



Loch Lomond & the Trossachs National Park Authority

Climate Change Adaptation Risks and Opportunities Assessment Loch Lomond & the Trossachs National Park

Final report Prepared by LUC March 2024

### Loch Lomond & the Trossachs National Park Authority

### **Climate Change Adaptation Risks and Opportunities Assessment**

Loch Lomond & the Trossachs National Park



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#### Contents

Climate Change Adaptation Risks and Opportunities Assessment March 2024

## Contents

Chapter 1 Introduction	1	Chapter 6 Recommendations and Next Steps	17
Chapter 2 Climate Change Projections	3	Appendix A	
Overview of the current climate Review of Extreme Weather Events Climate Projections Evidence of Environmental Responses to Projected Climate Change in LLTNP	3 4 6 9	Appendix B Mean summer temperature climate projections Mean winter temperature climate projections Mean summer precipitation climate	B-2 B-3
Chapter 3 Climate Change Risk Assessment Study limitations and data caveats	<b>12</b> 13	projections Mean winter precipitation climate projections Mean sea level climate projections	B-5 B-6 B-8
Chapter 4 Climate Change Risk Mapping	14	Appendix C Appendix D	
Chapter 5 Climate Change Opportunities	15		

## Chapter 1 Introduction

**1.1** LUC was appointed by The Loch Lomond & Trossachs National Park Authority (LLTNPA) in January 2024 to carry out a strategic climate change adaptation risks and opportunities assessment for the National Park.

**1.2** This study forms the first step in the production of an adaptation plan for the LLTNPA. The adaptation plan will be a standalone plan with elements potentially embedded into the next Local Development Plan (LDP). The information from this study will be used to drive discussion and develop a strategic approach to adaptation by bringing people together. It will feed into the wider partnership plan by outlining what climate change will mean for different areas of the National Park including infrastructure, residents, visitors, habitats and the local economy. The results of this study emphasise the need for adaptation and can be used to make the case to partners and funders.

- **1.3** This report presents the findings of the study and is structured as follows:
- Chapter 1: Introduction (this chapter) introduces the study and its purpose.
- Chapter 2: Local Climate Change Projections: includes an overview of the current climate, an overview of previous extreme weather events and localised climate change projections for the National Park.
- Chapter 3: Climate Change Risk Assessment: contains the risk assessment carried out for the Loch Lomond & the Trossachs National Park. It assesses the risk from the main local hazards against an agreed list of receptors. Receptors can be defined as the things which have the potential to be harmed by a hazard.
- Chapter 4: Climate Change Risk Mapping: contains maps showing concentrations of climate change risks in the National Park, based on the findings of the risk assessment.
- Chapter 5: Climate Change Opportunities: provides an overview of the opportunities associated with a changing climate in the National Park.

Chapter 1 Introduction

Climate Change Adaptation Risks and Opportunities Assessment March 2024

- Chapter 6: Recommendations and next steps: outline the next steps LLTNPA should undertake in using the findings of this study to inform the production of local climate adaptation plans.
- **1.4** A series of technical appendices are provided to support the information within the report.

**2.1** This chapter explores and analyses the climate variables that are relevant to the Loch Lomond and the Trossachs National Park Authority (LLTNPA) and its operations. This includes an understanding of the current climate and a description of the projected climate for the local area. In addition, there is an overview of the extreme weather events which are relevant to the LLTNPA which reflects the temporal and risk profiles relevant to ongoing operations and longer-term adaptation planning and investment decisions.

- **2.2** The climate variables identified as relevant to LLTNPA include:
- Seasonal temperature changes;
- Seasonal changes in precipitation; and
- Changes in the incidence and frequency of extreme weather events.

#### **Overview of the current climate**

**2.3** The current climate of the National Park's administrative region is expressed using data from the Helensburgh climate station, the closest station to the National Park, between the years of 1991 and 2020. This provides localised climate data over the area for three decadal periods. Data from the climate station is made available through the Met Office<sup>1</sup>.

#### Temperature

**2.4** The mean summer temperature in LLTNP was 13.8°C. The average maximum summer temperature was 17.4°C and the average minimum summer temperature was 10.1°C. The

<sup>1</sup> Met Office, Hollis, D., McCarthy, M., Kendon, M., Simpson, I., & Legg, T. (2018). Dataset Collection Record: HadUK-Grid gridded and regional average climate observations for the UK. Met Office. http://catalogue.ceda.ac.uk/uuid/4dc8450d889a491ebb20e724debe2dfb

Climate Change Adaptation Risks and Opportunities Assessment March 2024



Figure 2.1: The current climate at LLTNP: (A) Plot of mean annual and seasonal temperature (°C) over three decades (1991-2020); (B) Plot of mean annual precipitation (mm) over three decades; (C) Plot of mean annual wind speed at 10m for Scotland West (knots); (D) Plot of mean annual sea surface level (m) over three decades

### **Review of Extreme Weather Events**

**2.8** This review considers reported extreme weather-related events since 2010 within the National Park to highlight the relevant risks specific to LLTNP. Data was sourced from trustworthy and credible outlets to provide accurate and reliable information on extreme events. The scope of sources considered the UK's national weather services, major media outlets, and weather data repositories. It should be noted that the range of sources used will most likely focus on those major weather-related events that had significant impacts. This could exclude

mean winter temperature in LLTNP was 4.0°C, the average maximum winter temperature was 6.7°C, and the average minimum winter temperature was 1.3°C<sup>2</sup>.

#### Rainfall

**2.5** The average rainfall was 114.3mm in the summer and 173.3mm in winter. The average wind speed was 8.99 knots and 12.13 knots in summer and winter respectively for the west of Scotland.

#### Sea level

**2.6** Sea surface level data, measured from the closet tide gauge at Millport, was acquired from the Permanent Service for Mean Sea Level (PSMSL) (PSMSL, 2024).

**2.7** Recordings of sea surface level show a 2% increase between 1990 and 2023. However, it should be noted that sea surface data at this site is inconsistent, with significant data gaps especially between 2017 and 2018 which can affect results.

<sup>2</sup> Summer is defined as the months of June, July, and August, and winter is defined as the months of December, January, and February, in meteorological terms. Met Office. Seasons. https://www.metoffice.gov.uk/weather/learn-about/weather/seasons

Climate Change Adaptation Risks and Opportunities Assessment March 2024

unreported or less significant weather events reported in smaller media outlets have not been identified by the review. However, it is considered that information from the selected sources provides accurate and trustworthy information, as well as provide enough information about data collected. The following sources were used in the review of LLTNP's extreme weather events:

- The Met Office published case studies of extreme weather events in the UK.
- BBC News published extreme weather events.
- The Herald Scotland published wildfire events using data from Scottish Fire and Rescue Service (SFRS).
- NASA Cooperative Open Online Landslide Repository (COOLR) a data repository for landslide events.
- **2.9** A summary of the reviewed data and data sources is presented in Appendix A.

**2.10** The following presents the key extreme weather events relevant to LLTNP and compares these to data for the UK and Scotland as appropriate.

**2.11 Wildfires**: Data shows that grassland habitats have the highest reported incidences of wildfire followed by heathland/shrubland (which can lead to larger fires)<sup>3</sup>. Between 2017 and 2023, there have been 973 reported wildfires over 1000m<sup>2</sup> in Scotland, with most occurring during dry conditions between March and May<sup>4</sup>.

**2.12** There are few reported wildfires specific to LLTNP, such as that reported at Ben Lomond, in areas where natural regeneration of woodland had been taking place<sup>5</sup>. However, there have been 48 reported wildfires in Argyll and Bute and Stirling between 2017 and 2023<sup>4</sup>. These local

authority areas were used representing a significant portion of the National Park's administrative boundary.

**2.13 Extreme temperatures**: The frequency of high temperatures and heatwaves in the UK and Scotland has increased over the last decade, with record breaking temperatures occurring in recent years. There have been 20 recorded case studies of extremely high temperatures and heatwaves occurring between 2010 and 2023<sup>6</sup>.

**2.14** Extreme temperatures are a widespread phenomenon, as such, this review considers events affecting the West of Scotland. The National Park has also faced periods of high temperatures and heatwaves, increasing the risk of wildfires that can destroy habitats and wildlife. There have been seven recorded case studies of high temperatures and heatwaves between 2010 and 2023<sup>6</sup>.

**2.15** Storms and flooding: Between 2010 and 2023, there have been 56 recorded case studies of storms, floods, heavy rain, and strong winds in the UK, most of which occur in the winter period<sup>6</sup>.

**2.16** Storm and flooding events are wide reaching, as such, LLTNP events have been assessed based on the West of Scotland affected areas or passing over the West of Scotland, in the case of storm events. The National Park has been exposed to 25 storm and strong wind events between 2010 and 2023<sup>6</sup>. There has been a 6% increase in the frequency of storms in LLTNP, recorded in the Met Office case studies of past extreme events, between years 2010-2016 and 2017-2023. This includes Storm Otto, Storm Babet, Storm Debi, and Storm Gerrit, occurring in 2023, which caused falling trees and major disruptions in the local area<sup>6</sup>.

**2.17 Landslips/landslides:** There have been 60 recorded landslides in Scotland between 2010 and 2023.

<sup>3</sup> <u>5</u> Investigation of patterns in the IRS wildfires dataset - Scottish Fire and Rescue Service (SFRS) - wildfire: incident reporting system - data analyses - gov.scot (www.gov.scot)

<sup>4</sup> Sabljak, E. (2023). Scotland's wildfires in maps and charts across all councils. *The Herald*. <u>https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/</u> <sup>6</sup> Met Office. (2024). Past weather events: Case studies of past severe weather events. Met Office. <u>https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events</u>

<sup>&</sup>lt;sup>5</sup> BBC. (2022). Wildfires break out at Mallaig and on Ben Lomond. BBC News. <u>https://www.bbc.co.uk/news/uk-scotland-60834170</u>

Climate Change Adaptation Risks and Opportunities Assessment March 2024

**2.18** Landslides are location specific as such this review considers landslides occurring within the National Park's administrative boundary. The National Park has experienced frequent landslides, causing damage to infrastructure especially to the A83 road<sup>7</sup>, where landslides are triggered by heavy rainfall or snow melt, normally occurring after prolonged wet periods<sup>8</sup>. There have been 11 recorded landslides in LLTNP between 2010 and 2015, located around the A83 and Rest and Be Thankful<sup>9</sup>, and more recent major landslides in January and August 2020 that blocked the A83 road near the Rest and Be Thankful pass after heavy rain<sup>7</sup>. The A83 was closed for 4 days in October 2023 after landslides at Glen Kinglas and the Rest and Be Thankful<sup>10</sup>. Mitigations such as passage via convoy or via diversion have been introduced to allow passage but these extend journey times.

#### Limitations

**2.19** The review of extreme weather events considers reported and recorded cases of weather-related events; however, it is important to note that some events can go unreported in media or unrecorded in relevant repositories which are not represented in this review.

**2.20** The scope of the review considers weather-related events between 2010 and 2023, as such recent events such as the February 2024 landslide at A83 at Rest and be Thankful<sup>11</sup>, were not included in the review or previous landslide events such as that on the A85 in Glen Ogle in 2004<sup>12</sup>.

### **Climate Projections**

**2.21** This summary provides an overview of LLTNP's climate projections. It includes an understanding of climate projections in the Scottish context.

#### What are climate change projections?

**2.22** In considering future climate change scenarios, 'probabilistic' projections are used for a range of variables including temperature, precipitation, and sea level rise. Wind speed and storm frequency/intensity are considered separately as global modelling information is currently more limited.

**2.23** The 2018 UK Climate Projections UKCP18, updated in 2022, produced by the Met Office Hadley Centre, provide the most up-to-date climate change projections for Scotland.

**2.24** The UKCP18 presents projections for temperature and precipitation, and considers three variables:

- Timeframe: The projections are presented between the years of 2010 and 2099. These are broken down into a series of time periods including 2020-2039, 2040-2059, 2060-2079 and 2080-2099.
- Probability: The projections are provided as probability distributions rather than single values, with figures provided for 5, 10, 50, 90 and 95% probability.
- Representative Concentration Pathways (RCP): Four pathways have been adopted. RCP2.6, RCP4.5, RCP6.0 and RCP8.5. These pathways describe different GHG and air pollutant emissions as well as their atmospheric concentrations and land use, with each one resulting in a different range of global mean temperature increases over the 21st century. RCP2.6 represents a scenario which aims to keep global warming below 2°C compared to pre-industrial temperatures. RCP4.5 and RCP6.0 represent intermediate scenarios whilst RCP8.5 describes a very high GHG emission scenario. According to the Climate Projections website, all scenarios are considered to be equally plausible.

**2.25** The assessment of LLTNP future climate uses projections for the time period 2080-2099 and RCP8.5 and utilises the figures relating to the 10, 50 and 90% probability projections. As

<sup>&</sup>lt;sup>7</sup> BBC. (2020). The Rest and Be Thankful: An infamous road through "a mountain in torment." BBC News. <u>https://www.bbc.co.uk/news/uk-scotland-53922077</u>

<sup>&</sup>lt;sup>8</sup> Bear Scotland. (2020). FAQ: A83 Rest and Be Thankful. Bear Scotland.

https://www.bearscot.com/fag\_rabt/

<sup>&</sup>lt;sup>9</sup> Kirschbaum, D. B., Stanley, T., & Zhou, Y. (2015). Spatial and temporal analysis of a global landslide catalog. Geomorphology, 249, 4–15. <u>https://doi.org/10.1016/j.geomorph.2015.03.016</u>

<sup>&</sup>lt;sup>10</sup> A83 and A815 to Reopen following Landslides | Traffic Scotland

<sup>&</sup>lt;sup>11</sup> Martin Williams, 2024. A83 at Rest and be Thankful suffers new landslip during closure.

https://www.heraldscotland.com/news/24104998.a83-rest-thankful-suffers-new-landslip-closure/

<sup>&</sup>lt;sup>12</sup> The Guardian (2004) 57 airlifted to safety after landslides | Environment | The Guardian

the most far-reaching projection, the 2080-2099 timeframe is considered to be appropriate due to the capability of current models and RCP8.5 is selected as a suitably precautionary approach, following recommended best practice from relevant guidance documents such as IEMA's Climate Change Resilience and Adaptation guidance<sup>13</sup>. However, Appendix B presents projections for LLTNP's low emission scenario (RCP2.6) and high emission scenario (RCP8.5) to provide further context for a range of projections.

**2.26** Information on wind speed and storms has also been considered, however changes in wind speeds are not currently available at the regional level and there remains considerable uncertainty in the projections with respect to wind speed and storms.

#### Temperature

#### **Scottish Context**

**2.27** The UKCP18 projections show a general trend towards warmer winters and hotter summers in Scotland. The temperature patterns vary across Scotland depending on seasonal and regional scales. It is expected that the variations within Scotland will continue in the future<sup>14</sup>.

#### Loch Lomond and the Trossachs National Park

**2.28** Temperatures within the LLTNP follow the general trend in Scotland, with projected increases in summer temperatures greatest, however, there is greater variation in the 90<sup>th</sup> and 10<sup>th</sup> percentiles, i.e., the likelihood of occurrence.

**2.29** The central estimate of increase in summer mean temperature is 4.2°C; which is 0.3°C hotter than the projections for Scotland in summer. It is highly likely that temperatures will exceed 1.4°C, 0.2°C less than in Scotland, and less likely that temperatures will exceed 7.2°C, 1°C more than in Scotland.

**2.30** The central estimate of increase in winter mean temperature is 2.7°C; which is 0.1°C more than Scotland's projections. There is a high likelihood of temperature change exceeding 0.2°C, which is 0.4°C less than Scotland-wide projections, and a low likelihood of temperature change exceeding 5.4°C, which is 0.7°C more than Scotland-wide projections.

**2.31** The table below presents the projected temperature change for LLTNP and Scotland.

 Table 2.1: Projected temperature change (°C) for LLTNP

		2080-2099 RCP8.5			
Context	Season	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	
Scotland	Winter	0.5°C	2.6°C	4.7°C	
Scotland	Summer	1.6°C	3.9°C	6.2°C	
	Winter	0.1°C	2.7°C	5.4°C	
	Summer	1.4°C	4.2°C	7.2°C	

#### Precipitation

#### Scottish Context

**2.32** The UKCP18 projections show a general trend towards wetter winters and drier summers in Scotland. However, rainfall patterns are also variable across Scotland depending on seasonal and regional scales.

<sup>13</sup> IEMA. (2020). IEMA - IEMA EIA Guide to: Climate Change Resilience and Adaptation (2020). <u>https://www.iema.net/resources/reading-room/2020/06/26/iema-eia-guide-to-climate-change-resilience-and-adaptation-2020</u> Chapter 2 Climate Change Projections

Climate Change Adaptation Risks and Opportunities Assessment March 2024

<sup>&</sup>lt;sup>14</sup> Met Office, Hollis, D., McCarthy, M., Kendon, M., Simpson, I., & Legg, T. (2018). Dataset Collection Record: HadUK-Grid gridded and regional average climate observations for the UK. Met Office. <u>http://catalogue.ceda.ac.uk/uuid/4dc8450d889a491ebb20e724debe2dfb</u>

#### Loch Lomond and the Trossachs National Park

**2.33** Projections for LLTNP follow the Scotland-wide trend. Winter rainfall is projected to increase, and summer rainfall is most likely to decrease.

**2.34** The central estimate of change in summer rainfall is a decrease of 32%; which is 8% more than Scotland-wide projections. It is highly likely that a decrease in precipitation will not exceed 64%, 17% more than Scotland-wide, and likely that an increase in precipitation will not exceed 14%, which is 9% more that projections for Scotland.

**2.35** The central estimate of change in winter mean precipitation is an increase of 23%; a 1% increase from Scotland projections. It is likely that a decrease would not exceed 19% which is significant as this is 19% less than is expected in Scotland-wide projections where no decrease in precipitation is included within the projections. It is likely that the increase in winter precipitation will not exceed 71%, which is 19% more than Scotland-wide projections.

			2080-2099 RCP8.5	
Context	Season	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile
Cootland	Winter	0%	22%	52%
Scolland	Summer	-47%	-24%	5%
	Winter	-19%	23%	71%
	Summer	-64%	-32%	14%

Table 2.2: Projected precipitation changes (°C) for LLTNP

#### Sea Level

**2.36** UK coastal flood risk is expected to increase over the 21st century and beyond under all RCP climate change scenarios. This means expected increases in the frequency and

Chapter 2 Climate Change Projections

Climate Change Adaptation Risks and Opportunities Assessment March 2024

magnitude of extreme water levels around the UK coastline. Rising sea levels increase the risk of coastal erosion and flooding associated with tidal surges and other extreme tidal events.

**2.37** The UKCP18 presents sea level projections in ranges for UK capital cities at 2100 including London, Cardiff, Edinburgh, and Belfast. Using Edinburgh projections as representative estimates for Scotland, RCP8.5 show 0.30m - 0.90m in sea level change relative to the 1981-2000 average.

**2.38** The central estimate of change at LLTNP is an increase of 0.4 m; it is more likely that levels increase by 0.2 m and less likely that levels increase by 0.7 m by 2100.

**2.39** New sea level models benefit from far reaching projections up to 2300. As such further context is given for 2280-2300 timeframes below. The central estimate of change between 2280-2300 is an increase of 1.6 m; it is more likely that levels increase by 0.9 m and less likely that levels increase by 2.8 m.

Table 2.3: Projected sea level change (m) for LLTNP

	2080-2099 RCP8.5		
Context	5 <sup>th</sup> Percentile	95 <sup>th</sup> Percentile	
Edinburgh	0.3m	0.9m	
LLTNP	0.2m	0.7m	

#### Wind Speed

**2.40** There are small changes in projected wind speed. Across the UK, near surface wind speeds are expected to increase in the second half of the 21st century with winter months experiencing more significant impacts of winds<sup>14</sup>. This is accompanied by an increase in frequency of winter storms over the UK. However, the increase in wind speeds is projected to be modest.

**2.41** Storm events recorded through the Met Office published case studies, show a 6% increase in storm events between the years 2010-2016 and 2017-2023 over the west of

Scotland. Future increases in the incidence of storms across the UK is likely to reflected in similar increases over the west of Scotland, in turn leading to further impacts.

# Evidence of Environmental Responses to Projected Climate Change in LLTNP

**2.42** The climate projections for LLTNP show how much temperature, precipitation, and sea level change is likely within LLTNP. The following evidence presents potential environmental responses to the changes in the key climatic variables based on a literature review of peer reviewed research on the impact of climate change for the environment and its ecosystems.

**2.43** Changes to species composition: Many of Scotland's species are adapted to specific climatic conditions<sup>15</sup>. The effects of temperature and precipitation changes, together with extreme weather events will cause direct and indirect effects on land-based species composition in the National Park. NatureScot identifies the Scotland-wide predicted effects such as species loss and the migration of new species like the nuthatch and rhododendron, which can shade out native woodland plants. Unpredicted effects can include changes in predator-prey relationships, pest/diseases and host relationships, and competitive balance between species<sup>15</sup>.

**2.44** The number of 'high' condition water bodies in the park decreased between 2007 and 2014, from 94.8% to a low of 77.6%, but by 2020 had increased to 82.8%<sup>16</sup>. There is a potential for regional temperature rises to result in changes in species composition within the lochs at

Climate Change Projections

Chapter 2

Climate Change Adaptation Risks and Opportunities Assessment March 2024

LLTNP. NatureScot identifies predicted species loss from temperature increases like the Arctic charr<sup>1517</sup>. Relevant studies also show that warming contributes to changes in species communities<sup>18</sup>, in some cases favouring spring species that can resist earlier stratification in mesotrophic lakes and summer species that can make the best trade-off between decreasing nutrient concentrations and increased water column stability<sup>18</sup>. This is relevant as Loch Lomond is classified as mesotrophic<sup>19</sup>.

**2.45** However, it should be noted that the magnitude and response of changes can be dissimilar and strongly modulated by differences in lake trophic status and fish management practices<sup>20</sup>.

**2.46** Rising temperatures can also affect species in rivers and burns, particularly where there is no shade from riparian woodland and trees<sup>21</sup>.

**2.47 Increases in landslides**: Observational data suggests a positive relationship between rainfall and the occurrence of translational landslides and debris flows<sup>2223</sup>, as such, projected increases in precipitation as well increases in heavier rainfall can lead to an increase frequency and intensity of landslides. Balzano et al., (2016)<sup>24</sup> discuss the potential increase in landslide risks to A83 trunk road at the Rest and Be Thankful.

**2.48 Land cover change**: The key drivers of land cover change in LLTNP include forest growth, deforestation, and agriculture-related changes<sup>16</sup>, and land cover change has significant impacts on biodiversity and ecosystem functioning. Extremely high temperatures have the potential to lead to, and exacerbate, degraded land ecosystems and soils, reduced water

<sup>15</sup> NatureScot. (2023, October 23). Impacts on species. NatureScot. <u>https://www.nature.scot/climate-change/climate-change-impacts-scotland/impacts-species</u>

<sup>16</sup> LLTNP. (2023). State of Nature 2023: Loch Lomond & The Trossachs National Park.

 <u>https://www.lochlomond-trossachs.org/wp-content/uploads/2023/09/State-of-Nature-2023-Report.pdf</u>
 <sup>17</sup> PLA, S., MONTEITH, D., FLOWER, R., & ROSE, N. (2009). The recent palaeolimnology of a remote Scottish loch with special reference to the relative impacts of regional warming and atmospheric contamination. Freshwater Biology, 54(3), 505–523. <u>https://doi.org/10.1111/j.1365-2427.2008.02127.x</u>
 <sup>18</sup> Berthon, V., Alric, B., Rimet, F., & Perga, M. (2014). Sensitivity and responses of diatoms to climate warming in lakes heavily influenced by humans. Freshwater Biology, 59(8), 1755–1767. https://doi.org/10.1111/fwb.12380 <sup>21</sup> NatureScot (2021) Fresh waters and climate change in Scotland

https://web.archive.org/web/20211018204659mp\_/https://www.nature.scot/sites/default/files/2017-07/B457867%20-%20Fresh%20waters%20and%20climate%20change%20in%20Scotland.pdf

<sup>&</sup>lt;sup>19</sup> May, L., & O'Hare, M. (2005). Changes in Rotifer Species Composition and Abundance along a Trophic Gradient in Loch Lomond, Scotland, UK. Hydrobiologia, 546(1), 397–404. <u>https://doi.org/10.1007/s10750-005-4282-3</u>

<sup>&</sup>lt;sup>20</sup> May, L., & O'Hare, M. (2005). Changes in Rotifer Species Composition and Abundance along a Trophic Gradient in Loch Lomond, Scotland, UK. Hydrobiologia, 546(1), 397–404. <u>https://doi.org/10.1007/s10750-005-4282-3</u>

<sup>&</sup>lt;sup>22</sup> Baliantyne, C. K. (2002). Debris Flow Activity in the Scottish Highlands: Temporal Trends and Wider Implications For Dating. Studia Geomorphologica Carpatho-Balcanica, 36, 7–27.

<sup>&</sup>lt;sup>23</sup> Postance, B., Hillier, J., Dijkstra, T., & Dixon, N. (2018). Comparing threshold definition techniques for rainfall-induced landslides: A national assessment using radar rainfall. Earth Surface Processes and Landforms, 43(2), 553–560. <u>https://doi.org/10.1002/esp.4202</u>

<sup>&</sup>lt;sup>24</sup> Balzano, B., Tarantino, A., & Ridley, A. (2016). Analysis of a rainfall-triggered landslide at rest and be thankful in Scotland. E3S Web of Conferences, 9, 15009. <u>https://doi.org/10.1051/e3sconf/20160915009</u>

LUC | 10

Chapter 2 Climate Change Projections

Climate Change Adaptation Risks and Opportunities Assessment March 2024

supplies, intensified and longer droughts, and thermal and moisture vegetation stress, leading to land cover changes<sup>25</sup>. Land cover change can result in the loss of species, habitats, and ecosystem services, leading to a decline in the overall health of natural systems<sup>16</sup>. However, it is also important to note that suitable land use practices can enhance ecosystem functioning.

**2.49 Increases in erosion rates**: In Scotland, 19% of the coastline has potential to erode, 78% is considered not to erode, and 3% has artificial defences<sup>26</sup>. However, key pressures faced by peatland within the National Park are drainage and active erosion located predominantly in the northern expanses of LLTNP<sup>16</sup>. Projections for temperature changes and wetter winters suggests potential for increased risks of erosion as higher overall rainfall, increased rainfall intensity, and extreme rainfall events can increase soil erosion directly, while higher air temperature can increase plant biomass, evapotranspiration rates, canopy density, and residue decomposition rate, and even decrease precipitation falling as snow, thus affecting soil erosion indirectly<sup>2728</sup>. However, vegetation restoration can be a safeguard measure to reduce soil erosion<sup>28</sup>.

**2.50** The potential for increases in storm events also has impacts for erosion rates as higher waves during storms can cause greater coastal erosion<sup>29</sup>.

**2.51 Increase in flooding risks:** Climate change projections indicate wetter winters, and the review of extreme events indicate more extreme weather events including more intense rainfall. Projections also indicate an increase in sea levels. Peer reviewed research suggests that the increase in frequency and intensity of extreme precipitation events from global warming increases the risk of flooding<sup>30</sup>, and a report by SEPA states that these projections may lead to an increase in the number of damaging floods in Scotland<sup>31</sup>.River, surface water, ground water and coastal flooding events are all projected to increase.

**2.52 Increases in storm impacts:** Storms can directly impact coastal and marine habitats and species through energy transfer to waves and currents, which then impact the life cycle of species, for instance, damage to nesting sites<sup>26</sup>.

**2.53** The transfer energy from storms to the ocean, can temporarily drive the mixing of the surface layers, leading to changes in sea level (storm surge), causing extreme water levels and currents. This could be further exacerbated by the projected increases in sea level in LLTNP.

**2.54** The overview of extreme weather events revealed a 6% increase in storm events between the years 2010-2016 and 2017-2023 over the west of Scotland, and highlights impacts from falling trees, flooding, debris flow and damage to infrastructure. High winds can also increase wave action, flooding and erosion around lochs. As such it is anticipated that further increases in storm events will lead to further impacts to LLTNP. These impacts can extent to park terrestrial and marine infrastructure and operations, as well as employee and visitor health and well-being, with the potential for injury and loss of life.

### **Assessment Limitations**

**2.55** Climate models are not able to represent all of the features in real climate and there are limitations in capabilities to project weather and climate.

**2.56** The projections for LLTNP present average projections over the National Park's entire administrative region for timeframes up to the year 2100. Therefore, changes from specific small-scale features such as mountains or land surface features, which may cause slight deviations in projections in that area of interest are expressed within the 25km resolution grid

<sup>&</sup>lt;sup>25</sup> Kogan, F. (2022). Land Cover Changes from Intensive Climate Warming. Remote Sensing Land Surface Changes, 181–216. <u>https://doi.org/10.1007/978-3-030-96810-6\_7</u>

<sup>&</sup>lt;sup>26</sup> Scotland's Marine Assessment. (2020). Storms, waves and coastal erosion. Scotland's Marine Assessment. <u>https://marine.gov.scot/sma/assessment/storms-waves-and-coastal-erosion</u>

<sup>&</sup>lt;sup>27</sup> Li, Z., & Fang, H. (2016). Impacts of climate change on water erosion: A review. Earth-Science Reviews, 163, 94–117. https://doi.org/10.1016/j.earscirev.2016.10.004

<sup>&</sup>lt;sup>28</sup> Luo, X., Bai, X., Shen, C., Yang, R., Cao, Y., Wu, L., Chen, F., Ran, C., Liu, M., & Zhang, Y. (2023). Increased precipitation weakenes the positive effect of vegetation greening on erosion. Geocarto International, 38(1). https://doi.org/10.1080/10106049.2023.2172216

 <sup>&</sup>lt;sup>29</sup> Scotland's Marine Assessment. (2020). Storms, waves and coastal erosion. Scotland's Marine Assessment. <u>https://marine.gov.scot/sma/assessment/storms-waves-and-coastal-erosion</u>
 <sup>30</sup> Tabari, H. (2020). Climate change impact on flood and extreme precipitation increases with water availability. Scientific Reports, 10(1), 13768. <u>https://doi.org/10.1038/s41598-020-70816-2</u>
 <sup>31</sup> SEPA. (2018). Flood Risk Management in Scotland 2018 Publication of NFRA and PVAs. <u>https://www.sepa.org.uk/media/399172/nfra-faq.pdf</u>

Climate Change Adaptation Risks and Opportunities Assessment March 2024

size of the entire park. For instance, predicted temperatures could be different in mountainous areas as temperatures typically decrease at higher elevations.

**2.57** Available higher resolution models are also downscaled from lower resolution models such as the 60km and 25km resolution model, as such the process of generating model data at higher spatial and/or temporal resolution, adds more detail but also increases the level of uncertainty, and does not necessarily provide greater confidence in modelling.

**2.58** Climate models typically provide greater confidence for long-term climate averages than extreme events or time series of daily or sub-daily values.

**2.59** The Met Office states that substantially larger rates of sea level rise over the 21st Century associated with the potential for accelerated loss of ice from the West Antarctic Ice Sheet, cannot be ruled out.

**2.60** Finally, it is important to note that climate models are likely to evolve with understanding of the climate system and model capabilities<sup>32</sup>.

<sup>32</sup> Fung, F., Lowe, J., Mitchell, J., Murphy, J., Bernie, D., Gohar, L., Harris, G., Howard, T., Kendon, E., Maisey, P., Palmer, M., & Sexton, D. (2018). UKCP18 Guidance: Caveats and Limitations. Met Office Hadley Centre, Exeter.

## Chapter 3 Climate Change Risk Assessment

**3.1** This chapter contains the results of the Climate Change Risk Assessment for the National Park.

**3.2** The risk assessment has been undertaken across the whole of the National Park, with the Park split into nine areas to aid analysis and future adaptation planning. The nine areas were identified using Community Council boundaries, taking into consideration the location of the main settlements so that each area includes at least one settlement. These areas are shown on Figure 1. The risk assessment is split into nine tables corresponding to the areas with each table identifying the specific receptors within each of the areas.

**3.3** The risk assessment was developed using a four-stage process:

**3.4** Firstly, the results of the localised climate projections and localised hazard identification were used to identify the primary climate hazards likely to cause damage or have an impact on activities or services within the National Park. The following main hazards were identified.

- Wildfire
- Flood risk
- Storms
- Increased temperature and extreme temperature events
- Reduced water availability/drought
- Increased precipitation
- Landslides

**3.5** Secondly, a list of the main receptors (things which can be harmed by a hazard) was identified and agreed in collaboration with the LLTNPA. The receptors can be categorised into; infrastructure, habitats, visitor and recreational destinations, settlements, historic assets and

Chapter 3 Climate Change Risk Assessment

Climate Change Adaptation Risks and Opportunities Assessment March 2024

agriculture and forestry. The receptors were selected on the basis that they were the most critical to support nature, communities, local economies, visitors and the LLTNPA operations.

**3.6** Thirdly, analysis was carried out to identify the risk of each of the above hazards occurring on each of the main receptors within each area. To carry out this analysis, several datasets were identified which could be indicative of the main hazards. These included:

- Wildfire: Land cover mapping of grassland and heathland habitats which are most susceptible to wildfire risk.
- Storms: Woodland cover with a 10m buffer to major infrastructure to account for the infrastructure which may be impacted by tree fall in storms.
- Flood risk: flood risk mapping which identified areas of high flood risk based on a 2080 high emissions scenario.
- Landslides: generalised susceptibility to landslides mapping.

**3.7** Full details of individual data sets used for each hazard, how they were used, and the limitations of these datasets can be found in Appendix C.

**3.8** Additional research was carried out for some receptors to identify their main features and their susceptibility to different types of risk. For example, the features of interest for each of the designated sites in the park (SSSI/SAC/SPA) were identified and further research undertaken to identify the main climate change risks to different habitat types (this is outlined in Appendix D).

**3.9** Finally, the risks identified were scored and awarded a risk rating based on an assessment of the severity of the risks identified for each of the receptors against each of the hazards. Each has been scored as either low, medium or high risk using the following criteria:

High Risk	Extensive damage to the receptor of high cost or high impact, with long lasting impact on associated activities. Or significant damage and impact but likely to be frequently occurring.
Medium Risk	Significant damage to the receptor of medium-high cost or high impact with a significant impact on associated activities. Or low damage and impact but likely to be frequently occurring.
Low Risk	Minimal to low damage to the receptor or impact on associated activities.

### **Study limitations and data caveats**

**3.10** It is important to note the limitations of the methodology and data set out in this report. The risk assessment has been carried out at a high level and provides a useful overview of the main types of risk that the National Park will experience due to climate change, and identifies where there are likely to be concentrations of risk. Limitations of the data and methodology include:

- Some datasets are mapped at a coarse scale and lack area specific detail e.g. landslides
- Some proxy data does not accurately reflect risk e.g. grassland and heathland mapping as a proxy for wildfire risk does not distinguish wet or dry grasslands, nor does the mapping include buffers to highlight higher risks from visitors.
- Existing measures to manage climate risks have not been taken into account e.g. maintenance of wayleaves for energy infrastructure passing through forestry.

**3.11** The use of the risk assessment for future planning must be supplemented by further locationally specific research and ground truthing to determine the exact nature and severity of the risk.



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Climate Change Adaptation Risks and Opportunities Assessment Loch Lomond and The Trossachs National Park Authority



### Figure 1: Risk assessment areas

### Risk assessment area

- Area 1: Crianlarich, Tyndrum and Killin
- Area 2: Lochearnheaed and Balquiddher
- Area 3: Callander
- Area 4: Brig O'Turk, Aberfoyle and Inversnaid
  - Area 5: Balmaha, Drymen and Rowardennan
- Area 6: Balloch
- Area 7: Luss and Iverbeg
- Area 8: Arrochar, Tarbert and Ardlui
  - Area 9: Lochgoilhead, Ardentinny and Glenbranter

## Risk assessment criteria

High Risk	Extensive damage to the receptor of high cost or high impact with long lasting impact on associated activities. Or significant damage and impact but likely to be frequently occurring.
Medium Risk	Significant damage to receptor of medium-high cost or high impact with a significant impact on associated activities. Or low damage and impact but likely to be frequently occurring.
Low Risk	Minimal to low damage to receptor or impact on associated activities.

## Area 1: Crianlarich, Tyndrum, and Killin

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>the A82 connecting Tyndrum, Crianlarich, and Ardlui.</li> <li>A85 connecting Crianlarich, and Lochearnhead, and Crianlarich to Killin via the A827</li> <li>A827 connecting Killin to Lochearnhead, and Crianlarich via the A85</li> </ul>	Large distances of the A82, A85, and A827, are within areas of wildfire susceptible habitats and areas with the potential of increased human activity including Munro summits and car parks. The most affected areas are: the entire stretch of the A85 connecting Crianlarich to the A827; the stretch of the A82 between Tyndrum and Auchreoch; and the A82 between Crianlarich and Inverarnan.	Significant stretches of the A82, A85, and A827 are in areas susceptible to river and surface water flooding. Key areas of flood risk include: The A827 between Killin and Mid Lix; the A85 between Mid Lix and Glenogle; sections of the A85 along River Dochart, Loch Lubhair and Loch Dochart; the A82 between Tyndrum and Auchtertyre, and along the River Fallen and River Falloch.	Significant stretches of the A82, A85, and A827 are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected areas are: Th stretch of the A85 between Mid Lix and Glenogle, the A82 between Tyndrum and Crianlarich; and the A82 between Crianlarich and Inverarnan.	The A84, A81, and A821 are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the A82, A85, and A827, through an increase the risk of flooding and landslides (see Flood risk and Landslide)	The entire A827, the A85 between Ledcharrie and Glenogle, and the A82 between Inverarnan and the roundabout south of Crianlarich, are in areas highly susceptible to landslides. Only small sections of road are in areas of high landslide risk and adjacent to steep slopes.
Rail line and stations	The rail line connecting Tyndrum, Crianlarich, and Ardlui. Tyndrum Upper and Lower Stations and Crianlarich Station are in the area.	Almost all stretches of the rail line are within areas of wildfire susceptible habitats. Tyndrum Upper and Lower stations are in areas susceptible to high fire risk.	Small stretches of the rail line are within areas susceptible to river and surface water flooding. Crianlarich station is susceptible to flood risk.	Almost all stretches of the railway lines are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. All stations are also susceptible.	The rail line is susceptible to impacts from high temperatures, including buckling and service delays.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the rail line through an increase the risk of flooding and landslides (see Flood risk and Landslide).	Stretches of the railway line between Inverarnan and Crianlarich are in areas highly susceptible to landslides.
Paths	<ul> <li>Key paths include:</li> <li>The network of core paths (NCP) connecting and around Tyndrum, Crianlarich, and Arudlui, as well as connecting and around Killin to Lochearnhead.</li> <li>The National Cycle Network (NCN) connecting Killin to Lochearnhead</li> <li>The long distance route: West Highland Way, connecting Tyndrum, Crianlarich, and Ardleish.</li> </ul>	Large stretches of the long distance routes: West Highland Way, NCP, and NCN, are within areas of wildfire susceptible habitats. The longest affected stretch is about 8 km of the long distance West Highland Way between Crianlarich, and Ardlui.	Stretches of the long distance routes: West Highland Way, NCP, and NCN, are in areas susceptible to flooding. The key areas of highest risk are around Tyndrum, along River Fallen, along River Falloch, at Crianlarich, at River Dochart near Ardchyle, along River Dochart near the Killin Holiday Home, and at Killin.	Almost all stretches of the long distance routes: West Highland Way, NCP, and NCN, pass through extensive areas of woodland and forestry with potential to be impacted by storm damage and fallen trees.	The NCN, the network of core paths, and long distance routes, are at risk of impacts from extreme temperatures including cracking and surface damage, and impacts to trail usage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the NCN, long distance routes, and the network of core paths, through an increase the risk of flooding and landslides (see Flood risk and Landslide).	The long distance routes: West Highland Way, connecting Crianlarich, and Ardlui is within areas of high susceptibility to landslides. The NCN and NCP connecting and around Killin and Lochearnhead are within areas of high susceptibility to landslides.
Energy infrastructure	<ul> <li>The overhead line towers and lines between:</li> <li>Inverarnan and about 2 km north of the Falls of Falloch;</li> <li>Crianlarich and Killin; and</li> <li>Killin and Lochearnhead</li> </ul>	Significant lengths of the OHLs and towers are in areas susceptible to wildfires. The longest affected areas are between Benmore Farm and Ledcharrie, at Glenogle, and between Inverarnan and about 2 km north of the Falls of Falloch.	Low risk/exposure and/or susceptibility.	Significant lengths of the OHLs and towers pass through extensive areas of woodland and forestry with potential to be impacted by storm damage and fallen trees. The longest affected areas are Glen Falloch, along the river Dochart and south of Killin.	The OHL is susceptible to impacts from extreme weather including sagging.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the OHL and towers, through an increase the risk of flooding and landslides (see Flood risk and Landslide).	Significant length of the OHL towers between Killin and Glenogle, and Inverarnan and 2 km South of the Falls of Falloch, are within areas of high susceptibility to landslides.

Receptors Habitats	Description Main habitats include:	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk The main water bodies are susceptible to flooding	Storms	Increased temperature/ extreme temperature events The main habitats are susceptible to	Reduced water availability/drought	Increased precipitation	Landslide
	<ul> <li>Raised and blanket bogs; and</li> <li>Alpine and subalpine grasslands</li> <li>The main water bodies are Loch Lubhair, River Falloch, River Fallan, and River Dochart.</li> </ul>	The main habitats are susceptible to impacts from wildfires including the dry grasslands and alpine/subalpine grasslands which are high risk habitats.	impacts. Floods can impact habitats leading to erosion in some areas and reduced rooting depth for species intolerant of winter water-logging, exacerbating the effects of summer drought.	Storm events can lead to damage and loss of vegetation.	temperature changes and extreme temperatures. Changing temperatures may change phenology and community composition.	Drought conditions will affect the main habitats impacting growth and increasing the risk of wildfires.	The main habitats are susceptible to increased precipitation impacts.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Protected habitats and species	<ul> <li>The SACs within Crianlarich, Tyndrum, and Killin are:</li> <li>Ben Lui – habitats, alpine pioneer formations</li> <li>River Tay – Atlantic salmon</li> <li>Meall na Samhna – Nardus grasslands</li> <li>Loch Lomond Woods - Old sessile oak woods</li> <li>Ben Heasgarnich – Nardus grasslands and Alpine pioneer formations</li> </ul> The SSSIs are: <ul> <li>Ben Lui – Dalradian, Mineralogy of Scotland, Upland Assemblage, Vascular Plant Assemblage and Invertebrate Assemblage</li> <li>Glen Falloch Pinewood - Pinewood</li> <li>Glen Falloch Pinewood - Pinewood</li> <li>Stob Binnein – Alpine heath, alpine moss health, lichen assemblage, tall herb ledge</li> <li>River Dochart Meadows – fen meadow and lowland neutral grassland</li> <li>Lochan Lairig Cheile – oligotrophic loch, open water transition fen and valley fen</li> <li>Innishewan Wood - Upland oak woodland</li> <li>Meall na Samhna - Bryophyte assemblage,</li> </ul>	All the SACs except River Tay are within areas susceptible to wildfires. Most terrestrial SSSIs are in areas susceptible to wildfires. A significant portion of the SPA is susceptible to wildfires.	The SACs and SSSIs are susceptible to flooding.	Small portions of the SACs and SSSIs are woodlands and forestry with potential to be impacted by storm damage.	The main SSSIs and SACs are susceptible to changes in temperature, and extreme heat as alpine habitats, aquatic habitats.	The main SSSIs and SACs, are susceptible to drought stress.	Increased precipitation can result in changes in water levels with potential for waterlogging for SSSIs and SACs.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought
	Lichen assemblage, Northern emerald dragonfly, upland assemblage and Vascular plant assemblage					
	<ul> <li>Falls of Dochart - Fluvial Geomorphology of Scotland</li> </ul>					
	<ul> <li>Loch Tay Marshes - Transition open fen and wet woodland</li> </ul>					
	<ul> <li>Coille Coire Chuilc - Beetle and fly assemblage, Native pinewood</li> </ul>					
	The SPA is Glen Etive and Glen Fyne – Golden eagle.					
Visitor and recreational destinations	The main visitor attractions and facilities are car parks and Munro summits.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	Both car park facilities in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.
Settlements	Key community services include: Crianlarich Primary School, Crianlarich Fire Station, Crianlarich Village Hall, Killin Medical Practice, McLaren Hall, Breadalbane Park and Recreation Ground, The Green Welly Stop, and a number of hotels.	Breadalbane Recreation Ground/play space and Tyndrum play space are in areas susceptible to wildfires. Other key community facilities, services and visitor attractions across the three settlements are in areas of potential indirect effects from wildfires such as health and wellbeing impacts.	There are a number of community services and facilities including Tyndrum play space and commercial areas, Crianlarich Village Hall, shop and play space susceptible to river flooding.	A number of facilities and services are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks
Historic and cultural designated sites and assets	The main cultural designated sites are: two scheduled monuments at Tyndrum and at Killin.	Low risk/exposure and/or susceptibility.	The Scheduled monument and parts of the Conservation Area at Killin and Tyndrum are in an area susceptible to flooding.	Heritage assets potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.
Agriculture and forestry	Extensive areas of plantation woodland around Tyndrum, to south of A82 between Tyndrum and Crianlarich and south west of Killin. Enclosed pasture in valley floors.	Extensive areas of grassland habitat, used for grazing are susceptible to fire risk and are, also in proximity to areas of plantation conifer forestry.	Extensive areas of flood risk in valley bottom overlapping with grazing land in valley floors.	Livestock vulnerable to storm events and forestry subject to wind throw.	Agriculture and forestry are susceptible to changes in temperature, and extreme heat.	All forestry and agricultural land is susceptible to drought stress.

Increased precipitation	Landslide
Increased precipitation can increase the risk of landslides.	The facility north of Ardlui is within areas of high susceptibility to landslides.
There are facilities and services, including Crianlarich Village Hall, shops and playspaces are in areas susceptible to river flooding which could be exacerbated by increased precipitation.	All the key community facilities and services are within areas of moderate susceptibility to landslides.
There are heritage assets in areas susceptible to river flooding which could be exacerbated by increased precipitation.	Low risk/exposure and/or susceptibility.
Increased precipitation can cause water logging, impeding access to land, reducing forage availability, and increasing disease risk.	Low risk/exposure and/or susceptibility.

## Area 2: Lochearnhead and Balquidder

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X%	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought
		cover) combined with				
Roads	<ul> <li>Main roads include:</li> <li>the A85 connecting Glenogle, Lochearnhead, and St Fillans.</li> <li>The A84 connecting Lochearnhead to Callander</li> <li>National Cycle Route 7 connecting Auchtubh and Inverlochlarig</li> <li>South Loch Earn Road connecting St Fillans to Lochearnhead</li> </ul>	Stretches of the A85, A84, the national cycle network, and South Loch Earn Road, are within areas of wildfire susceptible habitats and areas of increased human activity. The most affected length is the A84 around Lochearnhead.	Significant stretches of the A85, A84, the national cycle route, South Loch Earn Road, are in areas susceptible to flooding. Key areas of flood risk include: significant lengths of the A85 connecting Glenogle, Lochearnhead, and St Fillans, the South Loch Earn Road along Loch Earn, the A84 between Lochearnhead to Callander, and parts of the national cycle route along Loch Voil.	Significant stretches of the A85, A84, the national cycle route, South Loch Earn Road, are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected areas are: the A84 between Lochearnhead to Callander.	The A85, A84, the national cycle route, South Loch Earn Road, are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility
Paths	<ul> <li>Key paths include:</li> <li>NCN connecting Glenogle and Callander</li> <li>The Long distance route connecting Glenogle and Callander</li> <li>The NCP around and connecting Lochearnhead, Balquhidder, Strathyre, and Callander</li> </ul>	Significant lengths of the NCN are within areas of wildfire susceptible habitats and areas of increased human activity. The greatest length in risk areas is between Glenogle and Lochearnhead. Significant lengths of the NCP pass areas of wildfire susceptible habitats, especially north of Balquhidder and south of Lochearnhead. Small stretches of the Long distance routes north west of Lochearnhead pass areas of wildfire susceptible habitats.	Small lengths of the NCN around Loch Lubnaig, Loch Voil, and Loch Earn, are in areas susceptible to flooding. The lengths of the NCP concentrated around Loch Lubnaig, Loch Voil, and Loch Earn, are in areas susceptible to flooding. Small stretches of the Long distance routes around Loch Lubnaig are in areas susceptible to flooding.	Most of the NCN, the long distance routes, and NCP are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	The NCN, long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.
Energy infrastructure	The overhead line and towers are between Glenogle and St Fillians, along Loch Earn.	The length of the OHLs and towers is in an area susceptible to wildfires.	Low risk/exposure and/or susceptibility.	The length of the OHLs and towers pass through an area of woodland and forestry with potential to be impacted by storm damage and fallen trees.	The OHL is susceptible to impacts from extreme weather including sagging.	Low risk/exposure and/or susceptibility.
Habitats	<ul> <li>Main habitats include:</li> <li>Dry grasslands;</li> <li>Raised and blanket bogs; and</li> <li>Alpine and subalpine grasslands</li> <li>Temperate shrub heathland</li> </ul>	The main habitats are susceptible to impacts from wildfires including the dry grasslands and alpine/subalpine grasslands which are high risk habitats.	The main water bodies are susceptible to flooding impacts. Floods can impact habitats leading to erosion in some areas and reduced rooting depth for species intolerant of winter water-logging, exacerbating the effects of summer drought	Storm events can lead to damage and loss of vegetation, particularly woodland.	The main habitats are susceptible to temperature changes and extreme temperatures. Changing temperatures may change phenology and community composition.	Drought conditions wil affect the main habitat impacting growth and increasing the risk of wildfires.

Increased precipitation	Landslide
Increased precipitation has the potential to impact the A85, A84, the national cycle route, South Loch Earn Road, through an increased risk of flooding and landslides (see Flood <b>risk and Landslide</b> ).	The entire A85, A84, and South Loch Earn Road, are in areas highly susceptible to landslides.
Increased precipitation has the potential to impact the NCN, long distance routes and the network of core paths, through an increase the risk of flooding and landslides (see Flood <b>risk and Landslide</b> ).	The entire NCN, long distance routes and the network of core paths, are in areas highly susceptible to landslides.
Increased precipitation has the potential to impact the OHL and towers, through an increased risk of landslides (see Landslide).	The entire OHL is within areas of high susceptibility to landslides.
The main habitats are susceptible to increased precipitation impacts.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought
	The main water bodies are Loch Earn, Loch Voil, and Loch Lubnaig.					
Protected habitats and species	The SACs are: River Teith – Sea lamprey, Brook lamprey, River lamprey, Atlantic Salmon					
	The SSSIs are: Stob Binnein - Alpine heath, alpine moss health, lichen assemblage, tall herb ledge;					
	Stronvar Marshes - Loch trophic range, Open water transition fen and wet woodland;	Portions of the terrestrial SAC are/have habitats susceptible	The SACs associated with watercourses are susceptible to	Small portions of the SACs are woodlands and forestry	The main SSSI and SAC are susceptible to	The main SSSI and SAC, are susceptible to drought stress, includir low flow conditions.
	Loch Lubnaig Marshes – flies, Fluvial Geomorphology of Scotland, Freshwater pearl mussel and Open water transition fen;	to wildfires.	flooding.	with potential to be impacted by storm damage.	temperature, and extreme heat	
	Edinchip Wood – upland oak woodland and wet woodland;					
	Coille Chriche - Wet woodland;					
	Edinample Meadow - Lowland neutral grassland					
Visitor and recreational destinations	The visitor attractions and facilities include: Park Areas, Munro summits, and car parks	Low risk/exposure and/or susceptibility.	Key visitor attractions and facilities around Loch Earn and Loch Voil (i.e. campsites and car parks) are in areas within areas susceptible to flooding.	Key visitor attractions and facilities around Loch Earn and Loch Voil are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure.
Settlements	Key community services include: Lochearnhead Village Hall, Balquidder Village Hall, play space, and a number of hotels.	A couple of community facilities and services are in areas of potential indirect effects from wildfires such as health and wellbeing impacts.	Key facility and service, Balquidder village hall, is in an area potentially susceptible to river flooding.	Key community services are in areas with potential to be impacted by storm damage and fallen trees.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks.
Historic and cultural designated sites and assets	The historic and cultural designated sites and asset is the scheduled monument near St Fillans.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	The scheduled monument is in an area with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.
Agriculture and forestry	The forestry sites include highly artificial coniferous plantations south of Loch	Extensive areas of forestry and agricultural land adjacent to areas susceptible to wildfires.	Low risk/exposure and/or susceptibility on limited areas of improved grassland at loch edge.	Extensive areas of forestry which can be impacted by storm events.	Increased and extreme temperatures will impact forestry sites,	Forestry plantation ma be susceptible to drought stress,

Increased precipitation	n Landslide
Flood risk and landslid effects can be exacerbated with increased precipitation (see Flood Risk and landslides). Increased precipitation can result in changes water levels for marine SSSI and SACs.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Increased precipitation can exacerbate floodin and landslides impact for visitor attractions a facilities.	The visitor attractions and facilities around Loch Earn and Balquhidder are within areas of susceptibility to landslides.
Increased precipitation can exacerbate floodin and landslides impact around key facilities.	Low risk/exposure and/or susceptibility.
Increased precipitation can increase the risk o landslides.	n Low risk/exposure of and/or susceptibility.
Increased precipitation will impact growth rate and yield impacts. So	Low risk/exposure and/or susceptibility.

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought
	Earn and west of Loch Voil and Loch Lubnaig.				some tree species intolerant of drought.	depending on tree species.
	Areas of enclosed pasture in valley floors, e.g. around Auchtubh, Glen Ogle and Craggab.					

Increased precipitation	Landslide
tree species intolerant of waterlogging.	

### Area 3: Callander

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>the A84 connecting Callander and Strathyre and Lochearnhead</li> <li>A81 Between Callander and Port of Menteith</li> <li>A821 between Callander and Aberfoyle</li> </ul>	Large sections of the Old Military Road on the A84 through the Lots of Callander and Thornhill, and A821, passing between Callander and Trossachs, are within areas of wildfire susceptible habitats, and areas with the potential of increased human activity including campsites and PAs and car parks.	Large stretches of the A84 within Callander, are susceptible to flooding. Key areas of flood risk include multiple locations on the A84 on the Old Military Road along Loch Lubnaig, and Leny road; and at the Keltie Bridge. Short sections of the A81 within Callander at Bridgend, and within Port of Menteith around the Lake of Menteith at Coldon Lodge, and Gateside, are susceptible to flooding. A short distance of the A821 in Callander at the junction with the Old Military Road as well as along Loch Venachar, is susceptible to flooding.	Significant stretches of the A84 are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees, while there are three small stretches on the A81 which could be susceptible, and discrete susceptible stretches on the A821.	The A84, A81, and A821 are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure.	Increased precipitation has the potential to impact the A84, A81, and A821 within Callander and Port of Menteith, through an increased risk of flooding and landslides (see Flood risk and Landslide).	Sections of the Old Military Road on the A84 within Callander, between Ardchullarie and Corriechrombie, are in areas highly susceptible to landslides. Sections of the A84 within Callander, after Corriechrombie, the A81, between Strathard and Port of Menteith, and the A821, between Callander and Trossachs, are in areas with moderate susceptibility to landslides.
Paths	<ul> <li>Key paths include:</li> <li>The NCN between Callander and Trossachs</li> <li>NCP around Callander</li> <li>Long distance routes: Rob Roy way and the Great Trossachs Path</li> </ul>	Significant stretches of the NCN in Callander are within areas of wildfire susceptible habitats. The longest stretch of NCN path at risk of wildfire is around Bochastle and Dullater. Significant stretches of the network of core paths around Bochastle, Ben Gullipen, and Druim Buidhe.	Signficiant stretches of the NCN, long distance route (Rob Roy Way) and NCP around Callander is susceptible to flooding, particularly along Loch Lubnaig and at Bridgend.	A significant portion of the NCN, and core path network within Callander passes through extensive areas of woodland and forestry with potential to be impacted by storm damage and fallen trees. Almost all of the long distance routes pass through extensive areas of woodland and forestry with potential to be impacted by storm damage and fallen trees.	The NCN, the network of core paths, and long distance routes, are at risk of impacts from extreme temperatures and impacts to route usage.	Low risk/exposure.	Increased precipitation has the potential to impact the NCN, long distance routes, and the network of core paths within Callander, through an increase in the risk of flooding and landslides (see Flood <b>risk and Landslide</b> ).	Sections of the NCN, the network of core paths, and long distance routes, along Loch Lubnaig are within areas with high susceptibility of landslides. Sections of the network of core paths between Druim Buidhe and torn a Bhacain, are within areas of Significant sensitivity to landslides. Sections of the long distance routes between Wester Gartchonzie and Beinn Liath, are in areas of low to moderate susceptibility to landslides.
Other infrastructure	Loch Venachar provides compensatory water supply to River Teith, as part of Loch Katrine water supply	N/A	N/A	N/A	N/A	Periods of drought could affect water supply network.	N/A	N/A
Habitats	<ul> <li>Main habitats include:</li> <li>Coniferous woodland;</li> <li>Temperate shrub heathland;</li> <li>Seasonally wet and wet grasslands;</li> <li>Broadleaved deciduous woodland;</li> <li>Dry grasslands; and</li> </ul>	Significant portions of the habitats within Callander and Port of Menteith are susceptible to wildfires, including heathlands, grasslands, and woodlands.	The main water bodies and rivers within Callander and Port of Menteith, are susceptible to flooding. Habitats in close proximity to main water bodies and rivers within Callander and Port of Menteith, are susceptible to flooding.	The woodlands within Callander and Port of Menteith are susceptible to damage from high winds during storms.	The main water bodies within Callander and Port of Menteith, are susceptible to changes in temperature, and extreme heat (impacts on species) Habitats within Callander and Port of	The main water bodies within Callander and Port of Menteith, are susceptible to drought conditions (impacts on water levels). Bog habitats in Callander and Port of Menteith are	The main water bodies within Callander and Port of Menteith, are susceptible to increased precipitation which can lead to flooding events (see Flood Risk). Habitats within Callander and Port of Menteith are susceptible to increased	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.

Receptors	<ul> <li>Raised and blanket bogs.</li> <li>The main water bodies include: Loch Lubnaig, Loch Venachar, Lake of Menteith, Garbh Uisge, Eas Gobain, River Teith,</li> </ul>	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events Menteith are susceptible to changes in temperatures (impacts on species distribution, habitat productivity).	Reduced water availability/drought susceptible to drought stress.	Increased precipitation precipitation (impacts on soil saturation and disruption to ecosystems), and flooding events resulting from increased precipitation.	Landslide
					out and erode with rising temperature.			
Protected habitats and species	<ul> <li>The SSSIs are:</li> <li>Leny Quarry - Cambrian</li> <li>Pass of Leny Flushes – springs and upland oak woodland</li> <li>Mollands - Quaternary of Scotland</li> <li>Lake of Menteith- Mesotrophic loch, Pink-footed goose, Quaternary of Scotland and Vascular plant assemblage</li> <li>Loch Macanrie Fens - Hydromorphological mire range and raised bog</li> <li>The SACs are:</li> <li>River Teith – Sea lamprey, Brook lamprey, River lamprey, Atlantic Salmon</li> <li>Trossachs Woods - Old sessile oak woods</li> </ul>	Portions of key SSSI including Leny Quarry, Pass of Leny Flushes, Mollands, and Loch Macanrie Fens, are in areas susceptible to wildfires and in areas higher potential for human activity, at visitor attractions and facilities, which could cause wildfires.	Three SSSI are within areas susceptible to river and surface water flooding including Pass of Leny Flushes, Lake of Menteith, and Loch Macanrie Fens. The main SAC including River Teith is susceptible to flooding.	Key SSSI and SAC, including the Pass of Leny Flushes, Mollands, and Loch Macanrie Fens, are susceptible to direct damage from high winds during storms.	The main SSSI and SAC within Callander and Port of Menteith, are reliant on water availability susceptible to changes in temperature, and extreme heat.	The main SSSI and SAC within Callander and Port of Menteith, are susceptible to drought stress.	The main SSSI and SAC within Callander and Port of Menteith, are in areas susceptible to increased precipitation which can lead to flooding events (see Flood Risk), and increased precipitation (impacts on soil saturation and disruption to ecosystems).	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Visitor and recreational destinations	<ul> <li>The main visitor attractions and facilities in Callander are:</li> <li>Two car parks along Loch Lubnaig;</li> <li>Two car parks and a Campsite and PA along the Old Military Road;</li> <li>A park mobility site and two car parks near Bridgend,</li> <li>Two car parks along the core path network through Cnoc Dubh</li> <li>A car park and a campsite and PA along Loch Venachar</li> </ul>	Low risk/exposure.	Five of the visitor destinations include waterside locations and associated river flood risk, including the 2 car parks along Loch Lubnaig, a car park near Bridgend, and a car park and a campsite and PA along Loch Venachar Two destinations and facilities are within areas susceptible to surface water flooding including a car park and a Campsite and PA along the Old Military Road.	Almost all the main visitor attractions and facilities in Callander are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure.	Low risk/exposure.	Increased precipitation has the potential to impact visitor facilities through an increased risk of flooding and landslides (see Flood risk and Landslide) Seven of the destinations and facilities are within areas susceptible to flooding impacts from increased precipitation (see Flood risk)	Three of the destinations and facilities are within areas of high susceptibility to landslides including the two car parks along Loch Lubnaig and a car park along the Old Military Road. All other destinations and facilities are within areas of moderate susceptibility to landslides.
Settlements	Key community services include: Callander Primary School, McLaren High School, Callander Medical Practice, Callander library, and McLaren Community Leisure Centre.	Key community facilities and services are in areas of potential indirect effects from wildfires such as health and wellbeing impacts.	Two key facilities and services, including the Callander Primary School and Callander library, are in areas susceptible to river flooding.	Low risk/exposure.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks.	Two key facilities and services, including the Callander Primary School and Callander library, are in areas susceptible to river flooding which could be exacerbated by increased precipitation.	All the key community facilities and services are within areas of moderate susceptibility to landslides.

Receptors	Description	Wildfire Extensive areas of susceptible habitat (X% grassland and heathland cover) combined with	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
					including discomfort and overheating.			
Historic and cultural designated sites and assets	The cultural heritage designations within Callander and Port of Menteith are: around Bochastle, around Dunmore, around Claish farm, Chermbered Cairn, at Loch Venachar, around Cup and ring marked rocks, and at and along the Lake of Menteith.	With the exception of scheduled monument within Loch Venachar and the Lake of Menteith, all the cultural heritage designations within Callander and Port of Menteith are within areas susceptible to wildfires.	Scheduled monuments at and along Lake of Menteith, at Loch Venachar, and around Bochastle, are within areas susceptible to flooding.	Scheduled monuments along Lake of Menteith, around Bochastle, around Dunmore, and around Claish farm, are in areas with potential to be impacted by storm damage and fallen trees.	The species within the garden and designed landscape may be at high risk of damage from extreme temperature events.	Key species found in the garden and designed landscape may be intolerant of water logging or drought.	Scheduled monuments at and along Lake of Menteith, at Loch Venachar, and around Bochastle, are within areas susceptible to flooding from increases in precipitation.	Scheduled monuments in Callander are in areas with moderate susceptibility to landslides. Scheduled monuments within Port of Menteith are in areas with low susceptibility to landslides.
Agriculture and forestry	Areas of enclosed pasture adjacent to Loch Venachar, Lake of Menteith, Kilmahog and River Teith. Extensive areas of woodland and forestry through A84 corridor, south of Loch Venachar and south of Lake of Menteith.	Extensive areas of forestry and agricultural land within/adjacent to areas susceptible to wildfires.	Areas susceptible to river and surface flooding concentrated around Callendar Garbh Uisge, East Gobain, River Teith and Lake of Menteith.	Extensive areas of plantation forestry subject to wind throw risk.	Increased and extreme temperatures will impact agriculture and forestry.	Forestry and agricultural land are susceptible to drought stress.	Increased precipitation can cause water logging, impeding access to land, reducing forage availability and increasing disease risk.	Landslide risk is generally low, with higher risk adjacent to Loch Lubnaig, and forestry cover in this area reduces risk.

## Area 4: Brig O'Turk, Aberfoyle and Inversnaid

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>the A821 connecting Callander and Aberfoyle</li> <li>The B829 connecting Aberfoyle and Stronachlachar</li> <li>The A81 providing a south and eastwards connection from Aberfoyle</li> </ul>	Small stretches of the A21, B829, and A81 are within areas of wildfire susceptible habitats and areas with the potential of increased human activity. The most affected lengths are the A21 along Loch Venachar, and the B829 around Loch Arklet	Most of the A21, B829, and A81 are in areas susceptible to flooding. Key areas of flood risk include: the A21 along Loch Achray, the B829 along Loch Ard, along the River Forth and through Aberfoyle, and along the Arklet Water on the road to Inversnaid.	Most of the A21, B829, and A81 are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected areas are: the A21 along Loch Achray, the B829 between Frenich Farm and Milton, and at Inversnaid.	The A21, B829, and A81 are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the A21, B829, and A81, through an increase in the risk of flooding and landslides (see Flood risk and Landslide)	The B829 between Stronachlachar and Blairuskinmore, and the A821 between Lendrick Lodge and Easter Dullater are in areas highly susceptible to landslides.
Paths	<ul> <li>Key paths include:</li> <li>The NCN7 connecting Gartmore to Aberfoyle and Loch Venachar</li> <li>The Great Trossachs Path connecting Inversnaid to Brig O'Turk and the Rob Roy Way which skirts the East of the area</li> <li>The network of core paths (NCP) around the area and connecting Gartmore, Aberfoyle and Brig O'Turk</li> </ul>	Some lengths of the NCN7, long distance routes and the network of core paths are within areas of wildfire susceptible habitats and areas of increased human activity.	Small lengths of the NCN7, long distance routes and the network of core paths at Aberfoyle, and around Loch Drunkie and Loch Venachar, are in areas susceptible to flooding.	Most of the NCN7, the long distance routes and the network of core paths are adjacent to woodland and forestry with potential to be damaged or obstructed by storm damage and fallen trees.	The NCN7, the long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage dependent on their surfacing.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the NCN7, the long distance routes and the network of core paths through an increase the risk of flooding and landslides (see Flood <b>risk and Landslide</b> ).	Much of the Great Trossachs Way between Inversnaid and Brig O'Turk is in areas of high susceptibility to landslides.
Other infrastructure	Loch Katrine is the primary water reservoir for much of the city of Glasgow and its surrounding areas. The Aqueduct intake and outlet sits between Loch Katrine and Arklet	Sections of the aqueduct susceptible to damage from adjacent wildfires.	N/A	Sections of the aqueduct susceptible to damage from wind throw from storms.	N/A	Water supply could be impacted by extended periods of drought.	N/A	N/A
Habitats	<ul> <li>Main habitats include:</li> <li>Dry grasslands;</li> <li>Broadleaved deciduous woodland</li> <li>Temperate shrub heathland</li> <li>Highly artificial coniferous plantations</li> <li>The main water bodies are Loch Ard, Loch Katrine, Loch Aklet, and Loch Chon.</li> </ul>	Dwarf shrub heath, gorse, bracken and grasses are high risk habitats for wildfire. Broadleaves and coniferous woodland are low risk habitats for wildfire.	Increased flood events lead to more scouring on riparian rocks, banks, and tree bases, resulting in the loss of larger bryophytes. Increased silt loads during these floods degrade water quality, affecting clear-water species and their predators, potentially disrupting entire ecosystems' food chains.	Increased frequency of wind throw, leading to losses of mature and veteran trees. The loss of specialist species associated with veteran tree habitat.	Changing temperatures may change phenology and community composition.	The habitats and water bodies are susceptible to are susceptible to drought stress and changes in water level.	Increased precipitation will lead to changes in ecology and water levels.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Protected habitats and species	The SACs are: River Teith - Sea lamprey, Brook lamprey, River lamprey; Loch Lomond Woods - Old sessile oak woods The SSSIs are:	Small parts of Black Water marshes and Ben A'an and Brenachoile Woods are within areas susceptible to wildfires.	The SACs and SSSI around Lock Katine and Loch Venachar are in flood risk areas.	Some of the SACs and SSSIs are woodlands and forestry or rivers or wetlands with potential to be impacted by storm damage.	The main SSSI and SAC are susceptible to changes in temperature, and extreme heat, except Lime Craig Quarry Periods of low flow during seasonal drought conditions mean that	The main SSSI and SAC, are susceptible to drought stress except Lime Craig Quarry.	Flood risk and landslide effects can be exacerbated with increased precipitation (see Flood Risk and landslides).	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
	<ul> <li>Fairy Knowe and Doon Hill         <ul> <li>Upland oak woodland;</li> </ul> </li> <li>Drumore Wood - Upland oak woodland;</li> <li>Lime Craig Quarry - Arenig             <ul> <li>Llanvirn;</li> </ul> </li> <li>Cuilvona and Craigmore Woods - Upland oak woodland;</li> <li>Black Water Marshes - Flood-plain fen, oligotrophic loch, open water transition fen;</li> <li>Brig O'Turk Mires - Valley fen; Ben A'an and Brenachoile Woods - Upland oak woodland;</li> <li>Ben Lomond – Invertebrate, upland and vascular plant assemblage, snowbed, subalpine dry heath;</li> <li>Craig Royston Woods - Moth assemblage and upland oak woodland;</li> </ul>				events salmon migration is impacted.			
	<ul> <li>Poliochro woods – bryophyte and lichen assemblage, wet woodland and wood pasture and parkland</li> </ul>							
Visitor and recreational destinations	The main visitor attractions and facilities are found around Loch Achray, Loch Katrine and Loch Ard which contain: 3 Waterbus departures, 14 Campsites, 10 carparks Visitor centre: Aberfoyle Park mobility sites: Aberfoyle and Trossachs Pier	Three Lochs Forest Drive car park and Loch Achray South campsite are in areas susceptible to wildfires.	Two of the waterbus departures, two campsites and Aberfoyle park mobility site, visitor centre and carpark are susceptible to flood risk.	12 Campsites and six car parks are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	Increased precipitation can exacerbate flooding and landslides impacts for visitor attractions and facilities.	Low risk/exposure and/or susceptibility.
Settlements	Key community and visitor services in settlements include: Aberfoyle Primary School, a commercial centre (Main Street) and supermarket, Aberfoyle and Buchlyvie Medical Centre, Brig O'Turk bar and café, and a number of hotels.	Key community facilities and services (e.g. Aberfoyle play space) are in areas of potential indirect effects from wildfires such as health and wellbeing impacts from poor air quality.	There are several community services and facilities including Aberfoyle Main Street and Aberfoyle Primary School in areas susceptible to river flooding.	Key facilities around Brig O'Turk and Aberfoyle are adjacent to woodlands and forestry with potential to be impacted by storm damage.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks.	There are several community services and facilities including Aberfoyle Main Street and Aberfoyle Primary School in areas susceptible to river flooding which could be exacerbated by increased precipitation.	Low risk/exposure and/or susceptibility.
Agriculture and forestry	Extensive forestry sites include highly artificial coniferous plantations north of Loch Katrine,	Some forestry areas adjacent to areas susceptible to wildfires.	Limited areas of agricultural land susceptible to flood risk.	Extensive areas of plantation forestry subject to windthrow risk.	Increased and extreme temperatures will impact agriculture and forestry sites.	Forestry and agriculture are susceptible to drought stress.	Increased precipitation can cause water logging, impeding access to land, reducing forage	Some areas of forestry in areas of high landslide risk but overall

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
	north of Loch Chon, and Loch Ard and Archray Forest. Areas of enclosed pasture surrounding Gartmore in the south east of the area.	Enclosed pasture around Gartmore within areas susceptible to wildlife.					availability and increasing disease risk.	risk considered to be low.

## Area 5: Balmaha, Drymen and Rowardennan

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>The B837 connecting Balmaha to Drymen</li> <li>The minor road connecting Balmaha to Rowardennan</li> <li>The B858 connecting Drymen to the A811</li> <li>The Main Street connecting Drymen to the A811</li> <li>The A811 connecting East and West from Drymen</li> </ul>	Lengths of the B837, the minor road, B858, Main Street, and A811, are within areas of wildfire susceptible habitats and areas with the potential of increased human activity. The most affected length is the B837 around Milton of Buchanan and the A811 around Drymen.	Parts of the B837, the minor road along Loch Lomond and the A811 across Endrick Water, are in areas susceptible to flooding.	Lengths of the B837, the minor road, the B858, Main Street, and A811, are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected length is the minor road along Loch Lomond.	All roads, are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the B837 and A811, through an increase in the risk of flooding and landslides (see Flood risk and Landslide).	Low risk/exposure and/or susceptibility.
Paths	<ul> <li>Key paths include:</li> <li>The NCN7 connecting through Drymen at the far south of the area</li> <li>The West Highland Way connecting north to south from north of Rowardennan to south of Drymen</li> <li>The network of core paths (NCP) around and connecting Drymen, Milton of Buchanan, and Rowardennan</li> </ul>	Some lengths of the NCN7, West Highland Way and the network of core paths are within areas of wildfire susceptible habitats and areas of increased human activity. The greatest areas of risk is the path network around Drymen.	Small lengths of the West Highland Way and the network of core paths along Loch Lomond are in areas susceptible to flooding.	Intermediate stretches along the NCN7, long distance routes and the network of core paths are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected area is along Loch Lomond.	The NCN7, long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/ exposure and/or susceptibility.	Increased precipitation has the potential to impact the NCN7, long distance routes and the network of core paths, through an increase the risk of flooding and landslides (see Flood <b>risk</b> ).	Low risk/exposure and/or susceptibility.
Habitats	<ul> <li>Main habitats include:</li> <li>Broadleaved deciduous woodland</li> <li>Temperate shrub heathland</li> <li>Raised and blanket bogs</li> <li>The main water body is Loch Lomond.</li> </ul>	Extensive areas of dwarf shrub heath, gorse, bracken and grasses are high risk habitats for wildfire. Broadleaf woodlands are low risk habitats for wildfire, and bogs are low risk except in drought conditions.	Flooding can lead to reduced rooting depth for species intolerant of winter waterlogging, exacerbating the effects of summer drought. Main areas of flood risk at loch edge and River Endrick.	Main habitats include woodland and bogs, and east side of Loch Lomond. Storms will lead to damage, loss of mature and veteran trees, and can affect community composition. Increased surface runoff during storm events can also cause peat loss.	Broadleaved woodland (temperate rainforest) and bog habitats reliant on water availability. Peat bogs may dry out and erode with rising temperature and experience vegetation change.	Broadleaved woodland (temperate rainforest) and bog habitats reliant on water availability. Peat bogs may dry out and erode with rising temperature and experience vegetation change.	Increased precipitation can change ecological functions, cause water table fluctuations and changes in community composition. In degraded bogs, increased precipitation can increase erosion and in conjunction with increased temperatures could affect the growth of non-mire vegetation.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Protected habitats and species	<ul> <li>The SAC is:</li> <li>Loch Lomond Woods - Old sessile oak woods</li> <li>The Ramsar is:</li> <li>Loch Lomond - supports several scarce and one British Red Data Book wetland plants and also three rare species of invertebrates</li> <li>The SSSIs are:</li> </ul>	The Ben Lomond SSSI north of Rowardennan is susceptible to wildfires.	The SACs, Ramsar and SSSIs close to Loch Lomond are in high flood risk areas.	Most of the protected sites have vegetation with potential to be impacted by storm damage, including significant areas of woodland.	The main SSSI and SAC are susceptible to changes in temperature, and extreme heat due to reliance on higher levels of moisture for temperate rainforest woodland habitats, water levels within watercourses and mire and wetland species.	The main SSSI and SAC are susceptible to changes in temperature, and extreme heat due to reliance on higher levels of moisture for temperate rainforest woodland habitats, water levels within watercourses and mire and wetland species.	Increased precipitation will impact water tables causing ecological changes and changes in community composition.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought
	<ul> <li>Endrick Mouth and Islands – Beetle, bryophyte, breeding bird and vascular plant assemblage, Fluvial Geomorphology of Scotland, Greenland white- fronted goose, Greylag goose, Hydromorphological mire range, Upland oak woodland;</li> <li>Endrick Water - Brook and river lamprey, Quaternary of Scotland, Fluvial Geomorphology of Scotland and Scottish dock;</li> <li>Conic Hill - Alkaline fen, Ordovician Igneous, beetle and moth assemblage, Subalpine calcareous grassland, wet woodland, upland oak woodland;</li> <li>Rowardennan Woodlands - Upland oak woodland;</li> <li>Inchcruin – Capercaillie;</li> <li>Ben Lomond – invertebrate, vascular plant and upland assemblage, snowbed, subalpine dry heath;</li> <li>Craig Royston Woods – moth and unland oak woodland;</li> </ul>					
Visitor and recreational destinations	<ul> <li>The main visitor attractions and facilities are found to the east of Loch Lomond and include:</li> <li>Ben Lomond;</li> <li>Rowardennan and Balmaha Waterbus departures;</li> <li>Four Car parks;</li> <li>Lochan Maoil Dhuinne, Sallochy, Cashel, Millarochy Port Bawn campsites;</li> <li>Visitor centre: Balmaha;</li> <li>Inchcailloch North Jetty and Port Bawn Pontoon</li> </ul>	Ben Lomond is at risk of wildfire.	Two waterbus departures, Port Bawn Pontoon and Cashel car park are susceptible to flood risk.	Three campsites and two carparks are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure.	Low risk/exposure.
Settlements	Key community and visitor services in settlements include: Drymen commercial centre (the square) and a number of hotels/visitor accommodation and shops in Drymen, Balmaha and Rowardennan.	Key community facilities and services are in areas of potential indirect effects from wildfires such as health and wellbeing impacts of poor air quality. The highest risk is at Drymen.	Low risk / exposure across most of the area. High flood risk at Rowardennan.	Facilities in all settlements are adjacent to vegetation and forestry with potential to be impacted by storm damage.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilitie services are susceptible to impacts from reduced wat availability and drought ris
Historic and cultural designated sites and assets	Most of Drymen is a designated conservation area. There are a number of scheduled monuments in the south and west of the area.	Drymen is surrounded by areas of high wildfire risk and a number of scheduled monuments are within areas susceptible to wildfires.	Scheduled monuments on the shores of Loch Lomond and the Islands are susceptible to high flood risk.	Some scheduled monuments along the loch are at risk of damage through wind throw during storms.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.

	Increased precipitation	Landslide
	Increased precipitation can exacerbate flooding and landslides impacts for visitor attractions and facilities.	Destinations and facilities are within areas of moderate susceptibility to landslides.
ıd	Increased precipitation can increase flood risk. This would have most impact at Rowardennan.	Low risk/exposure and/or susceptibility.
	Increased precipitation will increase flood risk and may damage building fabric.	All designated heritage features are in areas with low landslide risk.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Agriculture and forestry	Extensive enclosed pasture at the south east of the area, around Drymen. Signfiicant areas of plantation forestry along the east of Loch Lomond and to the north of Drymen.	Forestry at Ben Lomond is adjacent to grassland which has a high fire risk. Areas of enclosed pasture within areas of wildfire risk.	Limited area of agricultural land at the south of the area is susceptible to high flood risk.	Extensive areas of plantation forestry subject to windthrow risk.	Increased and extreme temperatures will impact agriculture and forestry sites.	Forestry and agriculture are susceptible to drought stress.	Increased precipitation can cause water logging, impeding access to land, reducing forage availability and increasing disease risk.	Some areas of forestry in areas of high landslide risk but overall risk considered to be low.

### Area 6: Balloch

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought
Roads	Main roads include: The A811 connecting Drymen, Gartocharn, and Balloch. The A809 connecting Croftaime to the A811.	Most of the A811 and A809, are within areas of wildfire susceptible habitats.	Small lengths of the A811 at Balloch and A809 at Croftamie, are in areas susceptible to flooding.	Small lengths of the A811 and A809, are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected area is at Croftamie	The A811 and A809, are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.
Rail line and stations	Short distance of railway and station at Balloch.	Low risk/exposure and/or susceptibility.	Balloch Station is in an area at risk of surface water flooding.	Low risk/exposure and/or susceptibility.	The rail line susceptible to impacts from high temperatures, including buckling and service delays.	Low risk/exposure and/or susceptibility.
Paths	<ul> <li>Key paths include:</li> <li>The NCN connecting Croftamie and Balloch</li> <li>The John Muir Way</li> <li>The network of core paths (NCP) around Balloch, between Balloch and Gartocharn, and between Balloch and Cortamine</li> </ul>	Most of the NCN, long distance routes and the network of core paths are within areas of wildfire susceptible habitats.	Small lengths of NCN and long distance routes at Balloch and Croftamie, are in areas susceptible to flooding.	Intermediate stretches along the NCN, long distance routes and the network of core paths are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	The NCN, long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.
Habitats	Main habitats include: <ul> <li>Mesic grasslands</li> <li>Broadleaved deciduous woodland</li> </ul> The main water body is Loch Lomond.	Broadleaves are low risk habitats for wildfire, however, grasslands are high risk habitats for wildfires.	Floods can impact habitats leading to erosion in some areas and reduced rooting depth for species intolerant of winter water-logging, exacerbating the effects of summer drought.	Increased frequency of wind-throw, leading to losses of mature and veteran trees. The loss of specialist species associated with veteran tree habitat.	Species tolerance to drought varies with some tree death during dry summers.	Drought conditions will affect the main habitats impacting growth and increasing the risk of wildfires.
Protected habitats and species	<ul> <li>The SACs are:</li> <li>Loch Lomond Woods - Old sessile oak woods, otter</li> <li>The Ramsar is:</li> <li>Loch Lomond - supports several scarce and one British Red Data Book wetland plants and also three rare species of invertebrates</li> <li>The SSSIs are:</li> <li>Endrick Water – Brook and River lamprey</li> <li>Endrick Mouth and Islands – Beetle, bryophyte, breeding bird and vascular plant assemblage, Fluvial Geomorphology of Scotland, Greenland white-fronted goose, Greylag goose, Hydromorphological mire range, Upland oak woodland</li> <li>Caldarvan Loch - Eutrophic loch</li> <li>Blairbeich Bog - Raised bog</li> </ul>	Portions of the Endrick Mouth and Islands are susceptible to wildfires.	The SACs and SSSIs in and around Loch Lomond are in flood risk areas.	Most of the SACs and SSSIs have vegetation which can be impacted in storm events from tree fall, scouring and flooding.	The main SSSI, Ramsar, and SAC are susceptible to changes in temperature, and extreme heat, except Lime Craig Quarry.	The main SSSI and SACs, are susceptible to drought stress, except Lime Craig Quarry.

Increased precipitation	Landslide
Increased precipitation has the potential to impact the A811 and A809, through an increased risk of flooding and landslides (see Flood risk and Landslide).	Low risk/exposure and/or susceptibility.
Increased precipitation has the potential to impact the Balloch Station through an increased risk of flooding (see Flood risk).	Low risk/exposure and/or susceptibility.
Increased precipitation has the potential to impact the NCN, long distance routes and the network of core paths, through an increase the risk of flooding and landslides (see Flood risk and Landslide).	Low risk/exposure and/or susceptibility.
Increased precipitation can cause fluctuations in water tables.	Low risk/exposure and/or susceptibility.
Precipitation will increase the risk of flooding, changed water levels and impact plant and animal composition.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
	<ul> <li>Boturich Woodlands - Upland mixed ash woodland and wet woodland</li> <li>Inchmurrin - wet woodland</li> <li>The SPA is:</li> <li>Loch Lomond – Greenland White- fronted Goose and Western capercaillie</li> </ul>							
Visitor and recreational destinations	The main visitor attractions and facilities in Balloch are found south of Loch Lomond and include: Balloch Castle and Country Park, Loch Lomond NNR carpark and 2 carparks, a waterbus departure point, a visitor centre, a Park mobility site, Duncan Mills Memorial Slipway, Drumkinnon Pontoon and RSPB Loch Lomond.	Low risk/exposure and/or susceptibility.	Four destinations south of Loch Lomond are in an area susceptible to flooding (Waterbus departure: Balloch, Drumkinnon Pontoon, Duncan Mills Memorial Slipway, Car park: Duncan Mills Memorial Slipway).	Two car parks in Balloch (Moss o'Balloch and Loch Lomond NNR) are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	Four of the destinations and facilities are within areas susceptible to flooding impacts which could be exacerbated from increased precipitation (see Flood risk).	All destinations and facilities are within areas of moderate susceptibility to landslides.
Settlements	Key community services include: Balloch commercial areas (Balloch Road) and Lomond Shores commercial area, as well as hotels and play spaces.	Low risk/exposure and/or susceptibility	A few key facilities and services, including Lochside playspaces and Lomond Shores commercial areas, are in areas susceptible to river flooding.	Low risk/exposure and/or susceptibility.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks.	A few key facilities and services, including Lochside playspaces and Lomond Shores commercial areas, are in areas susceptible to river flooding which could be exacerbated by increased precipitation.	Low risk/exposure and/or susceptibility.
Historic and cultural designated sites and assets	Gardens and Designed Landscapes: Balloch Country Park and Ross Priory	Balloch Country Park and Ross Priory contain areas / are adjacent to areas susceptible to wildfires.	Areas of flood risk for Balloch Country Park and for Ross Priory where key tree species such as sycamore intolerant of water logging.	Trees and woodlands within the designed landscapes vulnerable to storm damage.	The species within the garden and designed landscapes may be at high risk of damage from extreme temperature events.	Key tree species such as sycamore intolerant of water logging or drought.	Built features within the gardens and designed landscapes are susceptible to damage.	Low risk/exposure and/or susceptibility.
Agriculture and forestry	Extensive enclosed pasture across east of the area. The forestry sites include plantations south of Drymen and Gartocharn (Finnery Plantation).	Extensive areas of agricultural land and forestry within / adjacent to areas susceptible to wildfires.	Low risk/exposure and/or susceptibility	Areas of plantation forestry and enclosed farmland subject to windthrow risk.	Increased and extreme temperatures will impact agriculture. Some tree species are intolerant of drought.	Forestry plantation may be susceptible to drought stress, depending on tree species.	Some tree species are intolerant of waterlogging.	Low risk/exposure and/or susceptibility.

## Area 7: Luss and Inverbeg

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>the A82 connecting Inverbeg, Luss, and Balloch</li> <li>The A817 connecting Shantron and Faslane</li> <li>The A818 connecting Arden and Helensburgh</li> </ul>	Limited lengths of the A82, and significant lengths of the A817, and A818, are within areas of wildfire susceptible habitats and areas of increased human activity. The most affected length	Significant stretches of the A82, A817, and A818, are in areas susceptible to flooding. The key area of flood risk is the A82 along Loch Lomond.	Significant stretches of the A82, A817, and A818, are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected areas are: the A82 along Loch Lomond and the	The A82, A817, and A818, are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the A82, A817, and A818, through an increase in the risk of flooding and landslides (see Flood risk and Landslide).	The A817 between Shantron and Blairnairn, A82 between Aldochlay and Shantron, and the A818 between Dumfin and Daligan, are in areas with localised significant susceptibility to landslides.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
	<ul> <li>The minor road between the Cross Keys and the Glen Fruin memorial</li> </ul>	is the A817 between Shantron and Faslane.		A817 between Shantron and Blairnairn.				
Paths	<ul> <li>The key paths are:</li> <li>The long distance route connecting Helensburgh and Garelochhead</li> <li>The NCP connecting Inverbeg, Luss, and Balloch</li> </ul>	Small lengths of the long distance routes and the network of core paths are within areas of wildfire susceptible habitats. Key lengths are in Glen Fruin.	Signficiant lengths of NCP along Loch Lomond, are in areas susceptible to flooding.	Most of the long distance routes and the network of core paths are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	The long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the Long distance routes and the network of core paths, through an increase the risk of flooding and landslides (see Flood risk and Landslide).	The long distance routes and the network of core paths south of Luss are in areas with localised significant susceptibility to landslides.
Habitats	<ul> <li>Main habitats include:</li> <li>Dry grasslands</li> <li>Seasonally wet and wet grasslands</li> <li>Broadleaved deciduous woodland</li> <li>The main water body is Loch Lomond.</li> </ul>	Grasslands are high risk habitats for wildfires.	Flooding events can lead to changes in water levels. Unseasonal inundation, such as summer flooding in temperate wet grasslands, has been observed to induce plant community, soil nutrient and biodiversity impacts.	Storm events can lead to damage and loss of vegetation, particularly woodland.	The main habitats may be impacted by changes in phenology and community composition.	The main habitats may be impacted by reduced water availability. Summer drought may favour annual species over perennials, leading to community change.	Direct impacts during heavy rainfall events, may be compounded by recreational erosion.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Protected habitats and species	<ul> <li>The SAC is Loch Lomond Woods</li> <li>Old sessile oak woods.</li> <li>The SSSIs are: <ul> <li>Ross Park - Lichen assemblage and Scottish dock</li> </ul> </li> <li>Inchmoan – raised bog</li> <li>Inchtavannach and Inchconnachan – Capercaillie and upland oak woodland</li> <li>West Loch Lomondside Woodlands - Upland oak woodland</li> <li>Inchlonaig - Upland oak woodland</li> <li>Inchlonaig - Upland oak woodland</li> </ul> <li>The SPA is Loch Lomond – Greenland white-fronted goose and Western capercaillie.</li>	Small portions West Loch Lomondside Woodlands and Ross Park are susceptible to wildfires.	The SAC and SSSIs in around Loch Lomond are in flood risk areas, and waterlogging may impact on the species composition.	The woodland SAC and SSSIs have vegetation which can be impacted in storm events.	The main SSSIs, and SAC are susceptible to changes in temperature, and extreme heat as they are reliant on water availability.	The main SSSIs and SAC, are susceptible to drought stress as they are reliant on water availability.	Precipitation will increase the risk of flooding, change water levels and affect plant and animal composition, impacting the SAC and SSSIs.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Visitor and recreational destinations	The main visitor attractions and facilities are three Car parks (Duck Bay, Luss South, Luss), a Waterbus departure (Luss), and 2 campsites (Culag Beach and Suie Field) along the south west of Loch Lomond.	Low risk/exposure and/or susceptibility.	Five destinations are in an area susceptible to flooding.	The two campsites are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	All of the destinations and facilities are within areas susceptible to flooding impacts which could be exacerbated from increased precipitation (see Flood risk and landslides).	All destinations and facilities are within areas of moderate susceptibility to landslides.
Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
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Settlements	Key community services include: Luss Primary School, Village Shop, and shops and hotels at Luss and Inverbeg.	Key community facilities and services are in areas of potential indirect effects from wildfires such as health and wellbeing impacts.	Low risk / exposure and/or susceptibility.	Facilities at Luss and Inverbeg are near vegetation and forestry with potential to be impacted by storm damage and fallen trees.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks	There are no key facilities and services in areas susceptible to river flooding. However, risk could be exacerbated by increased precipitation.	All the key community facilities and services are within areas of moderate susceptibility to landslides.
Historic and cultural designated sites and assets	<ul> <li>Designated assets are:</li> <li>Rossdhu garden and designed landscape</li> <li>Luss Conservation Area</li> <li>Luss Parish Church scheduled monument</li> </ul>	Both designated assets take in areas susceptible to wildfires.	Significant areas of flood risk for Rossdhu where key tree species may be intolerant of water logging. Parts of the Conservation Area and scheduled monument are also within an area at risk of flooding.	Trees and woodlands within the designed landscapes and Conservation Area vulnerable to storm damage.	The species within the garden and designed landscape may be at high risk of damage from extreme temperature events.	Key tree species may be intolerant of water logging or drought.	Built features within the Conservation Area and gardens and designed landscapes susceptible to damage.	Low risk/exposure and/or susceptibility.
Agriculture and forestry	Significant areas of enclosed pasture at southern end of Loch Lomond. Some areas of forestry adjacent to A82 and some areas south of A817.	Extensive areas of grassland and heathland particularly within upland and western parts of the area. Areas of enclosed pasture susceptible to wildfires.	Few areas of farmland are in areas of flood risk	Forestry areas have potential to be impacted by storm damage	Increased and extreme temperatures will impact agriculture. Some tree species are intolerant of drought.	Forestry plantation may be susceptible to drought stress, depending on tree species.	Some tree species are intolerant of waterlogging.	Low risk/exposure and/or susceptibility.

# Area 8: Arrochar, Tarbert and Ardlui

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>the A82 connecting Inverarnan, Ardlui, Tarbet and Inverbeg</li> <li>The A83 connecting Tarbet, Arrochar, and Achadunan</li> </ul>	Small stretches of the A82 and A83, are within areas of wildfire susceptible habitats and areas with the potential of increased human activity. The most affected lengths are the A83 around Rest and Be Thankful, and the A82 at Ardlui.	Most of the A82 and small stretches of the A83, are in areas susceptible to flooding. Key areas of flood risk include: stretches of the A82 along Loch Lomond and A83 at Arrochar.	Most of the A82 and A83, are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. The most affected areas are the A82 along Loch Lomond and A83 between Arrochar and the Rest and Be Thankful.	The A82 and A83, are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the A82 and A83, through an increased risk of flooding and landslides (see Flood risk and Landslide).	The A82 and A83, are in areas highly susceptible to landslides. In particular, the stretch from Artgarten to the Rest and be Thankful.
Rail line and stations	The rail line connecting Arrochar and Tarbert and Ardlui to the north and south.	Stretches of the rail line are within areas of wildfire susceptible habitats. The key lengths are along Loch Long and Loch Lomond.	Several small areas with susceptibility to flooding.	Almost all stretches of the railway lines are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	The rail line susceptible to impacts from high temperatures, including buckling and service delays.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the rail line through an increase in the risk of flooding and landslides (see Flood risk and Landslide).	The entire length of the rail line between Ardlui, and Craggan are in areas highly susceptible to landslides.
Paths	<ul> <li>The key paths are:</li> <li>The West Highland Way on the east side of Loch Lomond, Three Lochs Way in the south west, connecting to Inveruglas, and the Loch Lomond and Cowal Way</li> <li>The NCP connecting Inveruglas, Tarbet, Arrochar, Ardgartan, and the Rest and be Thankful</li> </ul>	Some lengths of the long distance routes and the network of core paths are within areas susceptible to wildfires. This includes much of the Three Lochs Way and NCP west of Arrochar.	Small lengths NCP along Loch Lomond and at Arrochar, are in areas susceptible to flooding.	Most of the long distance routes and the network of core paths are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees. Key lengths are around Tarbet, Arrochar, and along Loch Lomond.	The long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the long distance routes and the network of core paths, through an increase in the risk of flooding and landslides (see Flood risk and Landslide).	All the lengths of the long distance routes and the network of core paths are in areas highly susceptible to landslides.
Energy infrastructure	The overhead line towers and lines between: Inverarnan and Craggan; Inveruglas and Clachan At Inveruglas	Significant lengths of the OHLs and towers are in areas susceptible to wildfires.	Low risk/exposure and/or susceptibility.	Significant lengths of the OHLs and towers pass through extensive areas of woodland and forestry with potential to be impacted by storm damage and fallen trees. The area with the greatest lengths within susceptible areas is around Succoth.	The OHL is susceptible to impacts from extreme weather including sagging.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the OHL and towers, through an increase in the risk of flooding and landslides (see <b>Landslide</b> ).	The entire length of the OHL towers are within areas of high susceptibility to landslides.
Other infrastructure	Loch Sloy hydroelectric scheme	Infrastructure in areas susceptible to wildfires.	N/A	Low risk/exposure and/or susceptibility.	N/A	Reliant on water availability for operation.	N/A	N/A
Habitats	<ul> <li>Main habitats include:</li> <li>Dry grasslands</li> <li>Alpine and subalpine grasslands</li> <li>The main water body is Loch Sloy</li> </ul>	Grasslands are high risk habitats for wildfires.	Flooding events can lead to: Changes in water levels. Unseasonal inundation, such as summer flooding in temperate wet grasslands, has been observed to induce plant community, soil	Storm events can lead to damage and loss of vegetation.	Alpine and sub alpine grasslands vulnerable to high temperatures and drought. Water bodies including Loch Sloy and Loch Lomond vulnerable to changes in temperature and extreme heat.	Alpine and sub alpine grasslands vulnerable to high temperatures and drought. Water bodies including Loch Sloy and Loch Lomond vulnerable to changes in temperature and extreme heat.	Direct impacts on habitats during heavy rainfall events, may be compounded by recreational erosion.	Low risk/exposure and/or susceptibility.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
			nutrient and biodiversity impacts. Reduced rooting depth for species intolerant of winter water-logging, exacerbating the effects of summer drought.					
Protected habitats and species	<ul> <li>The SAC is Loch Lomond Woods - Old sessile oak woods</li> <li>The SSSIs are: <ul> <li>West Loch Lomondside Woodlands - Upland oak woodland</li> </ul> </li> <li>Glen Loin - Upland mixed ash woodland and upland oak woodland</li> <li>Ben Vorlich - Alpine flush, subalpine wet heath, tall herb ledge</li> <li>Garabal Hill - Caledonian Igneous</li> <li>Geal and Dubh Lochs - Hydromorphological mire range and oligotrophic loch</li> <li>Pollochro Woods - Bryophyte and lichen assemblage, wet woodland and wood pasture and parkland</li> <li>Beinn an Lochain - Siliceous scree, tall herb ledge and upland assemblage</li> <li>The SPA is Glen Etive and Glen Fyne – Golden eagle</li> </ul>	Ben Vorlich and Glen Loin, Garabal Hill and Geal have habitats that are susceptible to wildfires.	Small areas of Glen Loin and Garabal Hill are in flood risk areas.	Most of Glen Loin and areas of Garabal Hill have woodland vegetation which can be damaged and/or impacted in storm events. The upland vegetation of Ben Vorlich may also be impacted by storm events.	Loch Lomond woods, Glen Loin, Ben Vorlich, Geal and Dubh Lochs, and Pollochro Woods are susceptible to changes in temperature, and extreme heat as they are reliant on higher levels of moisture.	Loch Lomond woods, Glen Loin, Ben Vorlich, Geal and Dubh Lochs, and Pollochro Woods are susceptible to drought as they are reliant on higher levels of moisture, are susceptible to drought stress.	Precipitation will increase the risk of flooding, change water levels and affect plant and animal composition, impacting the SAC and SSSIs.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Visitor and recreational destinations	The main visitor attractions and facilities are: Four Munros, 6 Campsites, 2 waterbus departures, 3 carparks, found Northwest of Loch Lomond, 1 campsite, and 2 car parks for north of Loch Goil by Arrochar.	Low risk/exposure and/or susceptibility.	Carparks and campsites on the shores of Loch Lomond area within areas susceptible to flooding. As are car parks in Arrochar and Ardgartan.	Ten of the main visitor attractions and facilities are in areas with potential to be impacted by storm damage and fallen trees.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	All of the destinations and facilities are within areas susceptible to flooding impacts which could be exacerbated from increased precipitation (see Flood and landslide risk)	Several destinations and facilities are within areas of high susceptibility to landslides, including the visitor car park at Ardgarten, within Glen Croe which is an area of high susceptibility.
Settlements	Key community services include: Arrochar Primary School, Arrochar Surgery, Arrochar Fire Station, and hotels, shops, restaurants and playspaces at Arrochar, Tarbet and Ardlui.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	Facilities at Tarbet, Arrochar and Ardlui are adjacent to woodlands and vegetation which could be impacted during storm events.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks.	Low risk/exposure and/or susceptibility.	Community facilities and services are within areas of significant susceptibility to landslides.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Historic and cultural designated sites and assets	Scheduled monuments include Inveruglas Castle, Island I Vow Castle and settlement, and Pulpit Rock.	Low risk/exposure and/or susceptibility, both castles on islands in Loch Lomond.	Areas of flood risk for both islands.	Trees and woodlands on the islands vulnerable to storm damage.	Low risk/exposure and/or susceptibility.	Low risk/exposure and/or susceptibility.	Built features susceptible to damage.	Low risk/exposure and/or susceptibility.
Agriculture and forestry	Small areas of improved pasture, extensive areas of rough grassland and larger areas of forestry north of Tarbet and Arrochar and northern edge of Loch Long	Extensive areas of forestry and agricultural land adjacent to areas susceptible to wildfires.	Low risk/exposure and/or susceptibility on limited areas of improved grassland at loch edge.	Extensive areas of forestry which can be impacted by storm events.	Increased and extreme temperatures will impact forestry sites, some tree species intolerant of drought.	Forestry plantation may be susceptible to drought stress, depending on tree species.	Increased precipitation will impact growth rates and yield impacts. Some tree species intolerant of waterlogging.	Low risk/exposure and/or susceptibility.

# Area 9: Lochgoilhead, Ardentinny and Glenbranter

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Roads	<ul> <li>Main roads include:</li> <li>The B839 connecting Lochgoihead and Monevechadan.</li> <li>The A815 connecting Kilmun and Glenbranter</li> </ul>	Small lengths of the B839 and A815, are within areas of wildfire susceptible habitats. The most affected length is the B839 connecting Lochgoihead and Monevechadan.	Most of the B839 and A815, are in areas susceptible to flooding. Key areas of flood risk include: the B839 along Loch Goil, the A815 along Loch Eck.	Most of the B839 and A815, are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	The B839 and A815, are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the B839 and A815, through an increase in the risk of flooding and landslides (see Flood risk and Landslide).	The B839 between Lochgoihead and Monevechadan, and A815 between Glenbranter and Stuck, are in areas highly susceptible to landslides.
Paths	The key paths are: The Loch Lomond and Cowal Way running from the west of Loch Long and connecting to Lochgoilhead and Glenbranter. The NCP connecting the Rest and be Thankful, Lochgoilhead, Carrick Castle, Ardentinny, Kilmun, Coylet, and Glenbranter.	Small lengths of the long distance routes and the network of core paths are within areas of wildfire susceptible habitats. Key areas are near Strachur.	Small lengths of NCP near waterbodies are in areas susceptible to flooding.	Most of the long distance routes and the network of core paths are adjacent to woodland and forestry with potential to be impacted by storm damage and fallen trees.	The long distance routes and the network of core paths are susceptible to impacts from high temperatures, including cracking and surface damage.	Low risk/exposure and/or susceptibility.	Increased precipitation has the potential to impact the Long distance routes and the network of core paths, through an increase the risk of flooding and landslides (see Flood risk and Landslide).	The long distance routes and the network of core paths south of Luss are in areas with localised significant susceptibility to landslides.
Habitats	<ul> <li>Main habitats include:</li> <li>Dry grasslands</li> <li>Highly artificial coniferous woodland</li> <li>Broadleaved deciduous woodland</li> <li>The main water bodies are Loch Eck, and the sea lochs of Loch Goil and Loch Long</li> </ul>	Grasslands are high risk habitats for wildfires.	Flooding events can lead to changes in water levels and inundation of salt water from sea lochs.	Storm events can lead to damage and loss of vegetation including woodland and inundation of salt water from sea lochs.	Waterbodies may be impacted by altered water levels and temperatures during these events.	Waterbodies may be impacted by altered water levels and temperatures during these events.	Increased precipitation can result in changes in water levels, waterlogging and increased risk of storm damage, and inundation by salt water.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.
Protected habitats and species	<ul> <li>The SSSIs are:</li> <li>Beinn an Lochain - Siliceous scree, tall herb ledge and upland assemblage</li> <li>Hells Glen – Bryophyte and lichen assemblage and upland oak woodland</li> <li>Loch Eck - Common whitefish, artic charr, fish and bryophyte assemblage, Flood-plain fen, oligotrophic loch</li> <li>Craighoyle Woodland - Bryophyte and lichen assemblage</li> <li>The SACs are:</li> <li>Ben Heasgarnich – Species-rich Nardus grasslands and Alpine pioneer formations</li> <li>Flanders Mosses – Active raised bogs</li> </ul>	Low risk / exposure	Lock Eck and small areas south of Craighoyle Woodland are in areas of flood risk.	The Craighoyle Woodland and along Loch Eck includes vegetation which can be impacted in storm events.	The Craighoyle Woodland and Loch Eck are susceptible to changes in temperature, and extreme heat.	The main SSSIs and SAC, are susceptible to drought stress.	Precipitation will increase the risk of flooding, change water levels, and affect plant and animal composition, impacting the SAC and SSSIs.	Landslide risk assumed to be low overall, due to likely scale and extent of landslide.

Receptors	Description	Wildfire	Flood risk	Storms	Increased temperature/ extreme temperature events	Reduced water availability/drought	Increased precipitation	Landslide
Visitor and recreational destinations	The main visitor attractions and facilities are three car parks along Loch Eck, south of Loch Eck and at Ardentinny Beach.	Low risk / exposure and/or susceptibility.	The car park south of Loch Eck is in a flood risk area.	All car parks adjacent to woodlands and vegetation which could be impacted during storm events.	Low risk / exposure and/or susceptibility.	Low risk / exposure and/or susceptibility.	Low risk / exposure and/or susceptibility.	Low risk / exposure and/or susceptibility.
Settlements	Key community and visitor services within settlements include: Lochgoilhead Primary School, Lochgoilhead Medical Centre, Lochgoilhead Village Hall and hotels, shops and play spaces at Lochgoilhead and Ardentinny.	Key community facilities and services, including Lochgoilhead Primary School are in areas susceptible to indirect effects from wildfires.	There are a couple of community facilities in areas susceptible to flood risk.	Low risk/exposure and/or susceptibility.	Key community facilities and services are susceptible to direct and indirect impacts of temperature changes and extreme temperatures including discomfort and overheating.	All key community facilities and services are susceptible to impacts from reduced water availability and drought risks.	There are a few key facilities and services in areas susceptible to river or coastal flooding. Risk could be exacerbated by increased precipitation.	Low risk / exposure and/or susceptibility.
Historic and cultural designated sites and assets	<ul> <li>Designated assets are:</li> <li>Benmore Botanic Garden is a designated Garden and Designed Landscape</li> <li>A scheduled monument at Glen Finart</li> </ul>	The botanic garden is adjacent to and contains areas of grassland/ heathland which are subject to high wildfire risk.	Small area to the south of the garden is subject to high flood risk.	Much of the botanic garden is susceptible to storm damage, including via windthrow.	The unique flora and fauna found in the botanic gardens may be at high risk of damage from extreme temperature events.	The unique flora and fauna found in the botanic gardens may be at high risk of damage from reduced water availability.	Precipitation will increase the risk of flooding, change water levels and affect plant and animal composition.	Low risk / exposure and/or susceptibility.
Agriculture and forestry	The forestry sites include highly artificial coniferous plantations around Loch Eck, the west side of Loch Long and Cowal i.e. much of Argyll Forest Park. Small areas of enclosed pasture at Glen Finart and at Balliemore.	Coniferous forestry is located adjacent to areas of grassland/heathland which are subject to high wildfire risk and may spread to adjacent forestry.	Low risk/exposure and/or susceptibility for forestry. Areas of flood risk for enclosed pasture at Balliemore and Glen Finart.	Extensive areas of plantation forestry subject to windthrow risk.	Increased and extreme temperatures will impact pasture and forestry sites.	Forestry and pasture are susceptible to drought stress.	Increased precipitation can cause water logging, impeding access to land, reducing forage availability, and increasing disease risk.	Some areas of forestry in areas of high landslide risk but overall risk considered to be low.

# Chapter 4 Climate Change Risk Mapping

**4.1** This chapter contains climate change risk maps for each of the nine areas. These maps indicate where there are concentrations of high risk in each area. The high risk areas shown have been identified from the presence of one or more of the following combinations of risk, hazard and receptor;

- three or more high risks, for multiple hazards AND multiple receptor types
- three or more high risks for multiple hazards AND few receptor types
- three or more high risks for few hazards AND multiple receptor types.

**4.2** The main receptors within each area are shown on the maps including roads of interest (as identified by the LLTNPA), rail lines and designated sites. The locations of the main visitor and recreational destinations (which include visitor centres, car parks and Munros) are shown on the map as are the main settlement facilities and services (such as schools, libraries and hotels). While these are shown on the map, it is important to note that this does not necessarily mean that every risk in the high risk areas is applicable to every receptor and the risk assessment tables should be referred to for further detail.

**4.3** The areas provide an indication of the location of high risk areas, the extent of which would need to be identified through a ground truthing exercise, with areas potentially removed completely if mitigation measures are already in place.



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# Area 1 Crianlarich, Tyndrum and Killin: high risk priority areas

- Loch Lomond and The Trossachs National Park
  - Area 1: Crianlarich, Tyndrum and Killin
  - Settlement facilities and services
  - Visitor and recreational destination
  - Railway
  - River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled monument

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas



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# Area 2 Lochearnheaed and Balquiddher: high risk priority areas

- Loch Lomond and The Trossachs National Park
- Area 2: Lochearnheaed and Balquiddher
  - Settlement facilities and services
  - Visitor and recreational destination
  - River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled monument

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas



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# Area 3 Callander: high risk priority areas

- Loch Lomond and The Trossachs National Park
- Area 3: Callander
  - Settlement facilities and services
  - Visitor and recreational destination
  - River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled monument

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas



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## Area 4 Brig O'Turk, Aberfoyle and Inversnaid: high risk priority areas

- Loch Lomond and The Trossachs National Park
  - Area 4: Brig O'Turk, Aberfoyle and Inversnaid
  - Settlement facilities and services
  - Visitor and recreational destination River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas



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## Area 5 Balmaha, Drymen and Rowardennan: high risk priority areas

- Loch Lomond and The Trossachs National Park
  - Area 5: Balmaha, Drymen and Rowardennan
  - Settlement facilities and services
  - Visitor and recreational destination River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled monument

**Climate change risks** 

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide

High risk areas



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# Area 6 Balloch: high risk priority areas

- Loch Lomond and The Trossachs National Park
- Area 6: Balloch
  - Settlement facilities and services
  - Visitor and recreational destination
  - River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled monument
  - Registered Parks and Gardens

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- )
- High risk areas



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# Area 7 Luss and Iverbeg: high risk priority

- Loch Lomond and The Trossachs National Park
- Area 7: Luss and Iverbeg
  - Settlement facilities and services
  - Visitor and recreational destination
  - River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled monument
  - **Registered Parks and Gardens**

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas



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## Area 8 Arrochar, Tarbert and Ardlui: high risk priority areas

- Loch Lomond and The Trossachs National Park
- Area 8: Arrochar, Tarbert and Ardlui
  - Settlement facilities and services
  - Visitor and recreational destination
  - Railway
  - River
  - Road of interest
  - Special Area of Conservation
  - Site of Special Scientific Interest

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas



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## Area 9 Lochgoilhead, Ardentinny and Glenbranter: high risk priority areas

- Loch Lomond and The Trossachs National Park
  - Area 9: Lochgoilhead, Ardentinny and Glenbranter
  - Settlement facilities and services
  - Visitor and recreational destination River
  - Road of interest
  - Site of Special Scientific Interest
- Registered Parks and Gardens

- Wildfires
- Flood risk
- Storms
- Increased temperature / extreme temperature events
- Reduced water availability / drought
- Increased precipitation
- Landslide
- High risk areas

# Chapter 5 Climate Change Opportunities

**5.1** As well as risks, there may also be opportunities associated with climate change for the National Park. Opportunities are set within the context of a range of other influencing factors and there are likely to be a number of uncertainties and new risks associated with the opportunities identified. In addition, some opportunities may be associated with a specific adaptation response, and not directly linked to the changing climate. We recommend further review of opportunities from the next stages of the adaptation planning process, to reflect the adaptation actions identified.

**5.2** Informed by the UK Climate Change Risk Assessment (CCRA3) Summary for Scotland<sup>33</sup> the following opportunities are identified for Loch Lomond and the Trossachs National Park.

#### Communities

- Warmer winters are likely to reduce the risk of exposure to the cold and risks associated with snow and ice.
- As mean and summer temperatures rise, opportunities for more outdoor activities could increase, orividing physical and mental health benefits of increased physical activity and contact with nature.

#### Visitor economy

Increased tourism during the summer months associated with higher temperatures and lower precipitation.

<sup>&</sup>lt;sup>33</sup>SNIFFER (2021) Third UK Climate Change Risk Assessment Technical Report: Summary for Scotland. Available at: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-Scotland-Summary-Final-1.pdf

Chapter 5 Climate Change Opportunities

Climate Change Adaptation Risks and Opportunities Assessment March 2024

#### Skills and employment

- Transition to new skills or employment patterns as new skills are required to implement the climate resilience management practices.
- Further opportunities will emerge in response to actions to respond to climate change risks for example, co-benefits of habitat restoration for flood management, biodiversity and new employment opportunities.
- Climate change increases the need for repair and maintenance of heritage sites with greater requirements for materials and sector-specific skills (employees to repair traditional/historic buildings).

#### Energy

- Reduced energy consumption due to milder winters bringing benefits to both consumers and reducing demands on energy generation infrastructure.
- The development of back-up power supply to address risk of power disruption could be linked to opportunities for developing renewable energy generation and storage.

#### Transport

Reduced transport disruption due to weather impacts on the transport network due to ice and snow.

#### **Habitats and species**

- Some species will move and/or expand their ranges northwards or to higher altitudes to colonise new areas, especially mobile species which have suitable habitats and food sources in their potential new climate space.
- Actions to manage coastal flood risk through habitat creation may benefit biodiversity.
- Instances of milder and wetter climate may benefit carbon sequestration of peatland, however this could be negated by periods of higher temperature and drought, or damage from increased erosion.

#### Agricultural and forestry productivity

- The growing season is likely to become longer while new or alternative species may become suitable in Scotland's future climate, enhancing productivity. However, there may be key barriers to realising these opportunities. Additionally, the seasonal variation in climate may impact on ability to sow or harvest crops due to flooding or wet soils.
- There may be opportunity for new forestry species where temperature is no longer a limitation, however this is likely to be complicated by issues such as drought resilience and ability to tolerate wet conditions due to seasonal changes.
- New forestry and woodland planting may include a mix of species to help reduce future climate risks, which may also bring landscape and visual benefits.

# Chapter 6 Recommendations and Next Steps

**6.1** Climate adaptation is 'the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities'<sup>34</sup>. Adaptation requires a good understanding of future climate projections and the expected impacts of climate change. It involves the identification and implementation of appropriate methods to build resilience for existing receptors and adapt any future planning and development to ensure its suitability for the future climate.

**6.2** The results of this study provide an initial basis for the LLTNPA to proceed with further indepth analysis on the high risk areas of most interest to their operations and communities, and to prepare plans to adapt to these. The next steps the LLTNPA should undertake to progress this study are outlined below.

### **Next Steps**

#### Identification of existing adaptation measures and plans

**6.3** The risk assessment which has been undertaken through this study does not consider any existing adaptation measures or plans which may already be in place. The next stage of the process will involve the identification of these measures. Consultation with key stakeholders will form a key part of this, particularly those responsible for the resilience of road, rail and energy infrastructure who are likely to have undertaken their own specific climate risk assessments and have adaptation plans in place. In addition, a review of other plans and projects within the LLTNP should be undertaken to understand where actions may directly or indirectly be influencing future adaptation.

<sup>&</sup>lt;sup>34</sup> IPCC (2021) Sixth Assessment Report Annex VII: Glossary

Chapter 6 Recommendations and Next Steps

Climate Change Adaptation Risks and Opportunities Assessment March 2024

**6.4** Once a full picture of existing adaptation efforts has been established the risk register scoring should be reviewed, with the severity of some risks likely to decrease or potentially be removed altogether.

#### Updating the risk-register

**6.5** The findings of this report are based on available mapped datasets and supplementary research but is not fully comprehensive. Further analysis of combinations of additional data sets could provide further detail to identifying the location of risks.

**6.6** To ensure all risks are captured the LLTNPA should undertake consultation with land managers and communities to identify additional risks which may not have been apparent from the data-sets available.

**6.7** The risk register should be regularly updated to take into account new or updated datasets, new local and national research, the creation of adaptation plans for specific sectors and the implementation of adaptation measures.

#### **Raising awareness and building partnerships**

**6.8** This report, the risk assessment and area risk maps should be used to raise awareness of the nature and severity of risks associated with climate change for the National Park and the urgent need to begin to adapt. It will be critical to engage with different departments within the LLTNPA and key partners so that the relevant risks are taken into consideration in the preparation of other plans and strategies such as the National Park Partnership Plan and Local Development Plan.

**6.9** The risk mapping should also be used to raise awareness among communities and build support for the creation and implementation of adaptation plans.

#### **Preparation of adaptation plans**

**6.10** The LLTNPA intends to use this study to inform the development of climate adaptation plans for the National Park. When preparing these plans the LLTNPA should:

 Categorise risks into those within LLTNPA control and those within LLTNPA influence (e.g. through partnership working), and those out with LLTNPA control.

- Consider direct effects and secondary effects or consequences from other adaptation or LLTNPA activities e.g. impact of rewilding on fire risk.
- Identify timescales for adaptation.
- Identify any information gaps, whilst recognising the need for urgent action in some areas, particularly where adaptation efforts may take time to implement.
- Identify the costs of different adaptation responses, where these are managed by LLTNPA.
- **6.11** An action plan should then be developed using the following headings:
- Risk
- Adaptation response
- Existing mitigants
- Geographic variation
- Evaluation
- Costs
- Timeframe
- Responsibility
- LLTNPA role (responsible and with capacity to undertake action, or as an influencer only)
- Action owner (relevant department within LLTNPA)
- Date for action to be achieved.

# Appendix A

# Extreme weather events in the Loch Lomond and the Trossachs National Park

**A.1** This appendix details all of the extreme weather events in the Loch Lomond and the Trossachs National Park considered when preparing the localised climate change projections.

Year	Category	Title	Source
2023	Landslide	Rest and be Thankful road reopens after seven landslides	BBC, 2023. Rest and be Thankful road reopens after seven landslides. <u>https://www.bbc.co.uk/news/uk-scotland-67081947</u>
2023	Wildfires	Wildfires at Ben Lomond	BBC, 2022. Wildfires break out at Mallaig and on Ben Lomond. https://www.bbc.co.uk/news/uk-scotland-60834170
2023	Storm	Storm Gerrit	
2023	Storm	Storm Debi	
2023	Storm	Storm Babet	
2023	Heavy rainfall	Exceptional rainfall in Scotland	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
2023	Storm	Storm Otto	
2022	Heatwave	Unprecedented heatwave	
2022	Low temperatures	Spell of low temperatures	
2022	Wildfires	The Herald reported wildfires in Argyll and Bute	
2022	Wildfires	The Herald reported wildfires in Argyll and Bute	Ema Sabljak, 2023. Scotland's wildfires in maps and charts across all councils. The Herald. https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/
2022	Wildfires	The Herald reported wildfires in Argyll and Bute	Originating source: Scottish Fire and Rescue Service (SFRS)
2022	Wildfires	The Herald reported wildfires at Stirling	

Year	Category	Title	Source
2022	Wildfires	The Herald reported wildfires at Stirling	
2022	Storm	Storm Arwen	Met Office, 2024. Past weather events: Case studies of past severe weather events.
2022	Storm	Storms Dudley, Eunice, and Franklin	https://www.metonice.gov.uk/weathemean-abou/past-uk-weather-events
2022	Storm	Storms Malik and Corrie	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	Ema Sabljak, 2023. Scotland's wildfires in maps and charts across all councils. The Herald. <u>https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/</u> Originating source: Scottish Fire and Rescue Service (SERS)
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	

Year	Category	Title	Source
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Wildfires	The Herald reported wildfires in Argyll and Bute	
2021	Storm	Storm Christoph	
2021	High temperature	Extremes of temperature	Mat Office 2024 Past weather events: Case studies of past severe weather events
2021	Heavy rainfall	Heavy and persistent rain	https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
2021	Low temperatures	Snow and low temperatures including storm Darcy	
2020	Wildfires	The Herald reported wildfires in Argyll and Bute	
2020	Wildfires	The Herald reported wildfires at Stirling	Ema Sabljak, 2023. Scotland's wildfires in maps and charts across all councils. The Herald. <u>https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/</u> Originating source: Scottish Fire and Rescue Service (SERS)
2020	Wildfires	The Herald reported wildfires at Stirling	
2020	Storm	Storms Atiyah and Brendan	
2020	Storm	Storms Ellen and Francis	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
2020	Storm	Storm Alex and heavy rain	

Year	Category	Title	Source
2020	Storm	Storm Aiden	
2020	Storm	Storm Bella	
2020	Storm	Thunderstorms north-east Scotland	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	Ema Sabljak, 2023. Scotland's wildfires in maps and charts across all councils. The Herald. https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	Originating source: Scottish Fire and Rescue Service (SFRS)
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	

Year	Category	Title	Source
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires in Argyll and Bute	
2019	Wildfires	The Herald reported wildfires at Stirling	
2019	Storm	Storm Erik	
2019	High temperature	Exceptional warmth	
2019	Storm	Storm Garreth	Met Office, 2024. Past weather events: Case studies of past severe weather events.
2019	Heavy rainfall	Heavy rainfall	https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
2019	Heatwave	Record-breaking heatwave	
2019	High temperature	Record-breaking temperature	

Year	Category	Title	Source
2019	Storm	Storm Freya	
2018	Landslide	Rest and Be Thankful Landslide	Daily Record, 2018. Rest and be Thankful stays closed as A83 hit by MORE landslides as Storm Callum batters Scotland. <u>https://www.dailyrecord.co.uk/news/scottish-news/rest-thankful-stays-closed-a83-13407335</u> Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. <u>https://psmsl.org/data/obtaining/map.html#metadataTab</u>
2018	Wildfires	The Herald reported wildfires in Argyll and Bute	
2018	Wildfires	The Herald reported wildfires in Argyll and Bute	Ema Sabljak, 2023. Scotland's wildfires in maps and charts across all councils. The Herald. https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/
2018	Wildfires	The Herald reported wildfires in Argyll and Bute	Originating source: Scottish Fire and Rescue Service (SFRS)
2018	Wildfires	The Herald reported wildfires in Argyll and Bute	
2018	Low temperatures	Snow and low temperatures	
2018	Storm	Storm Callum	
2018	Storm	Storm Deirdre	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
2018	Storm	Storm Ali and Bronagh	
2018	Storm	Storm Hector	
2017	Wildfires	The Herald reported wildfires in Argyll and Bute	Ema Sabljak, 2023. Scotland's wildfires in maps and charts across all councils. The Herald. https://www.heraldscotland.com/news/23498843.scotlands-wildfires-maps-charts-across-councils/

Year	Category	Title	Source					
2017	Wildfires	The Herald reported wildfires in Argyll and Bute	Originating source: Scottish Fire and Rescue Service (SFRS)					
2017	Wildfires	The Herald reported wildfires in Argyll and Bute						
2017	Wildfires	The Herald reported wildfires in Argyll and Bute						
2017	Wildfires	The Herald reported wildfires in Argyll and Bute						
2017	Wildfires	The Herald reported wildfires in Argyll and Bute						
2017	Wildfires	The Herald reported wildfires at Stirling						
2017	Wildfires	The Herald reported wildfires at Stirling						
2017	Wildfires	The Herald reported wildfires at Stirling						
2017	Wildfires	The Herald reported wildfires at Stirling						
2017	Strong winds	Ex-Hurricane Ophelia	Mat Office, 2024. Reat weather events: Case studies of past severe weather events					
2016	High temperature	Exceptional warmth, September 2016	https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events					

Year	Category	Title	Source				
2016	Landslide	A83 Rest And Be Thankful	The Press and Journal, 2016. <u>https://www.pressandjournal.co.uk/fp/news/highlands/793906/woman-lucky-to-be-alive-after-landslide/</u>				
			Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab				
2015	Flood	Flooding in Cumbria December 2015					
2015	Flood	Further rainfall and flooding across north of the UK	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events				
2015	High temperature	Exceptional warmth, December 2015					
2014	Landslide	A83 Rest and Be Thankful	The Press and Journal, 2014. A83 reopens following major landslide. https://www.pressandjournal.co.uk/fp/news/highlands/389089/a83-reopens-following-major-landslide/				
			Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab				
2014	Landslide	A83 through Glenkinglas	Argyll Bute 24, 2014. <u>http://www.dunoon-observer.com/index.php?option=com_content&amp;view=article&amp;id=8161:heavy-rain-triggers-minor-mud-flow-&amp;catid=1:news&amp;Itemid=19</u>				
			Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab				
2014	Landslide	A83 Argyll and Bute	The Daily Record, 2014. A83 closed again after heavy rain causes landslide near the Rest and Be Thankful. <u>http://www.dailyrecord.co.uk/news/scottish-news/a83-closed-again-after-heavy-</u> <u>3212567#http://www.dailyrecord.co.uk/news/scottish-news/a83-closed-again-after-heavy-3212567</u>				
			Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab				

Year	Category	Title	Source						
2014	Landslide	Argyll and Bute	PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab						
2014	Landslide	A82 at Loch Lomond	BBC, 2014. http://www.bbc.com/news/uk-scotland-glasgow-west-25916386#http://www.bbc.com/news/uk-scotland-glasgow-west-25916386						
			Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab						
2014	Landslide	A83 Cairndow	BBC, 2014. <u>http://www.bbc.com/news/uk-scotland-glasgow-west-25759015#http://www.bbc.com/news/uk-scotland-glasgow-west-25759015</u>						
			Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab						
2013	Storm	Winter storms, December to January 2013	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events						
2012	Landslide	A83 Tarbet to Campeltown, Rest	The Press and Journal, 2012. http://www.pressandjournal.co.uk/Article.aspx/3017006/						
		and Be Thankful	Originating source: PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab						
2012	Landslide	A83 Rest and Be Thankful	The Herald, 2012. http://www.heraldscotland.com/news/transport/landslide-closes-road-for-fourth-time-in-five- years.16833775						
2012	Storm	Winter storms, early January 2012	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events						
2011	Landslide	A83 Rest and Be Thankful	PSMSL, 2024. PSMSL catalogue. Permanent Service for Mean Sea Level. https://psmsl.org/data/obtaining/map.html#metadataTab						

Year	Category	Title	Source
2011	Storm	Early winter storms, late 2011	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events
2010	Landslide	A83 between Dunoon rd. junction and Rest and Be Thankful, Argyll and Bute, Scotland	The Herald, 2010. <u>http://www.heraldscotland.com/news/home-news/anger-as-new-landslide-hits-vital-road-link-1.1055160?localLinksEnabled=false</u>
2010	Low temperatures	Snow and low temperatures, December 2010	Met Office, 2024. Past weather events: Case studies of past severe weather events. https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-event

**B.1** This appendix details the localised climate change projections for the LLTNPA.

Climate Change Adaptation Risks and Opportunities Assessment March 2024

### Mean summer temperature climate projections

Plots of summer temperature climate projections: (A) RCP2.6 scenario; (B) RCP4.5 scenario; (C) RCP6.0 scenario; (D) RCP8.5 scenario.



Met Office Funded by BEIS and Defra

Climate Change Adaptation Risks and Opportunities Assessment March 2024

## Mean winter temperature climate projections

Winter temperature climate projections: (A) RCP2.6 scenario; (B) RCP4.5 scenario; (C) RCP6.0 scenario; (D) RCP8.5 scenario.



Met Office Funded by BEIS and Defra

Climate Change Adaptation Risks and Opportunities Assessment March 2024

Table of mid to long-term temperature projections for LLTNP under low and high emission scenarios

		2050-2069					2080-2099						
		RCP2.6			RCP8.5		RCP2.6			RCP8.5			
Context	Season	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile
Scotland	Winter	-0.4°C	0.7°C	1.8°C	0.2°C	1.6°C	2.9°C	-0.3°C	0.8°C	2°C	0.5°C	2.6°C	4.7°C
	Summer	0.2°C	1.1°C	2°C	0.5°C	1.9°C	3.4°C	0.1°C	1.2°C	2.3°C	1.6°C	3.9°C	6.2°C
LLTNP	Winter	-0.9°C	0.8°C	2.5°C	-2.6°C	1.6°C	3.6°C	-1°C	0.8°C	2.7°C	0.1°C	2.7°C	5.4°C
	Summer	-0.3°C	1.2°C	2.8°C	0.5°C	2.1°C	4.3°C	-0.4°C	1.3°C	3.1°C	1.4°C	4.2°C	7.2°C

Climate Change Adaptation Risks and Opportunities Assessment March 2024

## Mean summer precipitation climate projections

Summer precipitation climate projections: (A) RCP2.6 scenario; (B) RCP4.5 scenario; (C) RCP6.0 scenario; (D) RCP8.5 scenario.


Climate Change Adaptation Risks and Opportunities Assessment March 2024

## Mean winter precipitation climate projections

Winter precipitation climate projections: (A) RCP2.6 scenario; (B) RCP4.5 scenario; (C) RCP6.0 scenario; (D) RCP8.5 scenario.



Climate Change Adaptation Risks and Opportunities Assessment March 2024

Table of mid to long-term precipitation projections for LLTNP under low and high emission scenarios

	2050-2069					2080-2099							
	RCP2.6		RCP8.5		RCP2.6		RCP8.5						
Context	Season	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile	10 <sup>th</sup> Percentile	50 <sup>th</sup> Percentile	90 <sup>th</sup> Percentile
Scotland	Winter	-1%	10%	22%	0%	15%	33%	-4%	7%	20%	0%	22%	52%
	Summer	-21%	-7%	8%	-29%	-11%	11%	-26%	-13%	1%	-47%	-24%	5%
LLTNP	Winter	-26%	9%	45%	-22%	16%	55%	-28%	7%	46%	-19%	23%	71%
	Summer	-47%	-14%	23%	-52%	-19%	22%	-50%	-16%	29%	-64%	-32%	14%

Climate Change Adaptation Risks and Opportunities Assessment March 2024

# Mean sea level climate projections

Mean sea level projections: (A) RCP2.6 scenario; (B) RCP4.5 scenario; (C) RCP8.5 scenario.



Climate Change Adaptation Risks and Opportunities Assessment March 2024

2050-2069 2080-2099 RCP2.6 RCP8.5 RCP2.6 **RCP8.5** 50<sup>th</sup> 95<sup>th</sup> 50<sup>th</sup> 95<sup>th</sup> 5<sup>th</sup> 50<sup>th</sup> 95<sup>th</sup> 50<sup>th</sup> 95<sup>th</sup> Context Percentile Edinburgh 0.1 0.3 0.2 0.5 0.1 0.5 0.3 0.9 0.1 0.1 0.1 0.2 0.3 0.2 0.4 0.2 0.4 0.2 0.4 0.7 LLTNP

Table of mid to long-term sea level projections for LLTNP under low and high emission scenarios

C.1 This appendix details the data sets which were used to prepare the risk assessment.

Risk	Dataset	Description	
	Grassland/ heathland from Landscover 2022 EUNIS level 2 (NatureScot/Space Intelligence): <u>https://spatialdata.gov.scot/geonetwork/srv/api/records/8462f345-6e9c-45de-b1d2-665a55b9d74a</u>	This is the most recent, high resolution (20m pixel size) land cover dataset for Scotland. The following land cover categories were extracted from the dataset because these categories are the most susceptible to wildfires in the event of high temperatures and extreme weather events (droughts):	
Wildfires	Baseline temperature data from the Met Office (Met Office; Hollis, D.; McCarthy, M.; Kendon, M.; Legg, T.; Simpson, I. (2018): HadUK-Grid gridded and regional average climate observations for the UK. Centre for Environmental Data Analysis, 21/03/2024. http://catalogue.ceda.ac.uk/uuid/4dc8450d889a491ebb20e724debe2dfb) Temperature climate projections (Met Office Hadley Centre (2018): UKCP18 Probabilistic Climate Projections. Centre for Environmental Data Analysis, 21/03/2024 http://catalogue.ceda.ac.uk/uuid/9842e395f2d04f48a177c3550756bf98)	n Alpine and subalpine grasslands (E4) n Temperate shrub heathland (F4) n Dry grasslands (E1) n Mesic grasslands (E2)	
		<ul> <li>Seasonally wet and wet grasslands (E3)</li> <li>The percentage change between baseline and projections was measured to assess the potential for more wildfires since extreme temperatures can increase the risk of wildfires.</li> </ul>	

Storms	Woodland from Landcover 2022 EUNIS level 2 (NatureScot/Space Intelligence) https://spatialdata.gov.scot/geonetwork/srv/api/records/8462f345-6e9c-45de-b1d2- 665a55b9d74a - buffered by 10m OS OpenRoads https://www.ordnancesurvey.co.uk/products/os-open-roads OS OpenMapLocal rail tracks https://www.ordnancesurvey.co.uk/products/os-open-map- local SSE Overhead lines and towers (not publicly available)	<ul> <li>This is the most recent, high resolution (20m pixel size) land cover dataset for Scotland.</li> <li>The land cover categories listed below were extracted from the dataset because these are woodland categories which present the risk of trees fall during storms, which are projected to become more frequent by the Met Office. These were buffered by 10m to account for the infrastructure that might be impacted by wood fall:</li> <li>Broadleaved deciduous woodland (G1)</li> <li>Scots pine woodland (G3.4)</li> <li>Highly artificial coniferous plantations (G3.F)</li> <li>Mixed deciduous and coniferous woodland (G4)</li> <li>The infrastructure datasets used to assess this risk are OS OpenRoads, OS OpenMap Local railway tracks and SSE overhead lines and towers</li> </ul>
Flood risk	SEPA River, Coastal and Surface Water Flood Maps: https://www.sepa.org.uk/environment/environmental-data/	These are the authoritative flood risk maps for Scotland. The maps show areas which are likely to flood from rivers, the sea and surface water. There are also two future flood maps available for river and coastal flooding, based on 2080 high emission scenario.

Increased temperature/extre me temperature events	<ul> <li>Water from Landcover 2022 EUNIS level 2 (NatureScot/Space Intelligence) https://spatialdata.gov.scot/geonetwork/srv/api/records/8462f345-6e9c-45de-b1d2- 665a55b9d74a</li> <li>Baseline temperature data from the Met Office (Met Office; Hollis, D.; McCarthy, M.; Kendon, M.; Legg, T.; Simpson, I. (2018): HadUK-Grid gridded and regional average climate observations for the UK. Centre for Environmental Data Analysis, 21/03/2024. http://catalogue.ceda.ac.uk/uuid/4dc8450d889a491ebb20e724debe2dfb)</li> <li>Temperature climate projections (Met Office Hadley Centre (2018): UKCP18 Probabilistic Climate Projections. Centre for Environmental Data Analysis, 21/03/2024 http://catalogue.ceda.ac.uk/uuid/9842e395f2d04f48a177c3550756bf98)</li> </ul>	This is the most recent, high resolution (20m pixel size) land cover dataset for Scotland. The following land cover category was extracted from the dataset because in the event of a drought some of these water bodies might get depleted (for instance Loch Katrine that provides water to Glasgow): n Surface standing and running waters The percentage change between baseline and projections was measured to assess the potential for more extreme temperatures to increase the risk of droughts.
Increased precipitation	Baseline precipitation data from the Met Office (Met Office; Hollis, D.; McCarthy, M.; Kendon, M.; Legg, T.; Simpson, I. (2018): HadUK-Grid gridded and regional average climate observations for the UK. Centre for Environmental Data Analysis, 21/03/2024. http://catalogue.ceda.ac.uk/uuid/4dc8450d889a491ebb20e724debe2dfb) Precipitation climate projections (Met Office Hadley Centre (2018): UKCP18 Probabilistic Climate Projections. Centre for Environmental Data Analysis, 21/03/2024 http://catalogue.ceda.ac.uk/uuid/9842e395f2d04f48a177c3550756bf98)	The percentage change between baseline and projections was measured to assess the potential for increased precipitation, which relates to an increase in flood risk and landslides.

Landslides	BGS GeoSure Landslides 5km hex grid map: <u>https://www.bgs.ac.uk/datasets/bgs-geosure-5-km-hex-grid</u> /	The BGS GeoSure 5 km hex grid datasets provide a generalised overview of the susceptibility to six naturally occurring geohazards in Great Britain (dataset freely available), including landslides. The hexagon grid provides a national-scale summary of the GeoSure data product. Note: the detailed GeoSure dataset is also available to licence and provides further detail at a scale of 1:50 000 (https://www.bgs.ac.uk/datasets/geosure/).
		BGS GeoSure takes into account the local geology and slope of an area along with the geotechnical and structural characteristics of a geological formation. These conditioning factors are combined in GIS and the result is a susceptibility map. Note: the GeoSure assessment does not show risk or seek to determine the temporal distribution of landslides

**D.1** This appendix presents the evidence for the identified risks for LLTNP as they relate to the habitats within LLTNP.

Climate Change Adaptation Risks and Opportunities Assessment March 2024

Table D.1: Risk factors for LLTNP identified habitats

	Risks					
Habitat	Wildfire	Storms	Flooding	Changing/extreme temperatures		
Alpine and subalpine grasslands	Alpine and subalpine grasslands may be at risk of wildfire	Stronger winds lead to the vegetation being ripped off exposed slopes and summits and bare soil is vulnerable to soil erosion.	Direct impacts during heavy rainfall events, may be compounded by recreational erosion	A decrease in snow lie means the montane ground will experience a decrease in area or even total loss of montane heaths and snow-bed vegetation. Taller, more vigorous sedges, herbs and shrubs may become established in summit heath at the expense of mosses and montane herbs as a result of lighter grazing and a longer growing season.		
Temperate shrub heathland	Dwarf shrub heath, gorse, bracken and grasses are high risk habitats for wildfire <sup>i</sup>					
Bare peat areas	Bogs are low risk except in drought conditions <sup>35</sup>	Increased surface runoff during storm events cause peat loss	Measures to restore peatland and peat soils could be less successful as a result of increased or more intense rainfall or periods of drying.			
Coniferous woodland	Young coniferous woodlands are high risk habitats <sup>35</sup>	In the conifer plantations there has been an increase in windthrow, particularly during the wetter winter months.		Woodland increases water demand. Sitka spruce struggles in drought susceptible soils		

<sup>35</sup> Forestry Commission, 2014. Building Wildfire Resilience into Forest Management Planning. <u>https://forestry.gov.scot/publications/99-building-wildfire-resilience-into-forest-management-planning</u>

Climate Change Adaptation Risks and Opportunities Assessment March 2024

			Risks	
Habitat	Wildfire	Storms	Flooding	Changing/extreme temperatures
Raised and blanket bogs	Bogs are low risk except in drought conditions <sup>35</sup>	Increased surface runoff during storm events cause peat loss <sup>36</sup>	Measures to restore peatland and peat soils could be less successful as a result of increased or more intense rainfall or periods of drying.	Increases of <i>Calluna</i> and losses of <i>Sphagnum</i> spp., and some floristic shift toward wet or even dry heath. Peat bogs may dry out and erode with rising temperature <sup>36</sup>
Dry grasslands	Dwarf shrub heath, gorse, bracken and grasses are high risk habitats for wildfire <sup>35</sup>			Milder winters may reduce frost heaving, which will reduce the amount of bare ground for the regeneration/recruitment of annual plants from the seed bank Summer drought may favour annual species over perennials, leading to community change. Phenology may change significantly, with flowering and seed setting occurring earlier in season. Community composition may shift to favour southern temperate and Mediterranean continental plant species <sup>37</sup> . Bracken Pteridium aquilinum may spread and dominate some areas.

<sup>36</sup> PDNP, n.d. Climate Change Vulnerability Assessment: Feature Assessment: Habitats / Blanket Bog. <u>https://reports.peakdistrict.gov.uk/ccva/docs/assessments/habitats/blanketbog.html</u> <sup>37</sup> Preston, C.D., Telfer, M.G., Arnold, H.R., Carey, P.D., Cooper, J.M., Dines, T.D., Hill, M.O., Pearman, D.A., Roy, D.B., Smart, S.M. (2002). The Changing Flora of the UK. London Defra

	Risks						
Habitat	Wildfire	Storms	Flooding	Changing/extreme temperatures			
Seasonally wet and wet grasslands	Based on Forestry Commission. (2014) <sup>35</sup> , it is appropriate to assume high risk during dry conditions and low risk during wet conditions.	Storms will affect community composition <sup>38</sup>	Unseasonal inundation, such as summer flooding in temperate wet grasslands, has been observed to induce plant community, soil nutrient and biodiversity impacts <sup>38</sup>	An increase in summer droughts could lead to a decline in distinctive wet grassland communities <sup>38</sup>			
Broadleaved deciduous woodland (Note: may include temperature rainforest)	Broadleaves are low risk habitats for wildfire <sup>35</sup>	Increased frequency of wind- throw, leading to losses of mature and veteran trees. The loss of specialist species associated with veteran tree habitat (primarily fungi, invertebrates and lichens).	Increased likelihood of wind-throw if tree root depth becomes restricted by increased rainfall and water-logging. Reduced rooting depth for species intolerant of winter water-logging, exacerbating the effects of summer drought	Alder, wild cherry, rowan, silver birch and goat willow are all intolerant to drought, with downy birch and bay willow very intolerant to drought. These species are therefore further impacted by climate change, with some tree death during dry summers. Some of the indicator species for rainforest habitat such as lichens and bryophytes will also be affected by changes in humidity and temperature <sup>39</sup> . Warmer Winters: Earlier bud burst, with potential for increased risk of frost damage. Incomplete winter hardening, potentially resulting in more serious winter cold damage. Reduced winter chilling, leading to reduced seed germination and natural regeneration of some species. Greater survival of pests			

 <sup>&</sup>lt;sup>38</sup> Chris B. Joyce, Matthew Simpson, Michelle Casanova, 2016. Future wet grasslands: ecological implications of climate change. <a href="https://doi.org/10.1002/ehs2.1240">https://doi.org/10.1002/ehs2.1240</a>
 <sup>39</sup> Woodland Trust (2019) The State of Scotland's Rainforest <a href="https://doi.org/10.1002/ehs2.1240">State of Scotland's Rainforest State of Scotland's Rainforest Report - Woodland Trust</a>

Climate Change Adaptation Risks and Opportunities Assessment March 2024

	Risks						
Habitat	Wildfire	Storms	Flooding	Changing/extreme temperatures			
Arable land and market gardens	Arable crops nearing and immediately after harvest and grasslands nearing harvest are high risk <sup>35</sup>	Wind erosion effects from frequent storm events <sup>36</sup> , which can negatively affect productivity <sup>36</sup>	Surface flooding and associated soil saturation often results in decreased soil quality through nutrient loss, reduced plant productivity, stimulated microbial growth and microbial community composition <sup>41</sup> .	Negatively affect productivity <sup>41</sup> .			
Surface standing and running waters		Increasing inputs of terrestrial material derived from catchments during heavy rainfall, and through increased mixing of the water column by high winds. Extreme events can alter ecological functioning. Can also cause temperature change but varies for each water body <sup>40</sup> .	With increased flood events along watercourses, increased scouring on the surfaces of rocks in the riparian zone, and also on waterside banks and tree bases, causes removal of some populations of larger bryophytes. Increasing silt loads result in deteriorating water quality during flood events. This affects species dependent on clear water, and the species that prey upon them, potentially impacting the whole food chain of entire ecosystems.	Periods of low flow during seasonal drought conditions mean that salmon migration is impacted. Atlantic salmon are adapted to live in relatively cool water, and river temperatures over 23°C can cause thermal stress and behaviour change. During the summer of 2018, it is estimated that around 70% of rivers in Scotland experienced temperatures over this threshold. Warmer temperatures may increase the symptoms of eutrophication (excess nutrients leading to algal growth) in plankton and loch-shore plant communities.			

<sup>40</sup> CREW, 2022. Assessing climate change impacts on the water quality of Scottish standing waters. <u>https://www.crew.ac.uk/publication/assessing-climate-change-impacts-water-quality-scottish-standing-waters</u>

Climate Change Adaptation Risks and Opportunities Assessment March 2024

		Risks					
Habitat	Wildfire	Storms	Flooding	Changing/extreme temperatures			
Coast		Impact sediment transport pathways Affect timing, quantity and potentially source of sediment Increase in erosion rates.	The frequency of intense storm events and sea level rise is expected to increase and lead to more coastal flooding.	Increased air and sea surface temperatures have resulted in changes in the range sizes and distribution of a number of coastal animals. Warmer- water species are shifting northwards (e.g. the molluscs <i>Osilinus lineatus</i> and <i>Gibbula umbilicalis</i> ) and warm-water kelp has become more abundant beyond its southern margin <sup>41</sup> .			

<sup>41</sup> UKRI (2015) Biodiversity Climate Change Impacts <u>101221-NERC-LWEC-BiodiversityClimateChangeImpacts-ReportCard2015-English.pdf (ukri.org)</u>