NatureScot
Scotland's Nature Agency

**NatureScot**

**SCIENTIFIC ADVISORY COMMITTEE**

**DISCUSSION PAPER**

# HORIZON SCANNING, March 2023

## Purpose

1. Following discussion in November 2022, a paper on horizon scanning is a standing item on the SAC agenda. A separate paper covers the deep-dive into plant health arising from the November meeting.

## Action

1. The SAC is invited to
   * discuss the paper, including any additional items to note, and to identify whether a deeper dive into specific issues is required (none identified/ recommended based on this paper)
   * comment on style and content, to refine future versions accordingly

## Preparation

1. The paper was written by Clive Mitchell and Des Thompson with contributions from David O’Brien, Debbie Bassett and Philippa Vigano. It is sponsored by Eileen Stuart.

## Background

1. With this standing item, the SAC contributes to a suite of horizon scanning activities carried out in NatureScot including:
   * Monthly SLT meetings (typically looking a few weeks/months ahead)
   * Quarterly Audit and Review Committee meetings (typically looking 6-12 months ahead)
   * Various staff activities and insights including annual contribution to Bill Sutherland’s look ahead for UK environmental legislation and policy (published via the BES), subject expertise and engagement with various horizon scanning networks (mainly Scottish Government, Defra, Natural Environment Social Research Network and UKRI projects (ACCESS).
2. Highlights are summarised below, grouped by STEEPLE (social, technology, environment, economy, political, legal and ethics), starting with the nearer-term (1-5 years) and then longer term (5-10 years).

*Near-term – 1-5 years*

1. *Social*. There is increasing awareness that the transition to a nature-positive net zero world will require significant behaviour change. This is not only the shallower ‘nudges’ that Government tends to focus on, but deeper systemic change. The evidence to support this will be both quantitative and qualitative, with the latter drawing heavily on the insights provided by social sciences including framings, context, situation, lived experience, politics and power relations. Science is not a ‘get out of politics free’ card[[1]](#footnote-1). We are involved in UKRI projects that aim to build social science capacity in dealing with climate-nature issues including [ACCESS](https://greenfutures.exeter.ac.uk/access/) (advancing capacity for climate environment social science), [RENEW](https://renewbiodiversity.org.uk/) (renewing nature through a people in nature approach) and [agrifood4netzero](https://www.agrifood4netzero.net/) (transforming the agrifood system towards net zero).
2. *Technology*.
   * ‘Omics’[[2]](#footnote-2) (genomics (DNA), transcriptomics (RNA), proteomics (proteins), epigenomics (chemical marks on the genome), metabolomics (metabolites), and meta-omics (community-level metagenomics and metatranscriptomics)) will be increasingly used to illuminate major drivers of biodiversity loss including invasive species, pollution, urbanization and climate change. These techniques have the potential to provide insights on species discovery, loss and preservation, enable better predictions of biodiversity responses to environmental disturbances and so inform the design of strategies to mitigate impacts. Translating theory into policy and practice remains a significant challenge1, but doing so will be necessary to fully deliver the Global Biodiversity Framework agreed at COP15[[3]](#footnote-3).
   * Synthetic biology has the potential to transform biodiversity conservation, both directly and indirectly, in ways that are negative and positive[[4]](#footnote-4). Applications include the wildlife trade (including trade in synthetic organisms), disease (e.g. vector control) and gene editing to control invasive species and pests, plus applications to change production methods for consumer products such as Omega-3 oils and others to reduce carbon emission and land use or improve nutrient cycles. However, applying these biotechnology tools to environmental questions is fraught with uncertainty and could harm cultures, rights, livelihoods, and nature.
   * LiDAR (Light Detection and Ranging)[[5]](#footnote-5) is a technology used to create high resolution relief or terrain models. Airborne LiDAR provides 3D mapping at 0.1 m compared to 10 m at best for satellite equivalent. This has the potential to transform the way that we map habitats and their condition; using proxies like surface roughness and composition, accurate change detection is possible from repeat scans and it can also map tree species and density. This depends on several factors such as spatial and temporal resolution and the skills to manage and interpret the data. There are plans for a Scotland LiDAR programme[[6]](#footnote-6) (Scotland is the only UK nation without a LiDAR programme), led by Scottish Government and NatureScot is involved in developing use cases for the data. We are planning to work with JNCC on 2 Simple ARD[[7]](#footnote-7) projects next year 2023/4 using LiDAR and other Very High Resolution data to map wetlands and coastal habitat change. We are also partners in FLS LiDAR programme which is going to fly an area on the west coast. Our contribution will mean that we get access to the data and a seat on the project board which will be an opportunity to upskill our EO team and understand how to develop a ground verification programme.

* The potential of IoT (sensors) and Earth Observation data is huge. This is the combination of in-situ data from sensors transmitted by satellite (IoT) with remotely sensed data. Multiple potential uses, and cost are probably the main barriers. It could be used to monitor change in condition, but we need to understand the temporal resolution that is needed. Some work is on-going with SIEC and the Forth ERA project (Forth Environmental Resilience Array)[[8]](#footnote-8) using sensors to monitor peatland condition and a CivTech 6.0 challenge[[9]](#footnote-9) “How do we better plan, manage and respond to the experiences of visitors and communities at visitor hotspots in rural and remote locations?” is using IoT sensors to gain real time information that is used in predictive algorithms to give visitors, rangers and planners the information that they need to make decisions.

1. *Environment*.

* The Climate Change Committee is increasing the emphasis on integration of its work across adaptation and mitigation, with land use and agriculture one of four themes to focus on[[10]](#footnote-10).
* Increased ability of invertebrate species to reproduce asexually. Freshwater invasive crustacean marbled crayfish (*Procambarus virginalis*), has spread across Europe and into Africa through asexual reproduction[[11]](#footnote-11).
* As farming systems in Scotland evolve to better tackle the climate-nature crisis, an increased knowledge of evidence in agroecology and functional agrobiodiversity will be required to support and advise the Scottish Government. A wide range of outcomes of practical farm-level and landscape scale measures are currently being investigated in contexts relevant to Scotland.

1. *Economy*. There is increasing awareness that transforming food systems is key to addressing the climate-nature emergency. We have been working with Scottish Government to extend their framing of the circular economy from materials flows and food waste to embrace the whole economy, including the biology that underpins the rural economy. This has a high profile in the draft Scottish Biodiversity Strategy and may form a Chapter in the Climate Change Plan currently in preparation. Significant challenges remain to develop business models for a circular economy.
2. *Politics*. A new First Minister could lead to changes in the dynamics of the SNP and Cabinet re-shuffles that affect our relationships with Scottish Government.
3. *Legal*. The SNP/Green Party Bute House Agreement legislative programme for the current Parliament includes Bills for Land Reform, Agriculture, Crofting, Muirburn, Hunting with Dogs, Grouse Moor Management, Natural Environment (30x30, nature networks, National Parks and strengthening marine protections), Human Rights, Circular Economy, Wellbeing and Sustainable Development. There is the potential for significant positive change from these Bills but challenges in ensuring the policy content is ambitious and the connections between Bills is constructive.
4. *Ethics*. A strengthening of the consumer-led trend to plant-based proteins could have implications for the role of livestock farming in Scotland, depending on the significance of the export market. A change in farming practice towards more agro-ecological practices is required to address greenhouse gas emissions, reduce exposure to climate risks and enhance the state of nature.

*Longer term (5-10 years)*

1. The list below is the 15 items highlighted in Sutherland and co-workers annual global review[[12]](#footnote-12), which are mainly technology-led and looks mainly 5-10 years ahead. A few notes are added for items that may be of particular relevance to Scotland:

* Increased demand for chitosan
* Development and expansion of selective lithium extraction technologies
* DNA-enabled biobatteries
* Advances in converting human urine into fertilisers
* Reducing use of inorganic fertilisers via custom-designed microbes and plants
* *Environment. Accelerating upper ocean currents* – shallowing and increasing by 15% per decade since 1990 leading to increased stratification and reduced biological productivity as well as more complex marine dynamics that are relevant to fisheries and conservation efforts.
* Submerged artificial-light fisheries
* *Environment. Diminished long-term resilience of coastal wetlands to sea-level rise* – concerns that the rate of landward migration of coastal wetlands and other habitats may be slower than previously thought and outpaced by rates of sea level rise, with losses also arising from more spatially extensive and non-linear processes of subsidence.
* Microbiome stewardship for conservation
* Potential effects of severe Perkinsea infection on amphibians
* *Legal. Reporting and increasing prioritisation of biodiversity impacts by private actors* – a range of activities linked to the Taskforce on Nature-related Financial Disclosures is helping to identify the exposure of business to biodiversity risks. This, with similar work for climate risks, influences the cost of capital that businesses can access and hence the ‘bottom line’. This work, together with natural capital accounting, supply chain traceability and green finance could advance biological conservation and restoration outcomes. Challenges include defining and articulating satisfactory natural capital valuations or metrics for biodiversity to characterise risk and, similarly, to stimulate private investment (green finance) in nature conservation
* Accelerated use of machine learning to create novel therapeutics and toxins
* Increasing efficiency of thermophotovoltaics
* Potential side effects of ocean garbage patches
* *Technology. Countering the expansion of invasive tree monocultures by genome editing –* recent CRISPR editing of cultivated pine species could be extended to other taxa to prevent plantation species from spreading into other ecosystems. But current costs of implementation and regulation are high and may divert resources from more effective ecological interventions – and there are risks of negative impacts of sterility in native species.

1. *Environment*. Note also that at current levels of greenhouse gas emissions, five of 16 known tipping points, including melting of the Greenland ice sheet, mass die-off of coral reefs, or fundamental loss of ecological resilience across the Amazonian rainforest, may be approaching[[13]](#footnote-13). Of greatest concern (Lenton, pers comm) is the potential collapse of convection in the Labrador and Irminger Seas off Greenland, which is part of the subpolargyre (SPG), due to warming-induced stratification. This would lead to a concentrated North Atlantic regional cooling of ~2 to 3°C, a northward-shifted jet stream, weather extremes (increased storminess) in Europe, and southward shift of the intertropical convergence zone (ITCZ). This could commence with increases of global temperature of ~1.8°C (1.1 to 3.8°C) (high confidence), a timescale of 10 years (5 to 50 years) (high confidence).
2. The SAC is invited to:
   * discuss the paper, including any additional items to note, and to identify whether a deeper dive into specific issues is required (none identified/ recommended based on this paper);
   * comment on style and content, to refine future versions accordingly.

Contact: Clive Mitchell, [clive.mitchell@nature.scot](mailto:clive.mitchell@nature.scot)

1. Adams WM and Sandbrook C (2013) Conservation, evidence and policy, *Oryx*, 47(3), 329–335 doi:10.1017/S0030605312001470 [↑](#footnote-ref-1)
2. De Leon et al (2023) Harnessing the omics revolution to address the global biodiversity crisis, *Current Opinion in Biotechnology* 80:102901 (<https://doi.org/10.1016/j.copbio.2023.102901>) [↑](#footnote-ref-2)
3. Hoban S et al (2022) Genetic diversity goals and targets have improved, but remain insufficient for clear implementation of the post‑2020 global biodiversity framework, *Conservation Genetics* (<https://doi.org/10.1007/s10592-022-01492-0>) [↑](#footnote-ref-3)
4. Macfarlane NBW et al (2022) Direct and indirect impacts of synthetic biology on biodiversity conservation. [iScience](https://pdf.sciencedirectassets.com/318494/1-s2.0-S2589004222X00114/1-s2.0-S2589004222016959/main.pdf?X-Amz-Security-Token=IQoJb3JpZ2luX2VjEAkaCXVzLWVhc3QtMSJIMEYCIQDTSenHoDIVnbaCE3DlJ9pqLOLWW10cDNu2wbktA5iZDQIhAOVC%2Buy8mLZjhqXzRoxwELtwOtmX5oKmYSrVbM69KUyWKtUECKL%2F%2F%2F%2F%2F%2F%2F%2F%2F%2FwEQBRoMMDU5MDAzNTQ2ODY1IgxyPyVq7giYWrIvwMMqqQRhtZx172pAYhuCjTDvZgNYLlvqgZM9h3yrMWGGYvLTNBH6cqJzLxcQjK8pYrl%2BL6RvOfdTe4lLUm2ns1NOvdWiztawZCpNWCu9%2FCW4hjFlAi0f5NvCUq7SnlBQe6maUFXFEpMdWmzas2BE1akmxUavKCEh3i8vkdnOgS7jr76lcAecLvjFuhYCKal9pzf96VfuQ6LsNVDLo6PGvpRZ1lKnytYfKhPUwzY20OQ%2F8yeWLux3BnU7ztrD6LG40ayKSd3nVPCFD7ekG7%2F1mQkxOWR1CxCAUAxIh3wMY7E1nQjdB1neOj1adD8G%2FuRfddMXjv7do4YKXrdrMqWdaCchDyqG0IhoDC944EGBChkRprVUYxs8VO5n87DY77g0Ke99%2Bb8wtqcwZpz3PHkPTUJP3UXYHhLFSptdRtM94Zts2y8M5ROAUl%2BVcWFtya%2FXDLssUA7SEax%2BKweII3YJIcSpN%2BWLv%2BSgMvciS2cEoVd41jIAmfFyNSejTYRfjHxqMKLZWm1nJOGYSw7zlMydgaz%2BQ%2F%2FA9tHgItZC8BwcEsmTXN1yg7rP1zIpVnsTr%2FPgkJqDA8BLZDoJQZDUHp6I4X3pwKRiHIrnlDH12FhTPD5oPBPgZiB%2BKA8irLAqIO867yPNjQuaDaQedhgoU05bdrpDTWeVJRN%2FzqGc3k9WIM3S7u7pc3DrwSrdX%2Fv%2F86VVCFeYjUEFB1BVe8k8Ri3qXo%2BRZh0E6JT%2FQx6SmHgXMJruzJ8GOqgBtpZvOHSxq6kgrsPQHC0ZcBVab0oVzBz05mbpv2hKT3TcieXHQDIR7oTakcOb9fKU%2BUPxyUQ%2FPBxB1Q6%2F2XkW%2BHPC4fop6%2Bck8B4YS6PL5q%2BsRKQ7y5HRgjpmsYXCPUvlMHejSITmVTWl4tjP%2FMJLnxGCJSw%2Ft1H5UHP%2BG8QceDXOwDW2ndym2VlX8pjw6MPlV%2FTZqfpYq%2BazhfPlH1bABnLUfGpPcb0P&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Date=20230220T095653Z&X-Amz-SignedHeaders=host&X-Amz-Expires=300&X-Amz-Credential=ASIAQ3PHCVTY27JMBKCO%2F20230220%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Signature=da2a2adde264601e46c695e3faab2cf04b91c4519e1a409c28d94e647333147f&hash=4c3720b9bd5a278db69c4c7128404f8eae976d1b84b1caf665a38f1d0669b9b7&host=68042c943591013ac2b2430a89b270f6af2c76d8dfd086a07176afe7c76c2c61&pii=S2589004222016959&tid=spdf-83c82f70-1694-4854-b4af-30868c2829f3&sid=2187016857f32342ef6a5598ed60cccc3c49gxrqb&type=client&tsoh=d3d3LnNjaWVuY2VkaXJlY3QuY29t&ua=0107585c0d545007005d&rr=79c65ff9bb24dca7&cc=gb) [↑](#footnote-ref-4)
5. National Library of Scotland. Using LiDAR layers for landscape research <https://maps.nls.uk/guides/lidar/> [↑](#footnote-ref-5)
6. Scottish Government Remote Sensing portal <https://remotesensingdata.gov.scot/> [↑](#footnote-ref-6)
7. JNCC Simple ARD project support and Copernicus User Uptake projects

   <https://jncc.gov.uk/our-work/copernicus-project/>

   <https://jncc.gov.uk/our-work/simple-ard-service-environmental-applications/> [↑](#footnote-ref-7)
8. Stirling University Scotland’s International Environment Centre

   <https://www.stir.ac.uk/about/scotlands-international-environment-centre/> [↑](#footnote-ref-8)
9. CivTech 6.8

   <https://www.civtechdemoday.com/challenge-8-wherevely> [↑](#footnote-ref-9)
10. Stark C (2023) [2023 – gearing up for the next cycle](https://www.theccc.org.uk/2023/01/10/2023-gearing-up-for-the-next-cycle/), Climate Change Committee, Insights [↑](#footnote-ref-10)
11. https://www.science.org/content/article/aquarium-accident-may-have-given-crayfish-dna-take-over-world [↑](#footnote-ref-11)
12. Sutherland WJ et al (2022) A global biological conservation horizon scan of issues for 2023, *Trends in Ecology and Evolution* (<https://doi.org/10.1016/j.tree.2022.10.005>) [↑](#footnote-ref-12)
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