-our-visitors/why-people-choose-scotland> (Accessed: 25 August 2024).

Visser-Quinn, A. *et al.* (2021) 'Mapping future water scarcity in a water abundant nation: Near-term projections for Scotland', *Climate Risk Management*, 32, p. 100302. Available at: <https://doi.org/10.1016/j.crm.2021.100302>.

Webb, S.A. *et al.* (2021) 'A framework for conceptualizing leadership in conservation', *Oryx*, 56(5), pp. 664–670. Available at: <https://doi.org/10.1017/S0030605320000629>.

Wheeler, H. and Root-Bernstein, M. (2020) 'Informing decision-making with Indigenous and local knowledge and science', *Journal of Applied Ecology*, 57, pp. 1634–1643. Available at: <https://doi.org/10.1111/1365-2664.13734>.

White, R.M. *et al.* (2023) 'The future starts in the past: embedding learning for sustainability through culture and community in Scotland', *Frontiers in Sustainability*, 4, pp. 1–18. Available at: <https://doi.org/10.3389/frsus.2023.1128620>.

Williams, F. *et al.* (2010) *The economic cost of invasive non-native species on Great Britain*. CAB/001/09. Wallingford: CABI, p. 199.

World Economic Forum (2023) *The Global Risks Report 2023: 18th Edition Insight Report*. Switzerland: World Economic Forum, p. 98. Available at: [https://www3.weforum.org/docs/WEF\\_Global\\_Risks\\_Report\\_2023.pdf](https://www3.weforum.org/docs/WEF_Global_Risks_Report_2023.pdf) (Accessed: 25 August 2024).

Xu, H. *et al.* (2021) 'Ensuring effective implementation of the post-2020 global biodiversity targets', *Nature Ecology & Evolution*, 5(4), pp. 411–418. Available at: <https://doi.org/10.1038/s41559-020-01375-y>.

## Appendix 1: Workshop prompts

Round 1 (20 mins)

### Biodiversity loss priorities / scenario focus

1. *individually* write 5 important\* types of biodiversity decline on post-its
  - 5 mins
  - 1 answer per post-it
2. discuss post-its
  - 10 mins
  - Go round the group, explaining post-its & clustering overlapping answers
3. agree and rank 5 most important answers
  - 5 mins
  - Write most important types of biodiversity decline on poster

\*considering economic, social and environmental importance

Round 2a (30 mins)

### Delayed-action scenario for 2045

#### Principles

- Biodiversity decline continues
- Policy and actions to restore biodiversity are not a government priority
- No further significant policy actions are taken in Scotland
- Public sector funding for nature remains at current levels
- In summary: what we have now, but nothing more...

#### ***What will Scotland be like under this scenario?***

For each listed biodiversity decline, discuss and write down:

- The ***economic, social and environmental consequences***
- The ***economic costs*** of these consequences
- Any ***examples*** or supporting evidence (incl. reports, studies and other sources)

Round 2b (10 mins)

## Delayed-action scenario for 2045

- Thinking holistically, what would 'delayed action' mean for Scotland?
  - Add your thoughts to the mind-map
  - Discuss as a group, but feel free add individually too
  - Consider economic, social and environmental consequences
  - Think of different sectors and parts of the country

Round 3a (30 mins)

## Taking-action scenario for 2045

### Principles

- Biodiversity decline has been stopped and there is evidence of net positive change
- Policy and actions to restore biodiversity loss are a government priority
- New significant policies and actions are taken in Scotland
- Public sector funding nature is increased
- In summary: nature is a priority and intervention are successful

### ***What will Scotland be like under this scenario?***

For each listed biodiversity decline, discuss and write down:

- The actions required to halt/reverse the decline
- The ***economic, social and environmental impacts*** (*positive and negative*) of taking these actions
- The ***economic costs*** of taking these actions
- Any ***examples*** or supporting evidence (incl. reports, studies and other sources)

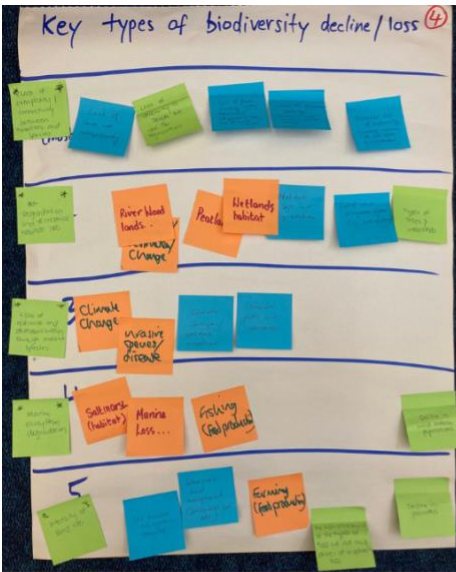
Round 3b (10 mins)

## Taking-action scenario for 2045

- Thinking holistically, what would 'taking action' mean for Scotland?
  - Add your thoughts to the mind-map
  - Discuss as a group, but feel free add individually too
  - Consider economic, social and environmental consequences
  - Think of different sectors and parts of the country

# Appendix 2: Workshop materials from each group

## Group A

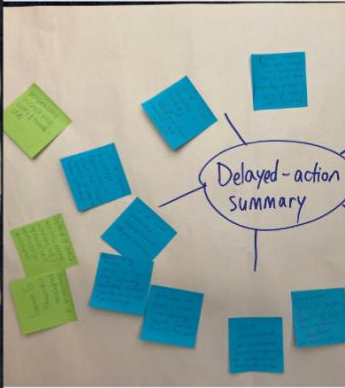


**Delayed-action Scenario: Key examples?**

1. Change in top marine predators  
Loss of genetic diversity within (breed) populations  
Marine loss of fish populations - diversity marine syndrome
2. Loss of Urban Squirrels - Hedge  
Habitat loss driven by Carbon Credits  
Commercial forestry impacts on Wooded areas  
Habitat loss driven by Carbon Credits  
Squirrels - also Squirrels
3. Invasive Species take hold - Squid  
Honeybees - other species  
Hedge - Carbon Chemicals are diagnosed and detection  
Short term solutions in a decade ->
4. Commercial aquaculture  
Sustainability of aquaculture  
Sustainability of aquaculture and biodiversity of aquaculture as consumers  
Increase in wild salmon populations - salmon are finding in rivers  
Increase in wild salmon populations - salmon are finding in rivers  
Increase in wild salmon populations - salmon are finding in rivers
5. Decline in pollinators  
Decline in pollinators and agricultural resources  
Decline in pollinators and agricultural resources  
Decline in pollinators and agricultural resources  
Decline in pollinators and agricultural resources  
Decline in pollinators and agricultural resources

**Delayed-action Scenario**

consequences?	costs? (£)
1. Loss of genetic diversity -> loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations	Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations
2. Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations	Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations
3. Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations	Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations
4. Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations	Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations
5. Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations	Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations Loss of genetic diversity within (breed) populations

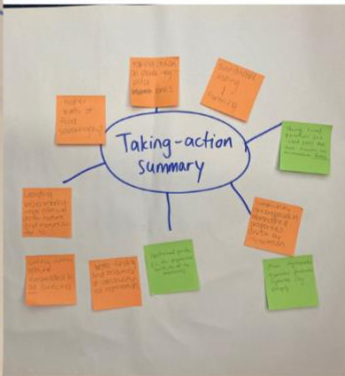


**Taking-action Scenario**

costs? (£)	Key examples?
1	Climate Biodiversity Strategy
2	
3	
4	Integrated aquaculture (Always mixed + seaweed) Sustainable fish Shellfish bioremediation (eg. biological waste demand and use of native oysters by Chamaeleon Dredging)
5	

**Taking-action Scenario**

actions?	impacts?
1. Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations	Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations
2. Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations	Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations
3. Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations	Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations
4. Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations	Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations
5. Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations	Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations Increase genetic diversity within (breed) populations



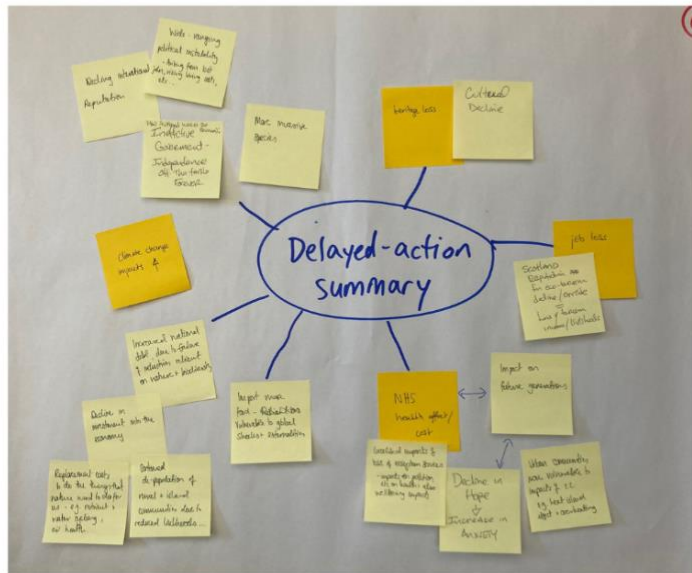
### Key types of biodiversity decline/loss (6)

- 1 Soil health:**
  - Things living within
  - Structure
  - Impact of human activities (farming, forestry, etc)
- 2**
- 3**
- 4**
- 5**

# Group B

### Delayed-action Scenario (6)

consequences?	costs? (£)
<p>Declining Agricultural Production → livelihoods, community cohesion/outlets</p> <p>Declining Plant Health</p> <p>Soil -&gt; Soil (concentrations) impacts Soil degradation &amp; erosion Soil depletes soil Nutrient impacts human health, reduces human well-being, Biodiversity → NBS demands</p> <p>(Re-visit = feedback)</p> <p>2. <b>Greenhouse emissions</b> = ↑ climate &amp; sea level rise            Plant-Specific biodiversity loss            Loss of local livelihoods re past environmental consequences            Disconnection between local people - land</p>	Seasonal -> 2nd -> 3rd -> 4th -> 5th -> 6th
<p>3. <b>Collapsed Fishing Industry</b> - Local economy &amp; livelihoods            Loss of food security &amp; nutrition            Marine-based eco-tourism loss</p>	
<p>4. <b>Food security decreases</b>            Decline in all pollinating-dependent species            Continued high level inputs of synthetic pesticides            Declining Plant Diversity &amp; Genetics</p>	
<p>5. <b>Small/loss of Green impacts</b>            Negative impact on well-being eco-tourism</p>	



### Taking-action Scenario (6)

actions?	impacts?
<p>Implement NBS - Natural flood mgmt.</p> <p>Decrease chemical inputs (organic)</p> <p>Increase research</p> <p>Provide regional funding + small-scale local initiatives - community ownership</p> <p>Diversity what-if games</p> <p>1. <b>Community land ownership</b></p> <p>Fill gaps to incentivise restoration activity</p> <p>Regulate/Regulations - introduce obligations to restore</p> <p>Incentivising private investment</p>	<p>→ Less erosion, less nutrient loss</p> <p>→ Increased productivity</p> <p>→ Knowledge &amp; resources increase, livelihoods</p> <p>→ Localised bird benefits &amp; stronger local economies</p> <p>→ Support biodiversity, food supply</p>
<p>2. <b>Remove obstacles for productivity</b></p> <p>Incentivise restoration - stocked benefits</p> <p>Land owners obligated to act (high priority)</p> <p>Robust carbon credits market</p>	<p>→ Increase nature biodiversity, while compensating/containing impact on fish</p> <p>→ Long term benefits</p> <p>→ Species as above</p>
<p>3. <b>Seabed restoration</b></p> <p>Regulate coral fishing with co-management + bottom up processes</p> <p>Regulate quantitative data impact on local stocks</p>	
<p>4. <b>Community leadership + involvement in nature networks</b></p> <p>Protecting pollinating species</p> <p>Regulation</p> <p>Decreased chemical inputs</p>	<p>→ Increased biodiversity, more pollinators - better green spaces</p> <p>→ More pollinators</p> <p>→ More food locally</p>
<p>5. <b>Enforcement of protected areas, species measures</b></p> <p>Monitoring - Citizen science</p> <p>Implement management measures</p>	<p>→ Appropriation of legislation met targets will be met</p> <p>→ Improved data</p> <p>→ contribute to meeting objectives of legislation</p>





Key types of biodiversity decline/loss

- 1. Indicators
- 2. Air Quality
- 3. Water
- 4. Land management
- 5. Species

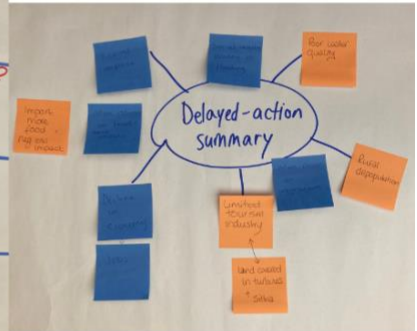
# Group C

Delayed-action Scenario ③

consequences?	costs? (£)
1. Decline in honey bees, beans, oil, farming, loss of jobs	£43M pa
2. Impact on whiskey industry - jobs, exports, crops 41,000 jobs created by whiskey industry	2023: £2.9 billion £7.1
3. Impacts on salmon, tourism - fly fishing, flooding, water quality - cost of water purification, loss of soil due to poor water management	Salmon - £578m - 2022 Flooding £250M pa
4. Paying farmers to produce food that is damaging biodiversity 19% green gas emissions are from agri	Ag Subsidies £620M pa
5. Tourism	£11 Bn - tourism

Delayed-action Scenario: Key examples? ③

- NatureScot Pollinators Strategy  
LBAP
- Whiskey Industry - water plan/framework?
- Flood mang plans  
SEPA regulations - Scottish Water regs
- Agricultural subsidy
- 

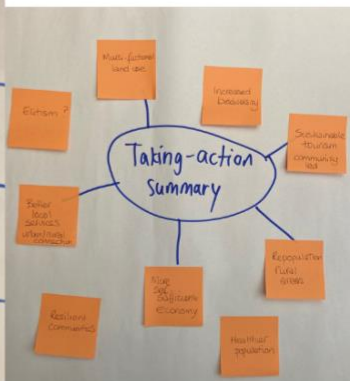


Taking-action Scenario ③

costs? (£)	Key examples?
1. Higher food prices: Tradeoff in subsidy Increased labour costs?	Rural Ag movement Rebuilding Britain
2. Related to education/awareness raising	Crop rotation + diversity Working with natural systems Allotments Nature Networks
3. Negotiation costs	Natural Flood Mang Beavers
4. Reduced costs on NHS	Scottish landscape Strategy
5. Tourism Infrastructure pos. + neg. long of INNS	South of Scotland Responsible Tourism Strategy

Taking-action Scenario ③

actions?	impacts?
1. Creation of habitats for pollinators to thrive Reduction of pesticide use	More pollinators
2. More viable land that we can use	More efficient production
3. Encouraging people to have ponds, wetland management, river flows - natural flood management	Wellbeing Community Wealth Building
4. Access to green spaces for mental wellbeing	Better wellbeing and happiness
5. habitat management, population management, management of (NNS) (universe non-native species)	Increase in species Populations appear from farmers



# Group D

### Key types of biodiversity decline/loss<sup>5</sup>

- (most key)**
  - Loss of habitats
  - Loss of genetic diversity
  - Over-exploitation
  - Food security
- Loss of genetic diversity
  - Loss of habitats
  - Over-exploitation
  - Food security
- Loss of genetic diversity
  - Loss of habitats
  - Over-exploitation
  - Food security
- Loss of genetic diversity
  - Loss of habitats
  - Over-exploitation
  - Food security
- Loss of genetic diversity
  - Loss of habitats
  - Over-exploitation
  - Food security

### Delayed-action Scenario<sup>5</sup>

consequences?	costs? (£)
1	1
2	2
3	3
4	4
5	5

### Delayed-action Scenario: Key examples?<sup>5</sup>

- 1
- 2
- 3
- 4
- 5



### Taking-action Scenario<sup>5</sup>

actions?	impacts?
1	1
2	2
3	3
4	4
5	5

### Taking-action Scenario

costs? (£)	Key examples?
1	1
2	2
3	3
4	4
5	5

