Summary for Policy Makers: Climate trends, future projections and extremes and their implications for Natural Capital and policy.

This summary presents information on how Scotland's climate has changed since 1960 and what the future projections may mean for our Natural Capital and their ability to provide ecosystem services, presented within a policy development context. It is a product of the Scottish Government Strategic Research Programme project JHI-D5-2 'Climate Change Impacts on Natural Capital' lead by the James Hutton Institute and summarises and augments three reports: Summary of climate trends, future projections and extremes in Scotland; Climate Trends and Future Projections in Scotland; Climate Extremes in Scotland. For further details, contact: mike.rivington@hutton.ac.uk

Key Findings:

The effects of climate change are already here: Scotland's climate has experienced substantial change since the 1960-1989 baseline period. This and likelihood of future change has serious consequences for Scotland's Natural Capital, society and our economy through changes in ecological processes. We have already experienced some changes in the climate that are comparable in magnitude to those projected for the future (2020 and 2049, and in the case of January and November precipitation, the 2050 -2079 period) by climate models. Observed changes and future projections include:

- November, December and January's mean monthly precipitation totals **have already increased since the 1960-1989 baseline period to amounts greater than those projected for the 2020-2049 period.**
- February observed temperatures **have already increased** to be at the lower end of the 12 climate projections (high emissions scenario) used in this study for the 2020-2049 period.
- August, September and autumn are likely to become drier in the future, but the winter is likely to become wetter. Spring shows large spatial and temporal variation, with risks of drought impacting crops and Nature.
- Lower precipitation and higher rates of evapotranspiration associated with higher temperatures are **likely to reduce water availability**, impacting ecological processes and agricultural production.
- There is good agreement between climate projections that large upland areas of central and eastern Scotland are projected to shift from climatic water surplus to deficit (evapotranspiration > precipitation). [Figure 1, dark red]
- **Climate extremes** have already changed and are projected to increase: longer dry periods; heavier rain in winter.

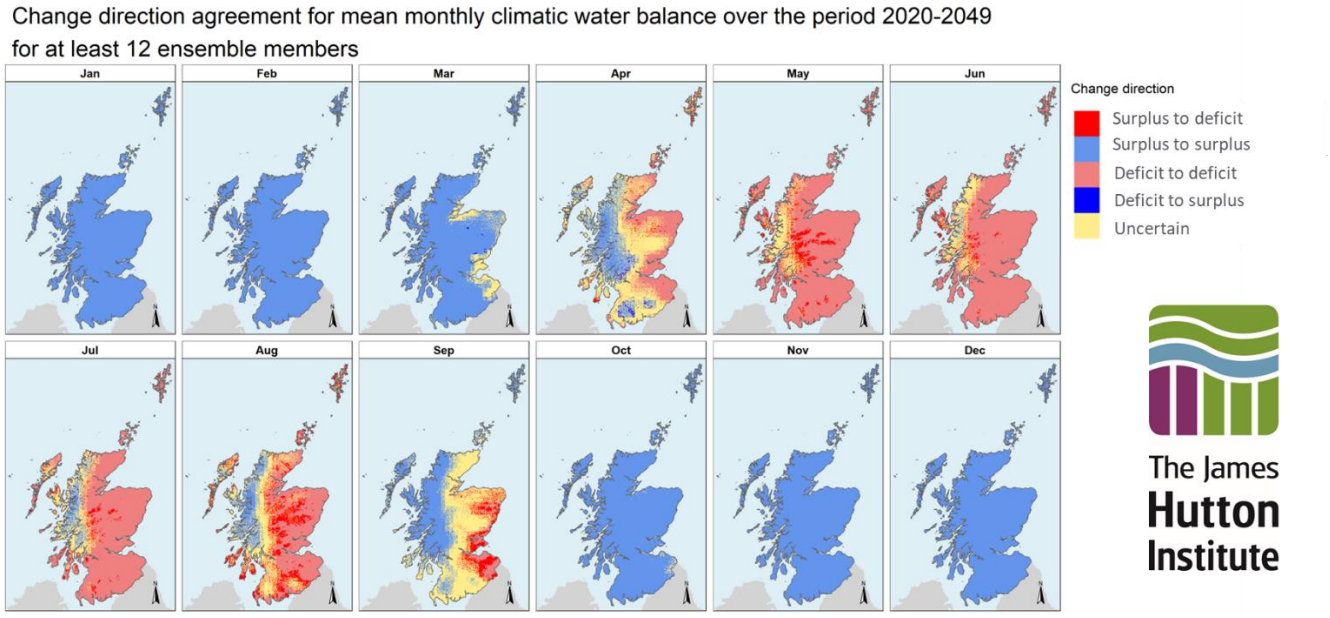

Figure 1. Agreement maps of projected changes in Climatic Water Balance (Precipitation – Evapotranspiration)

Implications of climate change on Natural Capital

Climate change impacts will vary across different types of Natural Capital and ecosystem service flows. Likely impacts:

- **Increased water stress** for multiple species and habitats, affecting ecosystem function and the provision of ecosystem services. Reduced water flow in streams, and higher soil and water temperatures.
- Increased species competition for water and nutrients, favouring those with broader tolerance ranges (i.e., pioneer and invasive species), risking species loss, habitat alteration and changes in ecological processes.

- Mismatches in the growth and development of species that rely on one another (e.g., pollinators and plant species) due to different responses to changed seasonal weather patterns.
- **Mixed range of impacts for Peatlands**: longer growing seasons may increase primary production and increase access and working conditions (i.e., if less snow cover) **which would benefit restoration efforts** (re-wetting). Reduced water in the summer and autumn will increase respiration. If a severe drought period, some decrease in primary production and risks of drying of exposed soils. Multiple drought years threaten poor recovery.
- Drier and more flammable vegetation and peatland soils **increases fire danger**, requiring investment in ignition prevention and mitigation measures including habitat management and increasing public awareness of risks.
- **Changes to crop yields**: potential increases when favourable weather conditions (adequate spring precipitation), but overall reductions, especially where soils have lower water holding capacity and / or on degraded topsoil (e.g., due to erosion, compaction) with low Carbon and hence low water retention.
- Flooding events increase the risk of: spreading invasive species; increased erosion and concentrated diffuse pollution flushes. Reduced snow cover will impact water flow rates, whilst warmer air temperatures and altered albedo (darker surfaces) will increase water temperature impacting river ecology, e.g., spawning fish populations.

Implications for Policy

Climate change impacts will likely have implications across a broad range of policy areas. Our findings have relevance to, but not exclusively: **Climate Change Plan; Agriculture (Scotland) Bill and new payment support schemes; National Planning Framework 4; Land Use and Land Reform; Biodiversity; Water quality and quantity; Tourism and Access; Food and Drink:**

- Combined changes in precipitation, temperature and evapotranspiration will affect land use management decisions, with **implications for ecological function and land use transformations to achieve Net Zero**.
- **Peatlands:** climate change projections indicate risks of **reduced** water availability hence the imperative is to restore peatlands sooner and at a larger scale of effort: the 2026 target of 110,000 ha of restored peatlands may need revision. **Our findings imply a risk that the anticipated emissions abatement goals from restored peatland may be at risk due to future climate change impacts**. Future drier conditions imply that peatlands that are currently in good condition risk deterioration. This implies the need for pro-active intervention now to ensure heathy peatlands remain wet under future climatic conditions.
- **Forestry:** our results indicate the potential for reduced Yield Class attainment and risks of tree establishment failure due to water scarcity and changes in soil processes in some years and locations because of climate change. **Existing values of future carbon sequestration potential through tree planting and growth may be over-estimated if they have not appropriately factored in reduced growth due to reduced water availability**.
- The proposed land use **Enhanced Conditionality** measures need to be screened to ensure they will remain viable and effective under future climates ('climate proofing'), particularly those that require significant capital investment and / or are hard to reverse measures. Coordination between land managers of measures uptake at a catchment scale may aid water management efforts to buffer against droughts and floods.
- **Regional land use planning:** incorporate Climate Change risk into Natural Capital approaches. For planning zonation, application of the NPF4 needs to consider potential changes in Land Capability for Agriculture and where land identified as Prime Agricultural may change. There is an increasing need for using of Nature Based Solutions now (due to establishment time lags) to counter future warming urban heat islands, such as tree planting, wetlands and larger greenspace and integrated building and vegetation design for cooling purposes.
- **The Land Reform Bill:** need for improved information for landowner and community involvement in climate mitigation. Climate impacts will likely vary spatially, requiring additional support for regional variations on policy implementation where climate goals are concerned. A revised Land Use Strategy will need to consider the spatial and temporal variation in climate change impacts, to facilitate local context solutions.
- Policy to shape and **govern private sector investment in land use** (as per The Interim Principles for Responsible Investment in Natural Capital) should explicitly require specific initiatives and standards (e.g., codes) to consider the effects of future climatic changes on the characteristics and capability of land and ecological function, to support investments that are both economically and environmentally viable.