Appendix 2: Environmental Baseline

Topic 1: Climatic Factors

> *"In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans."*
>
> Intergovernmental Panel on Climate Change (2014).

Scotland has a temperate climate with cool summers and mild winters. As a whole it is influenced by predominantly westerly depressions alternating with less frequent settled periods. A range of factors, including topography, latitude and altitude, affect these weather systems at a more local level.

Rainfall is spread throughout the year but there are regional differences. For example, the easterly position of the Cairngorms massif results in a climate that is less oceanic, and therefore drier, than the west of Scotland. The mountains exert a noticeable rain shadow effect that reduces the amount of rainfall on the eastern side of the country.

Scotland is currently experiencing climate change, which owing to the global emission of greenhouse gasses, is likely to continue into the future. The effects of this are likely to include:

- hotter, drier summers;
- milder, wetter autumns and winters.
- increased frequency and intensity of extreme rainfall; and
- reduced snowfall.

Past Trends

The 20th and 21st centuries have already seen a rise in average maximum and minimum temperatures throughout Scotland. This trend is reflected in the Cairngorms National Park, as demonstrated by historical data provided by the Breamar weather station (**Figure 8**). Records from the weather station also indicate that the National Park is experiencing a decrease in the number of days of air frost and an increase in annual rainfall (**Figure 9** and **Figure 10**). This is consistent with broader trends across Scotland.

Climate Projections

Climate Change projections are available from The UK Climate Projections (UKCP09) website, which is the leading source of climate information for the UK and its regions. Probabilistic projections are available for high, medium and low emission scenarios at resolutions as fine as 25km^2. It is possible therefore to analyse data for the area in which Braemar sits (Grid Box No. 612) (see **Figure 11** and **Figure 12**). It is recognised that this is a blunt proxy for the National Park as a whole, however it is useful when taken together with the historic climate data taken from the Braemar Weather Station. How this change relates to the UK as a whole is presented in **Figure 13**, **Figure 14** and **Figure 15**.

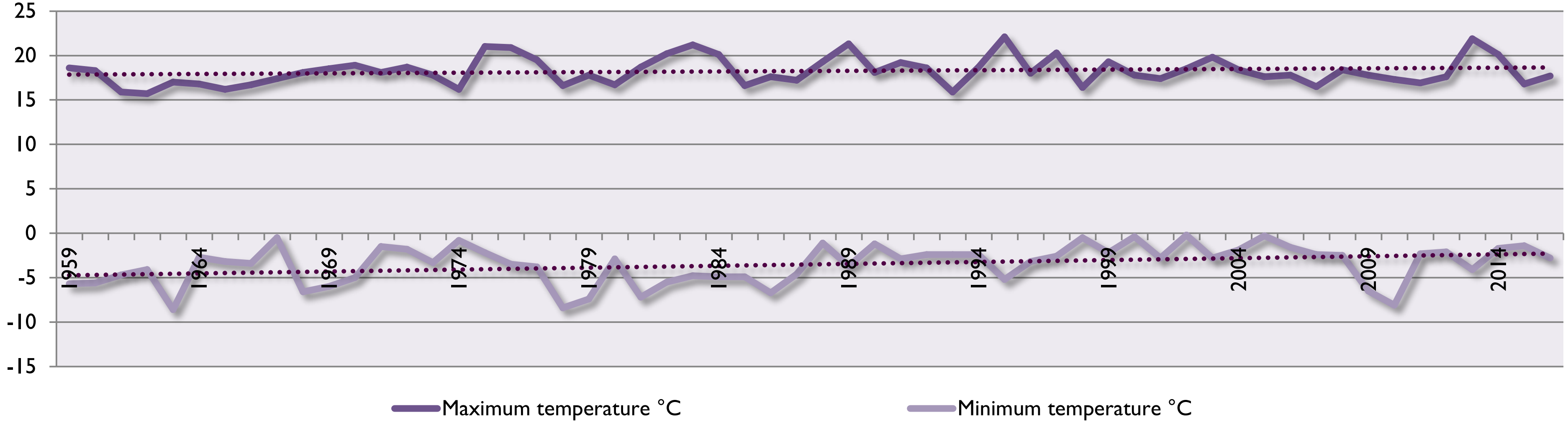


Figure 8 Maximum and minimum annual temperatures at Breaemar Weather Station 1959-2016[2] (Met Office, 2017).

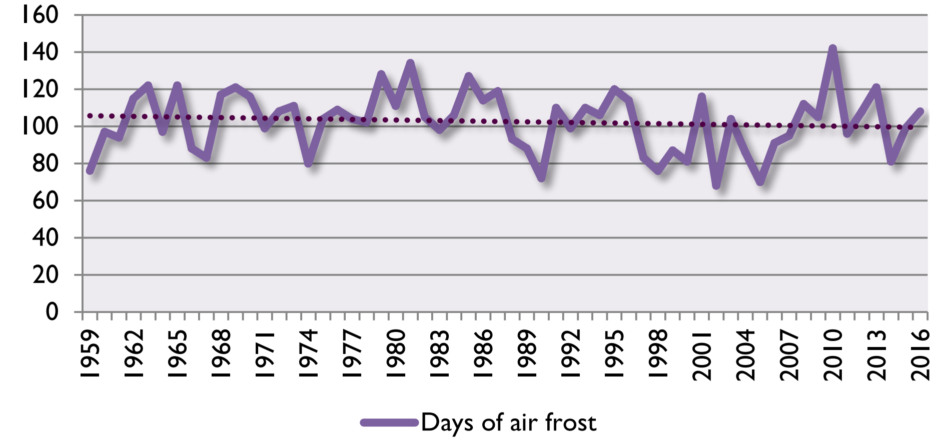


Figure 9 Days of frost at Braemar Weather Station 1959-2016 (Met Office, 2017).

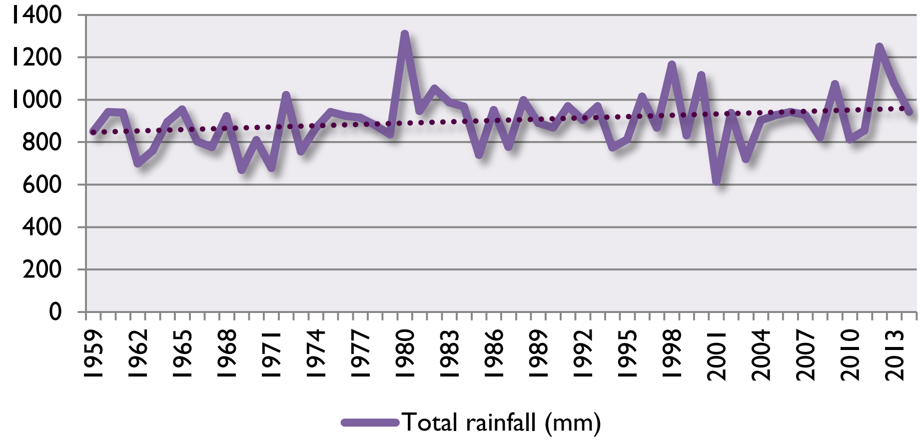


Figure 10 Total Rainfall at Braemar Weather Station 1959-2016 (Met Office, 2017).

[2] 2016 data is provisional.

In summary from the benchmark of 2009, by 2050, under the medium emissions scenario, the central estimate (50% probability level) for Braemar is for a:

- 2.4°C increase in mean annual temperature,
- 2.7°C increase in mean summer temperature,
- 2.1°C increase in mean winter temperature,
- 0.07% increase in mean annual precipitation, but with a
- 13.5% decrease in mean summer precipitation, and a
- 2% decrease in mean winter precipitation.

Although precipitation rates only show a relatively small net annual increase, as well as summer and winter decreases by 2050, it should be noted that this is but a snapshot. Annual precipitation between 2030 and 2059 is projected to be higher, at around 0.3% greater than in 2009.

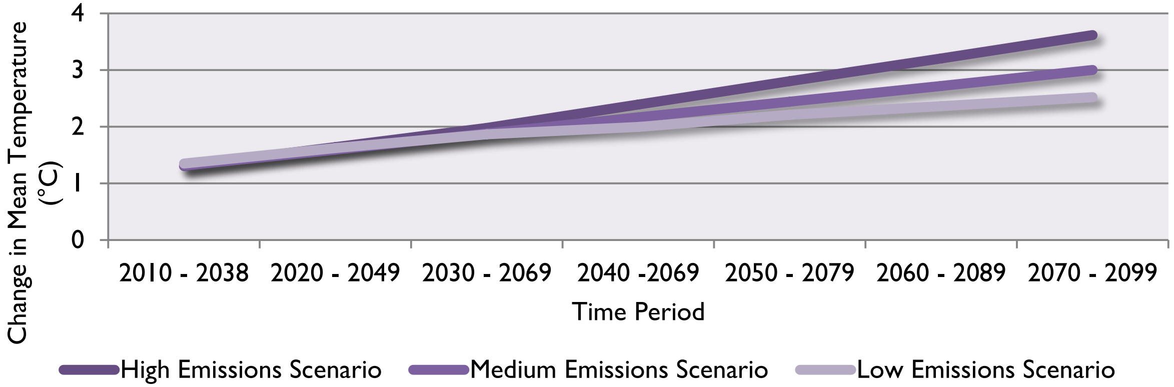


Figure 11 Central estimate for mean change in annual temperature for Grid Box No. 612 (Braemar area).

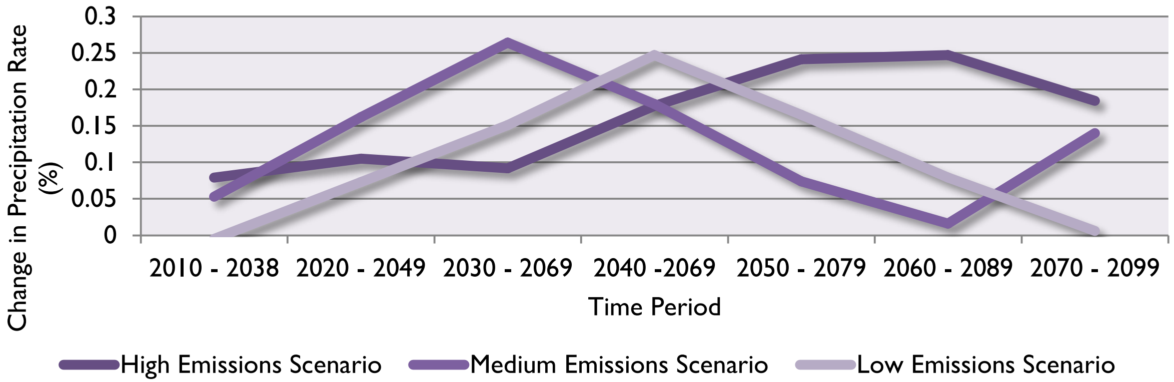


Figure 12 Central estimate for mean change in precipitation for Grid Box No. 612 (Braemar area).

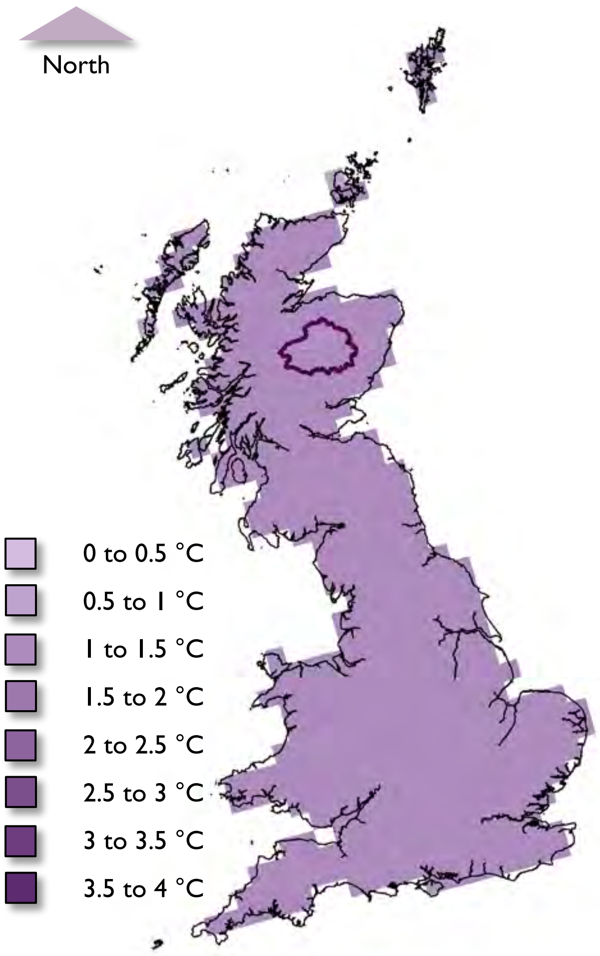


Figure 13 Mean annual temperature increase 2020s. Medium emissions scenario, central estimate.

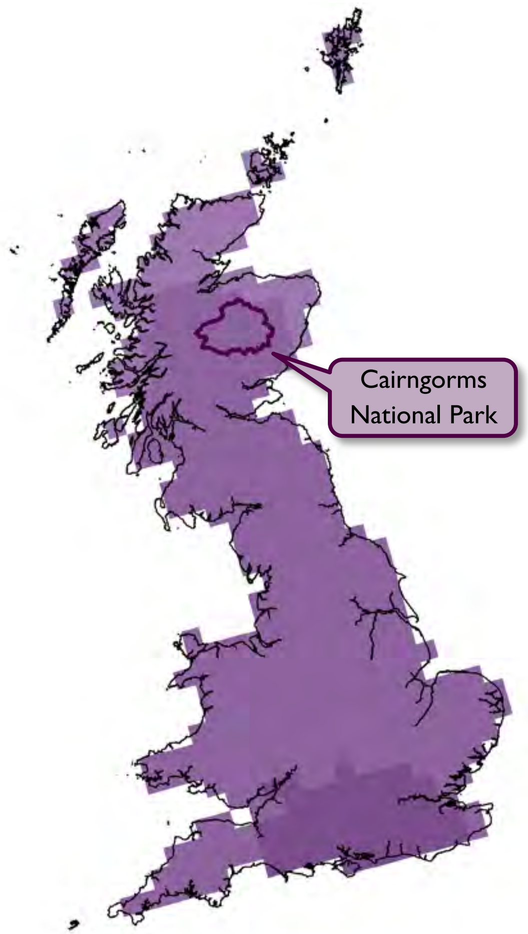


Figure 14 Mean annual temperature increase 2040s. Medium emissions scenario, central estimate.

Figure 15 Mean annual temperature increase 2080s. Medium emissions scenario, central estimate.

It should also be noted that the use of the medium emissions scenario combined with the central probability projection represents a relatively conservative picture of the area's possible future climate. Adjusting these variables, particularly the emissions scenario, can lead to more serious projections, which at the time of writing cannot be discounted. Even with the conservative estimates provided in this summary an annual increase in mean temperature of 2.4°C would leave the National Park with some serious challenges to face.

Greenhouse Gas Emissions

The causes of climate change are clearly greater than local in scale and there is a strong global consensus that a reduction in greenhouse gas (GHG) emissions is needed to avoid some significantly adverse effects. The Climate Change (Scotland) Act 2009 has introduced legislation to reduce Scotland's GHG emissions by at least 80% by 2050 against a 1990 baseline. In recent years, increasing emphasis has been placed

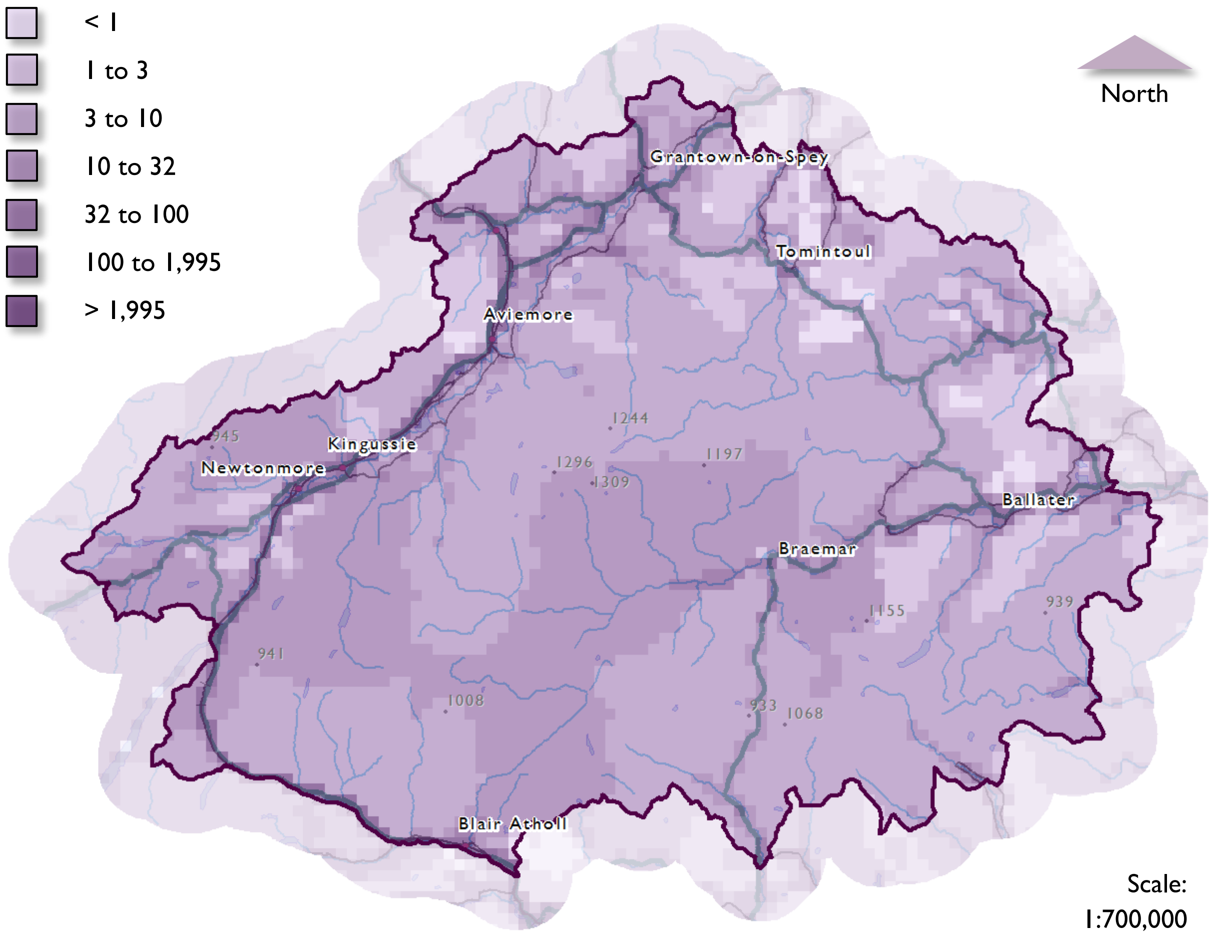


Figure 16 Carbon Dioxide (as Carbon) Emissions in tonnes for the Cairngorms National Park in 2012.

on the role of regional bodies and local government in contributing to energy efficiency improvements, and hence reductions in carbon dioxide emissions. It is clear therefore that the NPPP has a role in meeting this target.

Estimates of carbon dioxide emissions for Local Authority (LA) areas for 2005-2014 are available from The Department for Energy and Climate Change (DECC). Carbon dioxide emissions contribute the greatest proportion of total greenhouse gas emissions in the UK, accounting for around 82% in 2014 (Department of Energy and Climate Change, 2016). Annualised data for the UK's national parks is not available and therefore to get an approximation of the Cairngorms National Park's contribution (**Figure 16**) further assumptions need to be made.

Mid-year population estimates have been used as a proxy for proportionally attributing the emissions of the LAs that cover the National Park's area to the National Park itself. It is recognised that this is a blunt means of estimation, particularly in terms of commercial and transport data; indeed estimates based on estimates should always be treated with caution. However, in the absence of a detailed carbon-audit, the figures presented in **Table 11**, **Figure 17** and **Figure 18** offers a 'best-guess' and a generalised baseline for measurement over the plan period.

Table 11 Estimated CO_2 Emissions for the Cairngorms National Park. Based on Department of Energy and Climate Change (2016).

Year	Industry and Commercial (kt CO_2)	Domestic (kt CO_2)	Road Transport (kt CO_2)	Total (kt CO_2)[3]	Population (mid-year estimate)	Per Capita Emissions (t)
2005	68.6	60.9	47.7	177.3	17,264	10.3
2006	69.5	62.9	48.7	181.1	17,590	10.3
2007	68.8	61.4	49.3	179.5	17,835	10.1
2008	67.3	62.0	47.3	176.5	18,024	9.8
2009	59.1	57.2	46.6	162.8	18,061	9.0
2010	66.1	62.0	46.7	174.7	18,366	9.5
2011	60.6	53.3	45.8	159.8	18,461	8.7
2012	59.1	54.8	45.0	158.9	18,583	8.6
2013	59.0	52.0	45.3	156.3	18,420	8.5
2014	52.3	45.2	46.2	143.7	18,594	7.7

[3] Figures may not sum due to rounding.

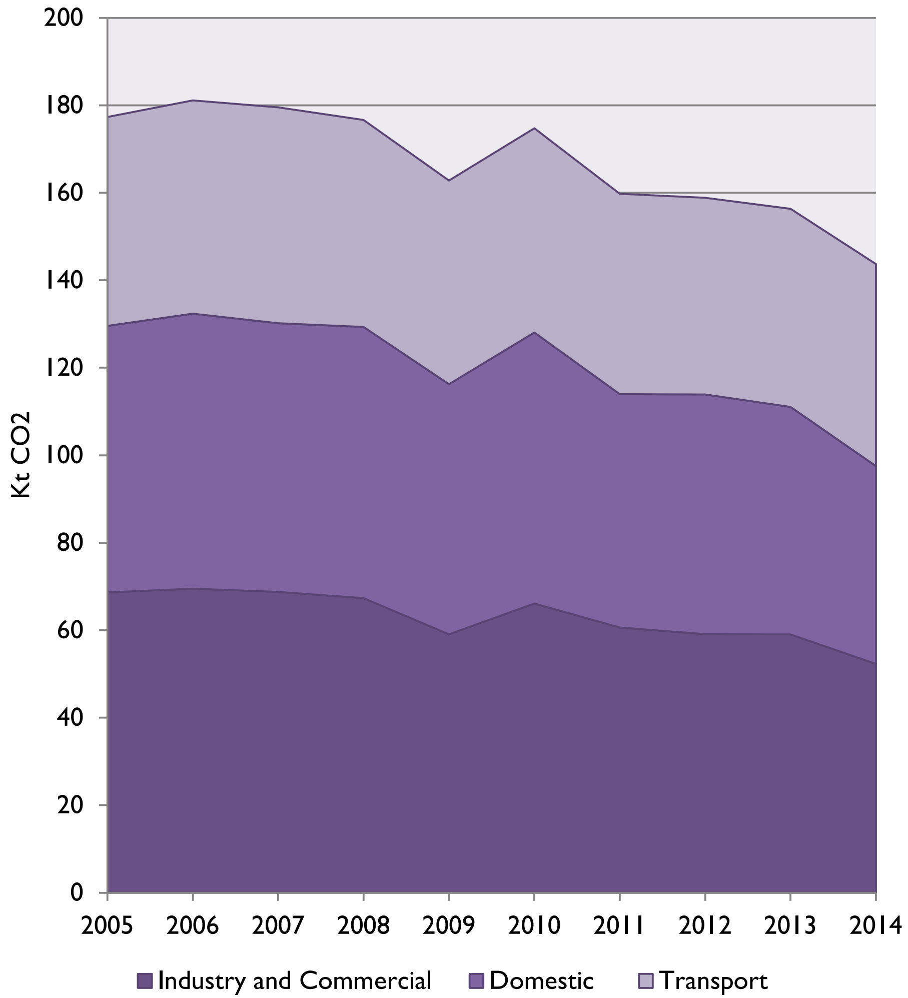


Figure 17 Estimated CO_2 Emissions for the Cairngorms National Park by sector.

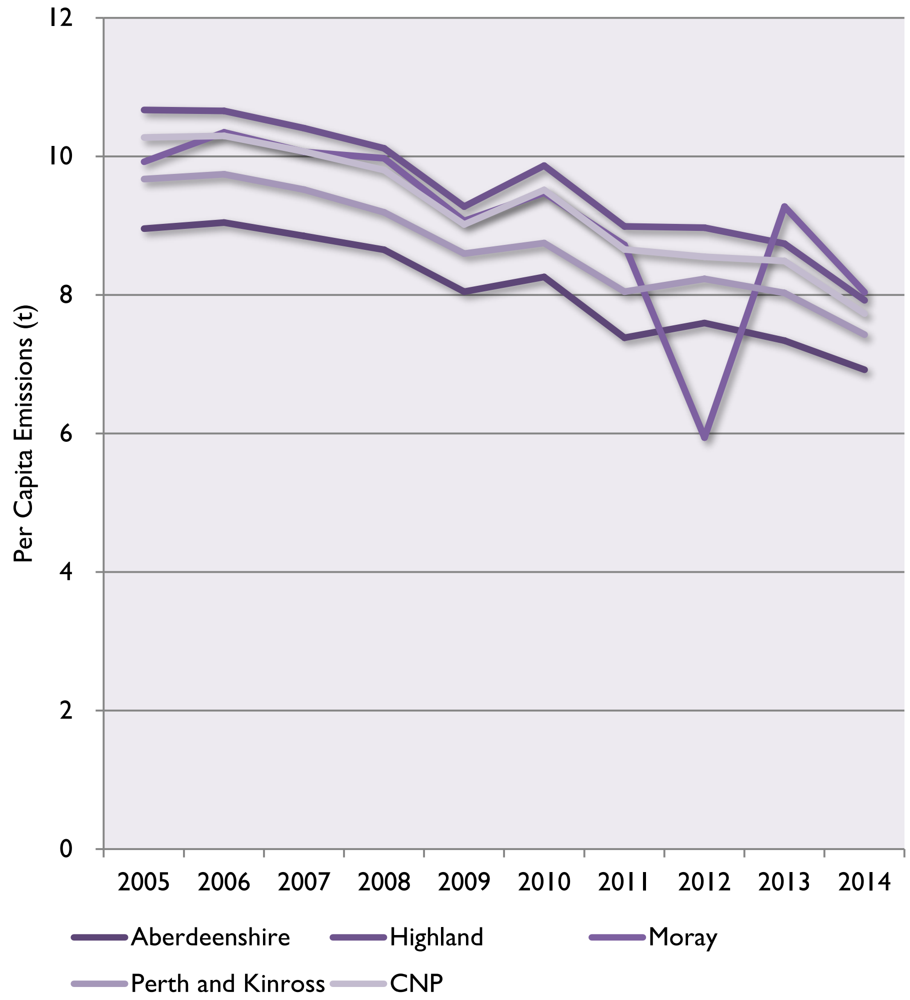


Figure 18 Estimated Per Capita CO_2 Emissions for the Cairngorms National Park by Local Authority.

Based on Department of Energy and Climate Change (2016).

Emissions from motorways, diesel railways, land use, land use change and forestry and EU ETS industrial installations are absent from the national dataset, while for the purpose of the estimates in this document, emissions for 'Large Industrial Installations' have been removed while emissions from gas, a fuel source that is only available via private supply within the National Park, have been subsumed as a generalised source of emissions into the overall 'Industry and Commercial' and 'Domestic' categories of the table. The energy consumed by the comparatively high number tourists and visitors to the National Park have not been adjusted for. It should also be noted that estimating the population of the National Park is not a simple task either as data-zone[4] boundaries do not exactly match the National Park's boundary. Further information on the methodology used to identify boundaries and statistical areas used in the analysis of the Cairngorms National Park can be found in **Appendix 3.**

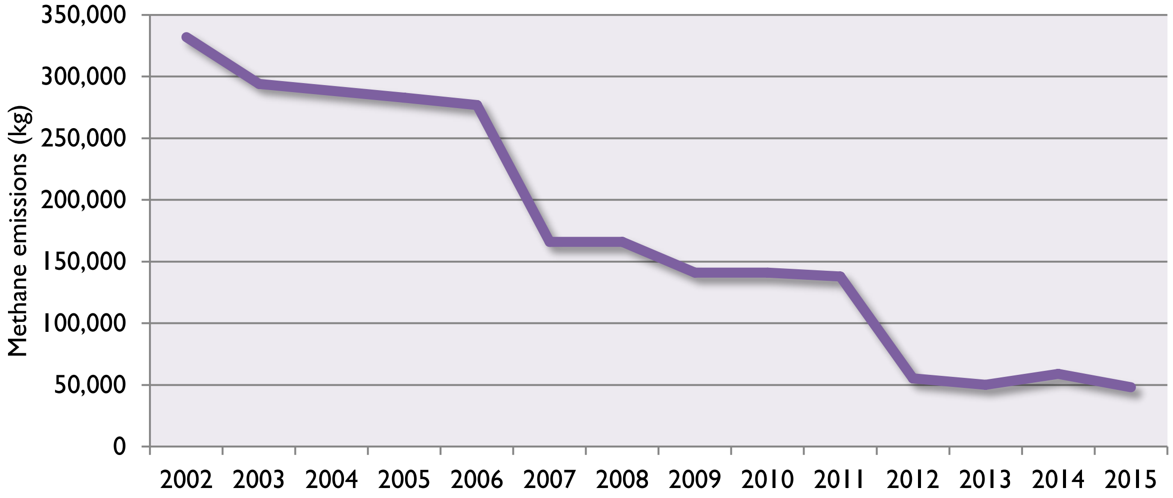


Figure 19 Estimated levels of methane released from Granish Landfill Site, Aviemore 2002-2015 (Source: http://apps.sepa.org.uk/SPRIPA/Search/ViewReturn.aspx?returnId=30683).

The most recently available data relates to 2014, and estimates that per capita emissions in the National Park are 7.7 tonnes of CO_2, which is above the Scottish average of 5.7 tonnes of CO_2 per capita. This may be attributed to the deeply rural nature of the National Park and the consequent reliance on private motor vehicles as a mode of transport (see **Figure 64** to **Figure 78** and **Figure 171** and **Figure 172**). Nevertheless, there is an indication that per capita emissions are on a downward trend, which is consistent with the national situation.

This is supported by information from the only facility within the National Park that contributes towards the Scottish Pollutant Release Inventory (SPRI) - Granish Landfill site, which is operated by the Highland Council (**Figure 19**). Estimates of the site's methane emissions are available as far back as 2002, with data suggesting a net decrease of 283,800 kg from that year.

[4] The data zone is the key small-area statistical geography in Scotland.

Key Messages

Climate change is set to affect the Cairngorms National Park with the UK's climate projections offering a central estimate of a 2.4°C increase in mean annual temperature.

The drivers of climate change are greater than the National Park, however it is estimated that the Park is contributing towards a nationwide reduction in GHG emissions with per capita emissions falling to 7.7 tonnes in 2014.

The NPPP may have an effect on GHG, particularly through its influence over the extent and location of future housing and economic growth.

Inter-relationships with other topics

Topic 2: Air

> *"In order to protect human health and the environment as a whole, it is particularly important to combat emissions of pollutants at source..."*
>
> Ambient air quality and cleaner air for Europe Directive (2008/50/EC).

Air pollution results from the introduction of a range of substances into the atmosphere from a wide variety of sources, including industry, transport and power generation. Even domestic activities such as driving, heating and cooking contribute, as do natural sources like sea salt, wildfires, volcanic activity, soil erosion and farming (Scottish Government, 2015).

Poor air quality can have both short term and long term effects on health. In general, healthy people may not suffer from any serious ill effects; however people with pre-existing health conditions (e.g. heart disease, lung conditions and asthma) may be affected by day to day changes in air pollution levels. It is estimated that in 2010, particulate matter in the air (PM_{10} and $PM_{2.5}$) could have caused the deaths of 2,094 people in Scotland.

Air pollution can also damage the wider environment, causing the acidification of soils and water, damaging plant and animal life in forests, lakes and rivers. It can also add nutrients to soil, which can affect biodiversity. Air pollution can also damage the fabric of buildings and historic monuments (Scottish Government, 2014).

The air quality objectives for Scotland are set out in the Air Quality (Scotland) Regulations 2000 and its 2002 Amendment. The main pollutants of concern are:

- Nitrogen oxides (NO_x);
- Particulate matter (PM_{10} and $PM_{2.5}$);
- Sulphur dioxide (SO_2);
- Non-methane volatile organic compounds (NMVOCs);
- Ground-level ozone (O_3) and
- Ammonia (NH_3)

Scotland's air quality is generally better now than it has been at any time since before the Industrial Revolution, with increasingly strict controls over industrial emissions, tighter fuel and emission standards for road vehicles and the control of smoke from domestic premises yielding positive results. Between 1990 and 2012 significant reductions were seen in the emissions of particulates (-59%), nitrogen oxides (-65%) and sulphur dioxide (-79%) (Sailsbury *et al.* 2014).

Human exposure to air pollution is now largely associated with transport emissions. The effects of this pollution are not confined to Scotland's cities but occur in many of the country's built areas. Where air quality objectives are not being met, Local Authorities have a duty under section 83(10 of the Environment Act 1995 to designate Air Quality Management Areas (AQMAs), where plans must be implemented to improve air quality. All air quality objectives are currently being met within the Cairngorms National Park and therefore no AQMAs exist within its boundary (the nearest AQMAs are located in Aberdeen and Inverness). It is therefore unlikely that the NPPP will cause air quality objectives to be exceeded.

Nevertheless, the influence spatial planning has over traffic levels means that air quality could be a policy concern. In particular, the potential for increasing pollutants associated with traffic emissions such as PM_{10} (**Figure 20**) and Nitrogen dioxide (NO_2) (**Figure 21**) needs to be given consideration. Spatial data on the emission of both is available from the UK National Atmospheric Emissions Inventory for 2012. As might be expected, the highest emissions for both are located along the A9 and within National Park's main settlements of Aviemore, Grantown-on-Spey and Ballater, where traffic volumes are greatest.

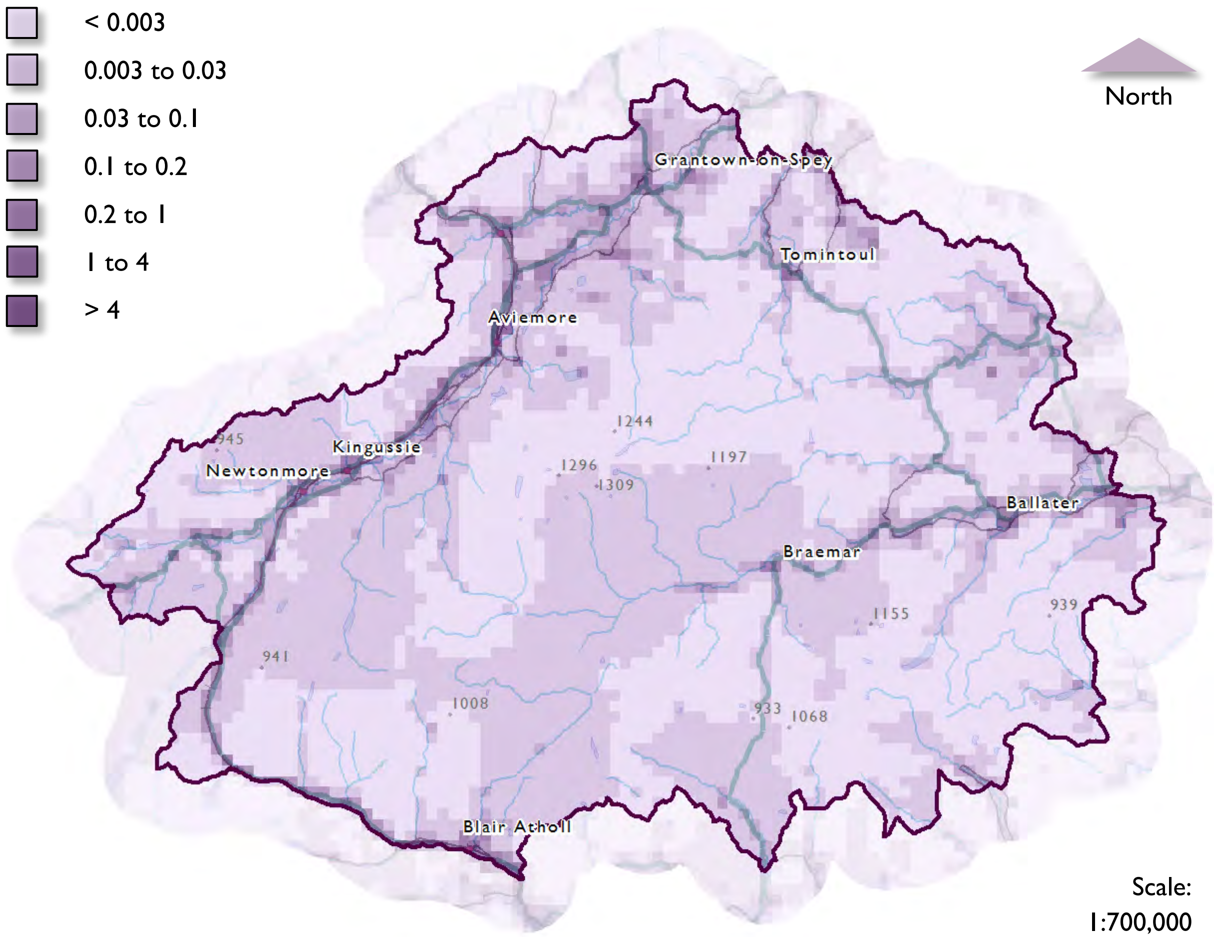


Figure 20 Emissions of PM_{10} in tonnes in the Cairngorms National Park in 2012.

Scottish Household Survey data for 2012 / 2013 (Scottish Government, 2014) indicates that private motorised vehicle use is the main mode of transport for the LAs that cover the National Park's area, ranging from around 77% in Aberdeenshire to around 65% in Highland. While specific data for the National Park is unavailable, it is assumed that due to the area's rurality, a similar level of use exists within its boundary. Indeed, Census information collected on household access to cars or vans supports this assumption (see **Topic 5: Material Asset**, p. 129) Road traffic is on the increase across Scotland (Transport Scotland, 2014) and owing to population growth and increasing visitor numbers, is also likely to rise within the National Park over the Plan period. It is estimated that the A9 alone will see a growth in traffic in the region of 10 to 15%, even without the effects of the planned dualling (Transport Scotland, 2013).

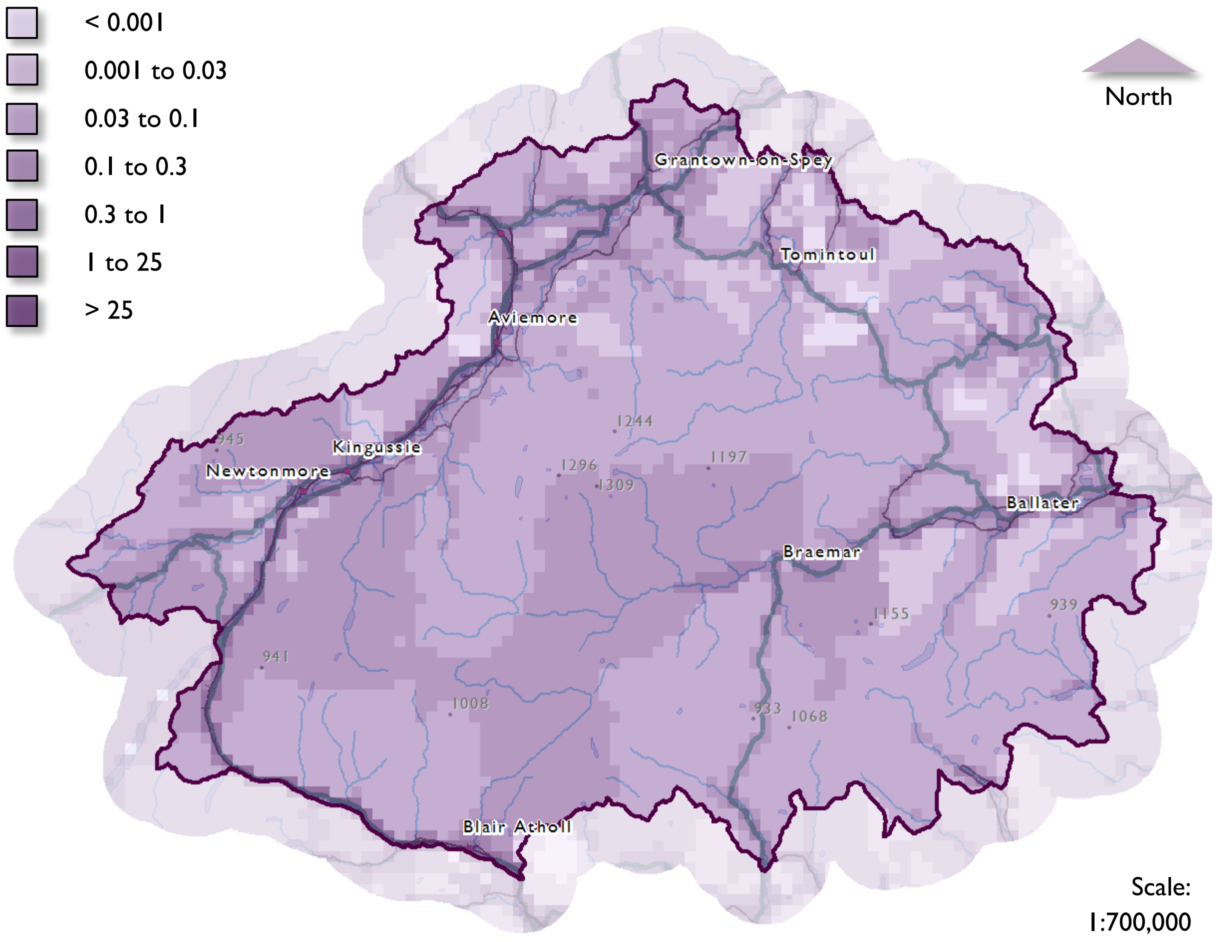


Figure 21 Emissions of Nitrogen Oxides (NO_x) as NO_2 in tonnes in the Cairngorms National Park in 2012.

The Plan's spatial strategy will therefore need to carefully consider its impact on traffic levels and seek to avoid adverse effects on air quality. It will also need to consider its relationship with the A9 Dualling Strategy (Transport Scotland, 2015), which is predicted to result in a reduction in ambient roadside carbon, NO_x and particulate levels through resultant improved traffic flows (Transport Scotland, 2013).

Key Messages

Air pollution is relatively low within the Cairngorms National Park, with no AQMAs within its boundary. However, there are localised areas along the main transport corridors where pollutants related to vehicle use are high enough to generate concern should they not be managed appropriately.

The NPPP may have an influence over air quality both on its own and in combination with other PPS such as the A9 Dualling Strategy. The Plan's ability to influence the level and distribution of development as well as its aim to encourage greater visitor numbers to the National Park, means that spatial options should be carefully considered.

Inter-relationships with other topics

- Topic 3: Water 101
- Topic 4: Soil 118
- Topic 6: Biodiversity, Fauna and Flora 148
- Topic 8: Population and Human Health 250

Topic 3: Water

> *"Water is a heritage which must be protected and defended."*
>
> The European Union Water Framework Directive (2000/60/EC).

The Cairngorms National Park encompasses the headwaters of three of Scotland's major rivers as well as many smaller ones (**Figure 22**). Many of the rivers and their tributaries as well as lochs and wetlands are designated as Natura sites and Sites of Special Scientific Interest (SSSIs). The rivers in particular provide water for society in the National Park, and for people outside the Park, as they flow downstream towards the sea.

Three of the National Park's rivers are subject to catchment management plans, the Dee, the Esk and the Spey. These plans aim to protect water quality, direct the use of the rivers as resources, protect against flooding, enhance biodiversity, and promote access and economic development.

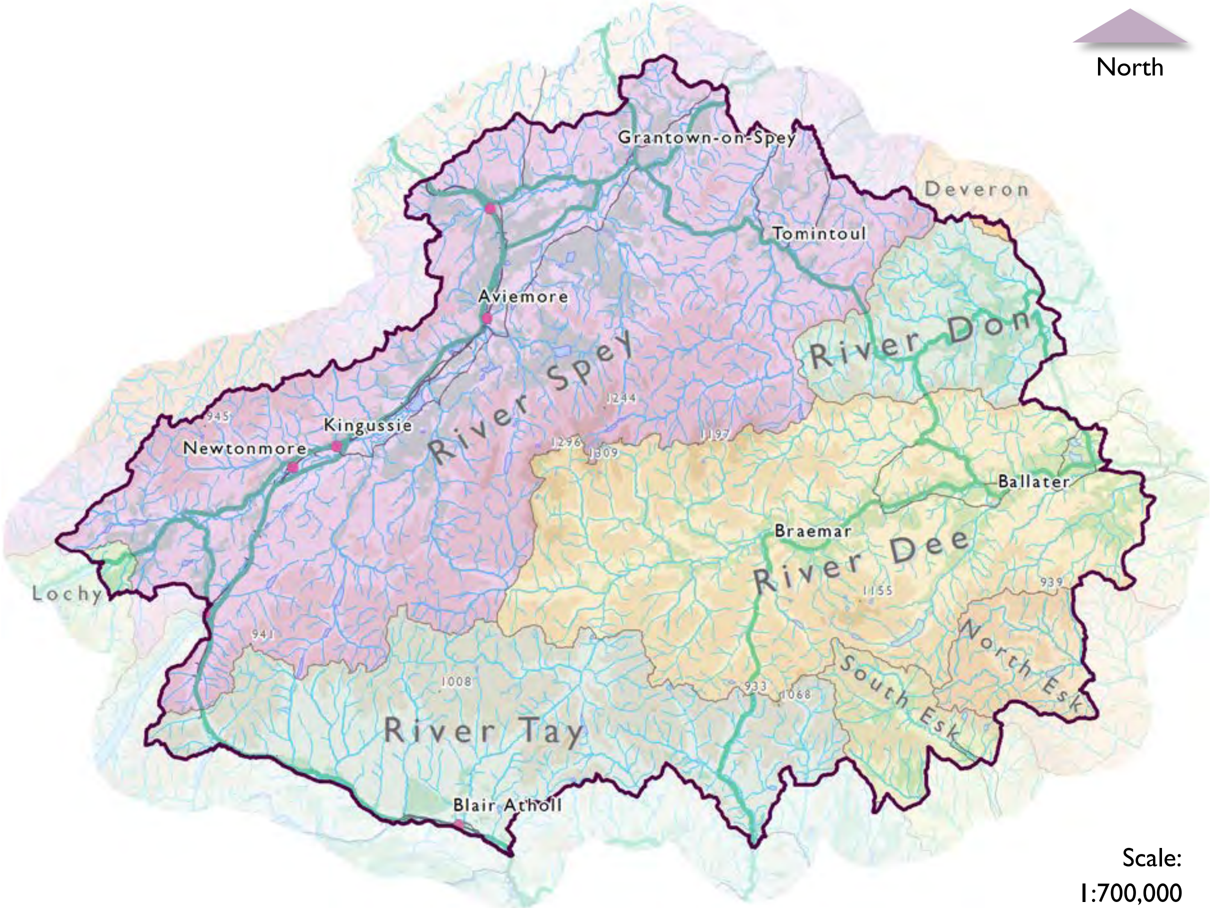


Figure 22 River catchment areas within the Cairngorms National Park.

Water Quality

Pollution leading to the deterioration of water quality can originate from one of two sources, point and diffuse.

Point source discharge means a release of effluent or other matter to the water environment or land, via a pipe or outlet. For example, this includes sewage and trade effluent; surface water discharges from urban areas; and abandoned mine discharges.

Diffuse pollution is the release of potential pollutants from a range of activities that, individually, may have no effect on the water environment, but, at the scale of a catchment, can have a significant effect. Activities associated with diffuse pollution are varied and include run-off from roads, houses, commercial areas, farmland, forestry activities and community and amenity green spaces; seepage into groundwater from developed landscapes of all kinds; and yard run-off from industrial activities.

Government regulation has been extremely successful in reducing instances of point source pollution and therefore diffuse pollution is now of greatest concern. Diffuse sources of water pollution can have a significant effect of biodiversity and human health. The effects include:

- Groundwater and surface water contamination and the subsequent loss, or need for treatment of drinking water resources;
- Nutrient enrichment and eutrophication of water bodies;
- Oxygen depletion of water bodies;
- Toxicity to plant and animal life, including endocrine disruption in fish; and
- Smothering of freshwater pearl mussel beds and fish spawning gravels (Dee Catchment Partnership, 2007).

Of particular significance is the effect of water pollution on freshwater pearl mussel populations, as good water quality is essential for the completion of their life cycle (Young, 2005). Freshwater pearl mussel is one of the species on the Nature Action Plan List (Cairngorms National Park Authority, 2013) and is one of the qualifying features for a number of the National Park's SACs, including the River Spey and River Dee SACs. Further information may be found under **Topic 6: Biodiversity, Fauna and Flora** (p. 148).

The European Union Water Framework Directive (2000/60/EC) (WFD), adopted in 2000, is the operational tool that sets out the objectives for water protection in Scotland. The WFD sets out a number of objectives in respect of which the quality of water is protected. The key ones at European level are:

- General protection of the aquatic ecology;
- Specific protection of unique and valuable habitats;
- Protection of drinking water resources; and
- Protection of bathing water.

All these objectives must be integrated for each river basin. It is clear that the last three - special habitats, drinking water areas and bathing water - apply only to specific bodies of water (those supporting special wetlands; those identified for drinking water abstraction; those generally used as bathing areas). In contrast, ecological protection should apply to all waters: the central requirement of the WFD is that the environment be protected to a high level in its entirety (European Commission, 2014).

SEPA are the responsible authority for monitoring water quality in Scotland to the requirements set out by the WFD. The Directive requires all water features in a category (i.e. rivers, lochs, transitional waters, coastal waters and groundwater) above a certain size threshold to be defined as water bodies.

Surface water bodies are classified using a system of five quality classes – high, good, moderate, poor and bad, with groundwater classified as good or poor. In general, the classification of water bodies describes by how much their condition or status differs from near natural conditions. Water bodies in a near natural condition are at high status, while those whose quality has been severely damaged are at bad status.

The ultimate overall aim of the WFD is therefore to ensure that these water bodies don't deteriorate in status and that all water bodies achieve at least 'good' status by 2015, unless it is demonstrated that less stringent objectives should apply (Scottish Environment Protection Agency, 2007).

The overall status and water quality classification of waterbodies within the Cairngorms National Park for years 2010-2014 is presented in **Figure 23**, **Figure 24**, **Figure 25** and **Figure 26**. The main reasons for waterbodies not achieving overall good status is the presence of a large number of barriers to fish and poor morphology (this covers catchment/landuse matters such inputs of fine sediments or impacts to hydrology and direct impacts such as through engineering or condition of riparian corridor).

The status of waterbodies for 2015 was not available at the time of writing. The definition of what constitutes a waterbody in the National Park is set out in **Appendix 3**.

As can be seen, the current situation is mixed, and while only a minority of waterbodies are in bad or poor condition, there has been an increase in the number of waterbodies changing to a worse status or classification.

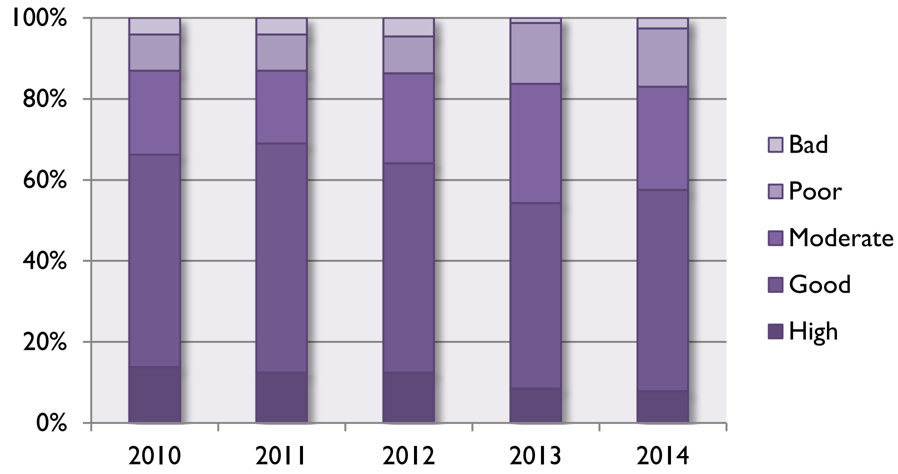


Figure 23 Overall status of waterbodies within and overlapping the Cairngorms National Park.

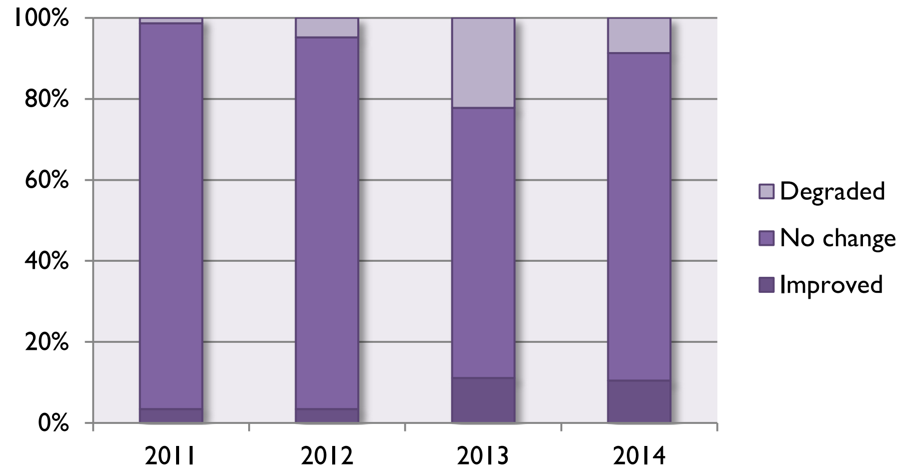


Figure 24 Change from previous year in the overall status of waterbodies within or overlapping the Cairngorms National Park

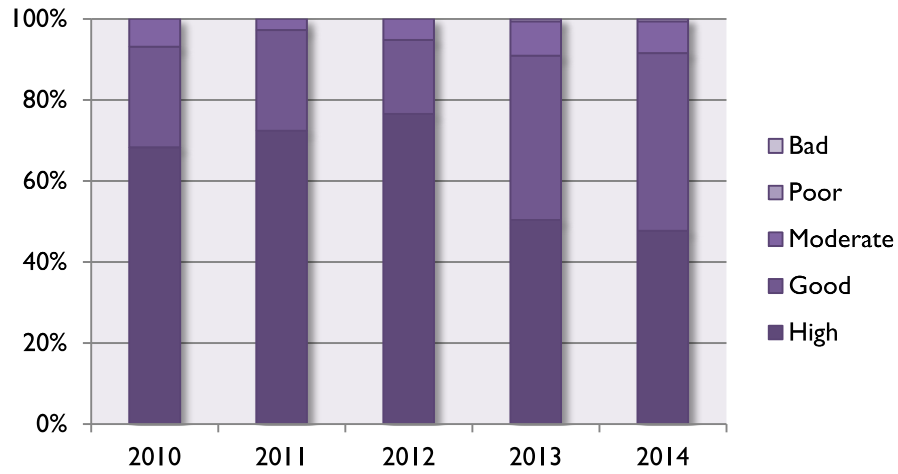


Figure 25 Water quality classification of waterbodies within and overlapping the Cairngorms National Park.

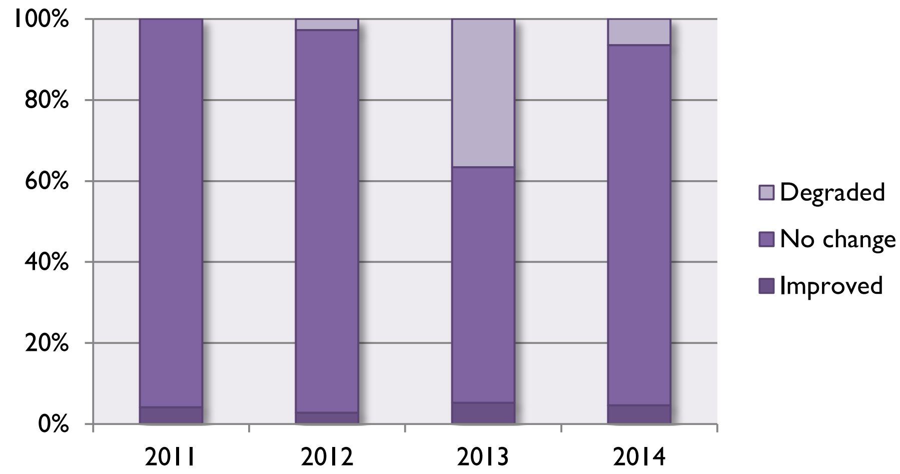


Figure 26 Change from previous year in the water quality of waterbodies within or overlapping the Cairngorms National Park

Source: www.environment.scotland.gov.uk/get-interactive/data/water-body-classification/

Water Quantity

In order to provide information for the management of water resources, SEPA monitor water levels at 20 sites within the Cairngorms National Park, as well as at a number of locations just outside the Park's boundary. Water levels are converted to flow at most river gauging stations. The information gathered may inform the SEA, since trends may be used as an indicator of climate change or as an identifier of potential risks, such as flooding.

Figure 27 and **Figure 28** represent the series of maximum instantaneous peak flows within a given water year (October to September) for monitoring stations on the River Spey and River Dee. The data from both stations shows a general trend for higher annual maximums over the time they were monitored. The causes of this are uncertain; however, it highlights the importance of taking into account the potential for an increase in the number and severity of flood events over the lifetime of the NPPP and beyond.

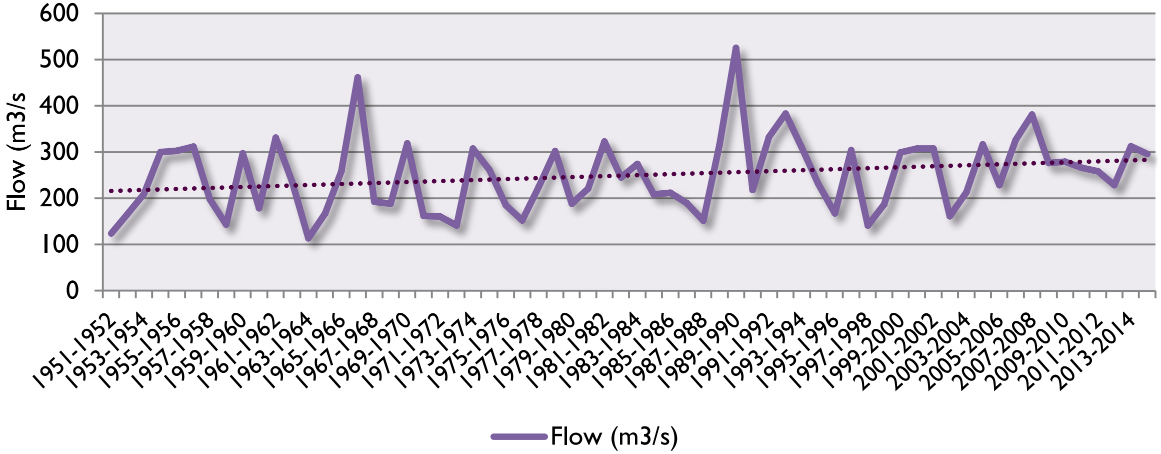


Figure 27 Annual maximum (AMAX) data for the River Spey at Grantown-on Spey (Station 8010). Contains SEPA data © Scottish Environment Protection Agency and database right 2017. All rights reserved.

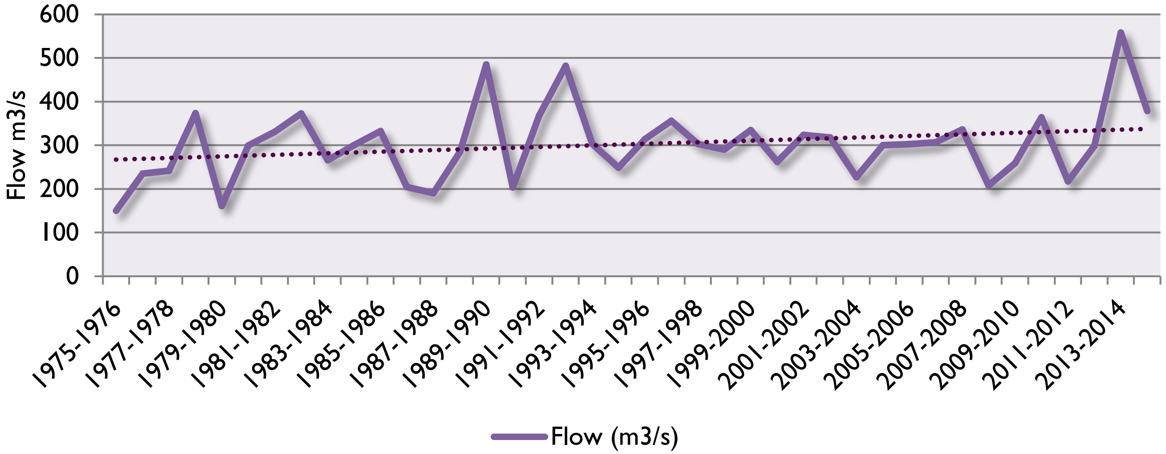


Figure 28 Annual maximum (AMAX) data for the River Dee at Polhollick, near Ballater (Station 12003). Contains SEPA data © Scottish Environment Protection Agency and database right 2017. All rights reserved.

Water Infrastructure

Whilst Scottish Water (SW) is funded to provide any strategic capacity that may be required for water supply / waste water treatment ('part 4' assets) to facilitate development, it is necessary to consider the timescale to deliver new strategic capacity to ensure that the provision of it is timed to enable development in the right place at the right time. The implications of this on any programme of development must therefore be considered. The current capacity status of the water and waste treatment works that serve the National Park's settlements is shown in **Table 12**.

Including all planned and committed development proposals, capacity exists at most of the SW water treatment works serving settlements in the National Park. There are however constraints in certain locations. For example, there is currently not enough capacity to supply the 1,500 units permitted at An Camas Mòr.

Table 12 Capacity of water and waste treatment works serving the Cairngorms National Park, July 2015 (Source: Scottish Water).

Local Authority	Settlement	Water Treatment Works	Capacity (housing units)	Waste treatment Works	Capacity (housing units)
Aberdeen-shire	Ballater	Ballater	93	Ballater	93
	Braemar	Braemar	315	Braemar	63
	Dinnet	Ballater	93	Dinnet	<10
	Strathdon	Lumsden	<10	Private	N/A
Angus	Angus Glens	Private	N/A	Private	N/A
Highland	An Camas Mòr	Aviemore	966	Aviemore	60
	Aviemore	Aviemore	966	Aviemore	60
	Boat of Garten	Aviemore	966	Boat of Garten	96
	Carr Bridge	Aviemore	966	Carr Bridge	87
	Cromdale & Advie	Aviemore	966	Cromdale	105
	Dalwhinnie	Dalwhinnie	20	Dalwhinnie	<10
	Dulnain Bridge	Aviemore	966	Dulnain Bridge	24
	Glenmore	Private	N/A	Glenmore	<10
	Grantown of Spey	Aviemore	966	Grantown	197
	Insh	Aviemore	966	Insh	<10
	Inverdruie & Coylum Bridge	Aviemore	966	Aviemore	60

More significantly, the current capacity of many waste treatment works serving the National Park is a constraint to development. For example, the Aviemore treatment works, which serves the eponymous town and much of the surrounding area, including An Camas Mòr, only has capacity for a further 60 units.

Therefore, investment in both water and waste treatment works will be necessary for the National Park's permitted and projected growth to be met sustainably.

Where there is no public water supply network within the vicinity there would be a need either for a private water treatment system or to lay a new water infrastructure to the existing public network, and early discussion with SW would be required. Where there is no public sewer network a private wastewater treatment system may be required. Early engagement with SEPA to discuss the specific requirements and approval of any private systems is essential.

Local Authority	Settlement	Water Treatment Works	Capacity (housing units)	Waste treatment Works	Capacity (housing units)
Highland	Kincraig	Aviemore	966	Kincraig	52
	Kingussie	Aviemore	966	Kingussie	327
	Laggan	Laggan Bridge	<10	Laggan Bridge ST	<10
	Nethy Bridge	Aviemore	966	Nethy Bridge	70
	Newtonmore	Aviemore	966	Newtonmore	208
Moray	Glenlivet	Tomnavoulin	<10	Private	N/A
	Tomintoul	Blairnamarrow	65	Tomintoul	46
Perth & Kinross	Blair Atholl	Killiecrankie	2000+	Blair Atholl	16
	Bruar & Pittagowan	Killiecrankie	2000+	Private	N/A
	Calvine	Killiecrankie	2000+	Private	N/A
	Glenshee	Private	N/A	Private	N/A
	Killiecrankie	Killiecrankie	2000+	Killiecrankie	<10

Flooding

All of the National Park's rivers and watercourses have the potential to flood to some degree (**Figure 29**). Most concern is generated along the National Park's main straths and glens, as when the rivers and tributaries that flow along these, namely the Spey, Dee and Don, break their banks, they often result in economic, and occasionally human, cost. Small watercourses also represent a risk but are often poorly understood with respect to the severity of the flood hazard that can be generated on a catchment scale. Furthermore, in some areas surface water flooding, which can arise for a number of reasons, is a significant risk.

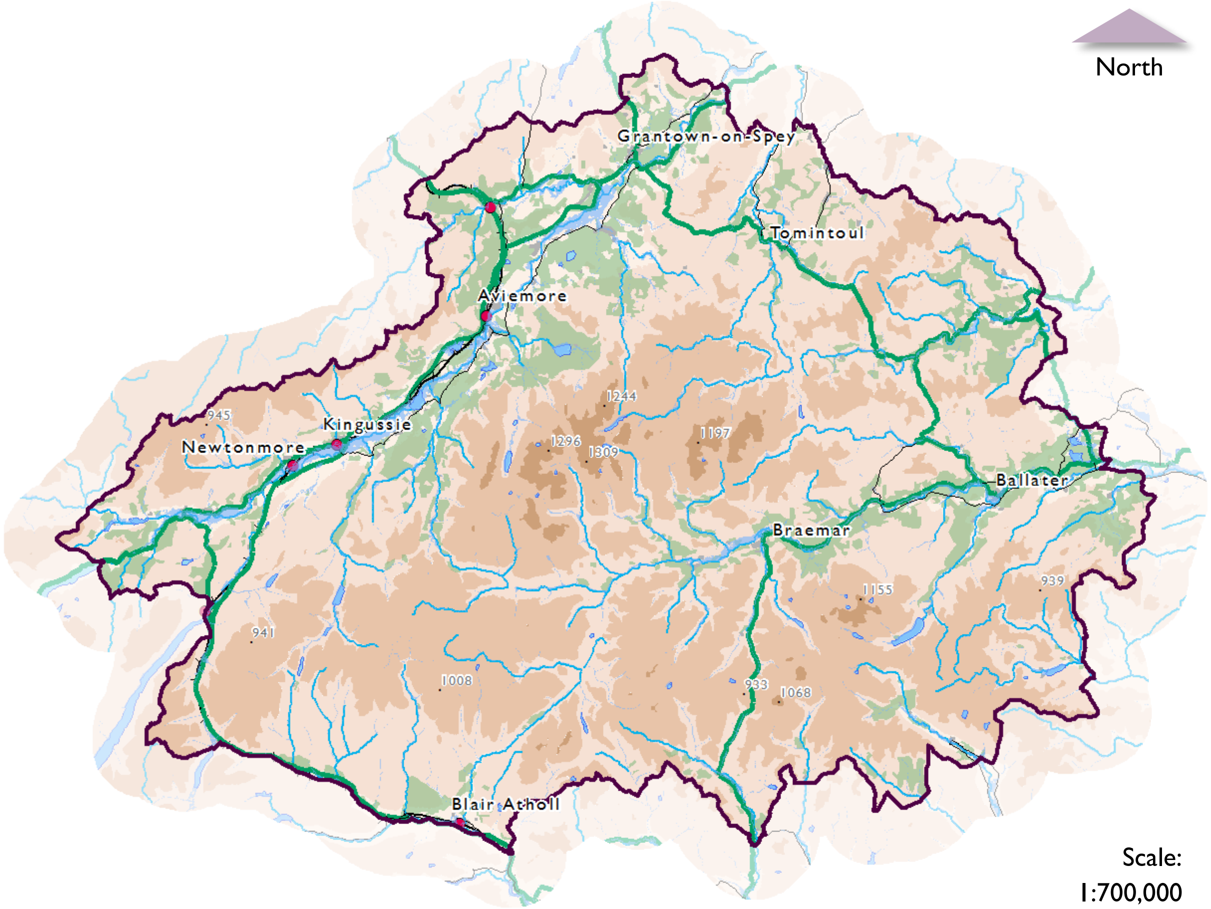


Figure 29 Indicative river flooding extent (medium probability 1 in 200 years) in Cairngorms National Park.

River Spey

The River Spey (**Figure 30**) rises in the high ground of the Monadhliath and Cairngorm Mountain ranges and flows in a northeasterly direction through narrow straths and scenic river valleys before discharging into the Moray Firth beyond the fertile farmlands of Morayshire. The upper part of the catchment is characterised by its mountainous areas, the highest point being the summit of Ben Macdui at 1,309 metres above sea level.

The River Spey is the seventh largest river in Britain, with a catchment area of over 3,000 km^2, and a stream network length of about 36,500 km, of which the main river comprises 157 km (Spey Catchment Steering Group, 2003).

There is a long history of flooding within the Spey catchment area, with a notable event, known as the Great Muckle Spate, destroying several bridges in 1829. The River Spey and its tributaries continue to flood regularly, with heavy rains and melting snows increasing the volumes of water in

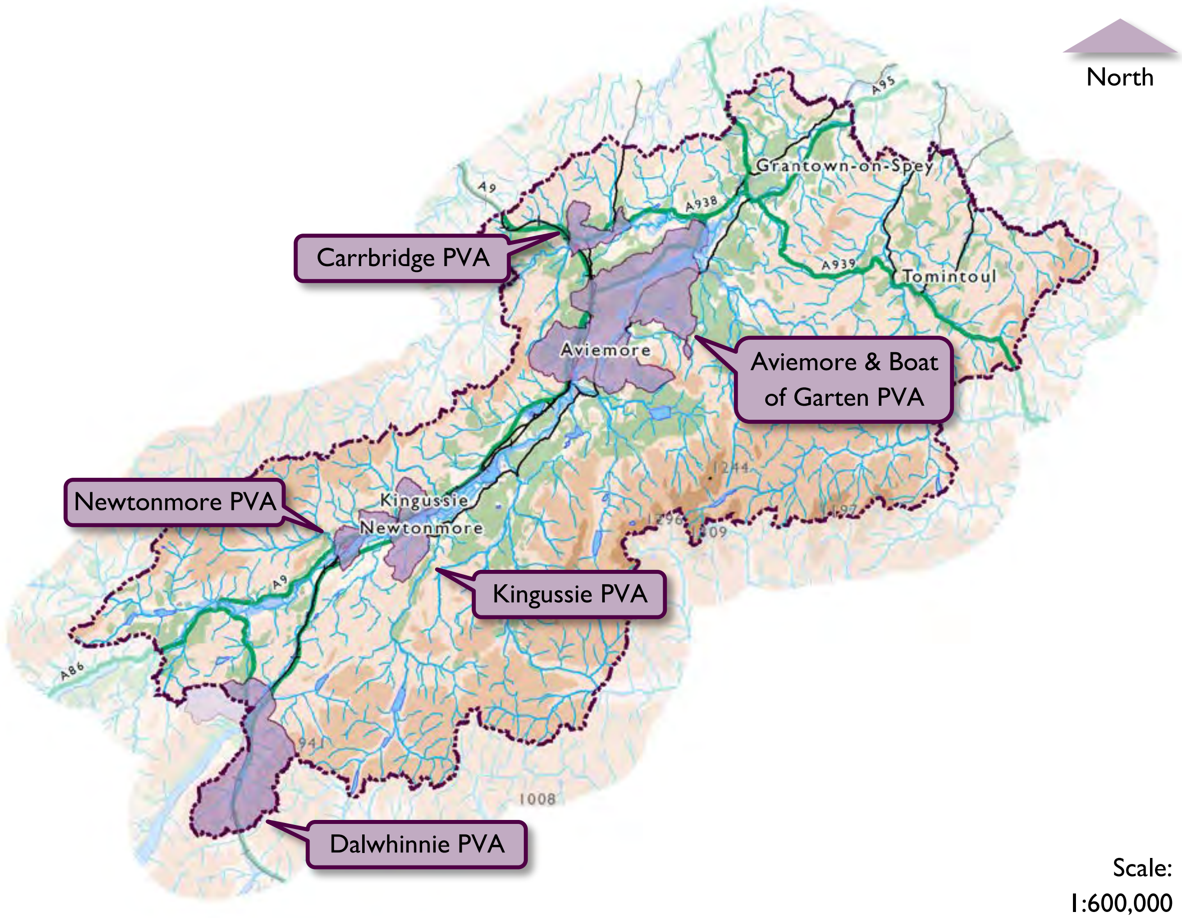


Figure 30 River Spey PVAs in the River Spey catchment area within the Cairngorms National Park and indicative river flooding extent (medium probability 1 in 200 years).

the catchment. These floods have damaged properties in Newtonmore, Aviemore and Carrbridge on a number of occasions. Most recently in 2014, Gynack Burn broke its banks in Kingussie, damaging local buildings and infrastructure (Scottish Environment Protection Agency, 2015).

In December 2015, flooding associated with Storm Desmond the caravan park in Aviemore was evacuated during the night by swiftwater rescue teams and was reported that water was "fast flowing and chest deep". Business properties in the town were also flooded.

Flood management practices are being undertaken at a number of locations. The Spey Catchment Initiative has carried out natural flood management / river restoration works on a tributary upstream of the River Dulnain (Spey Catchment Initiative, 2013). There are also agricultural embankments along the River Spey between Aviemore and Boat of Garten and further embankments at Dalwhinnie. The standard of protection (and condition) provided by these embankments is however

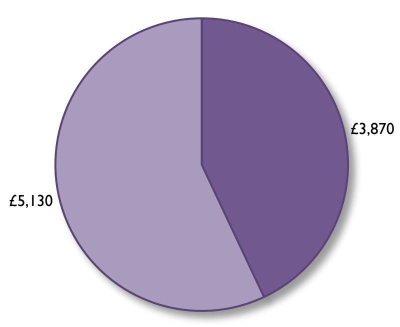


Figure 31 Annual average damages in Carrbridge PVA (PVA 05/10).

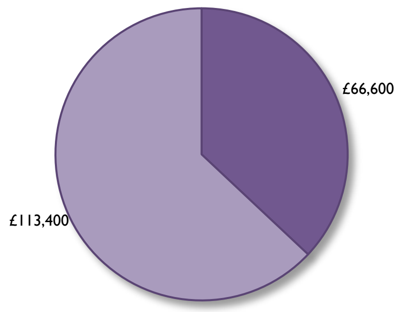


Figure 32 Annual average damages in Aviemore and Boat of Garten PVA (PVA 05/11).

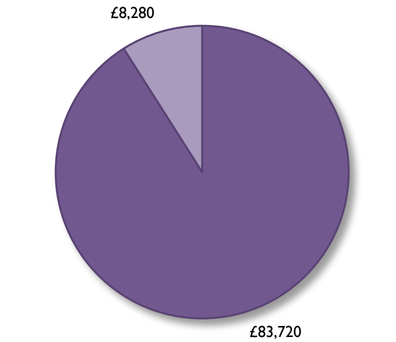


Figure 33 Annual average damages in Kingussie PVA (PVA 05/12).

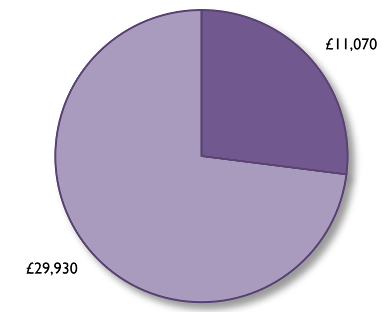


Figure 34 Annual average damages in Newtonmore PVA (PVA 05/13).

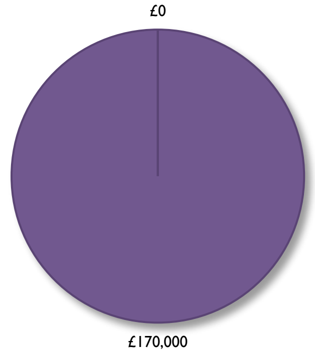


Figure 35 Annual average damages in Dalwhinnie PVA (PVA 05/14).

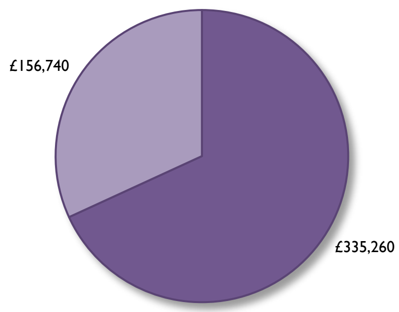


Figure 36 Annual average damages of all National Park PVAs in Spey Catchment area.

River flooding | Surface water flooding

(Source: Scottish Environment Protection Agency, 2015).

unknown (Scottish Environment Protection Agency, 2015).Due to the potential risk caused by flooding within the catchment area, five Potentially Vulnerable Areas (PVAs) have been identified within the National Park (**Figure 30**), at:

- Carrbridge (PVA 05/10);
- Aviemore and Boat of Garten (PVA 05/11);
- Kingussie (PVA 05/12);
- Newtonmore (PVA 05/13); and
- Dalwhinnie (PVA 05/14).

The estimated total average annual cost of damage in these areas is £492,000 (**Figures 31** to **36**). Around £335,000 (68%) of this damage is caused by river flooding (Scottish Environment Protection Agency, 2015).

SEPA have identified a number of actions for managing flood risk in these areas, which were consulted on in 2015.

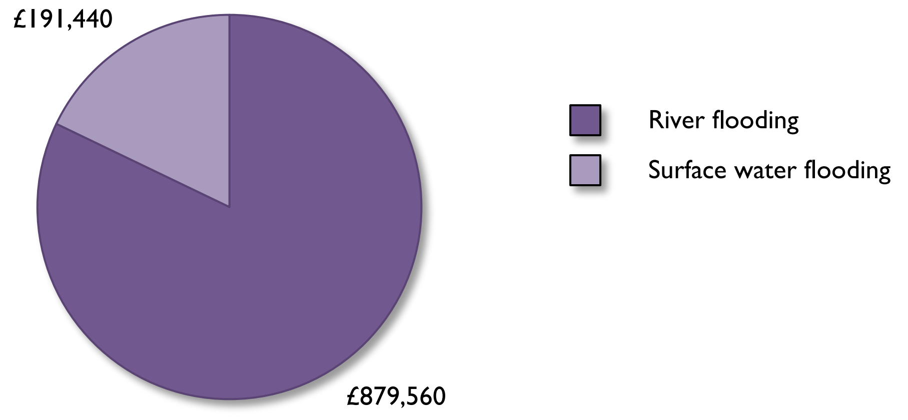


Figure 37 Annual average damages of all PVAs within or overlapping the Cairngorms National Park (Scottish Environment Protection Agency, 2015).

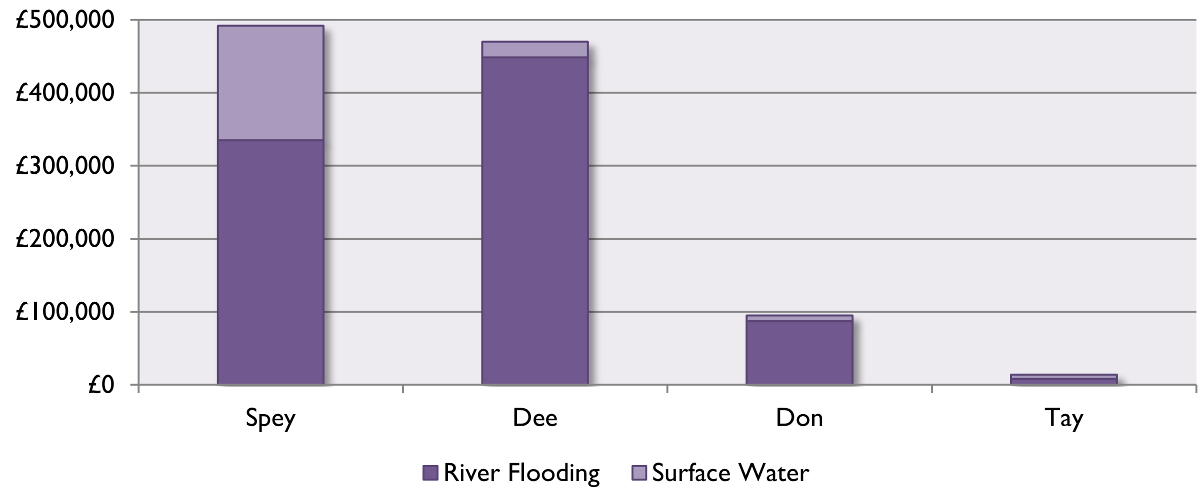


Figure 38 Annual average damages of all PVAs within or overlapping the Cairngorms National Park by catchment area (Scottish Environment Protection Agency, 2015).

River Dee

The River Dee (**Figure 39**) rises in the Cairngorm Mountains east of Braemar on the semi-arctic Braeriach-Cairn Toul plateau. For the majority of its course, the river flows eastwards through a broadening valley, which becomes much gentler in relief as it leaves the National Park. Within the National Park, the river is fed by a number of important tributaries, namely the Lui, Clunie, Gairn, Muick and Tanar, the latter's confluence located just outwith the National Park Boundary (Dee Catchment Partnership, 2007).

The river is considered to be the best example of a natural highland river in Scotland (Maitland, 1985). The notable characteristics of the river include its great altitudinal range, its unique succession of plant communities, and its seep profile compared to other large British rivers (Dee Catchment Partnership, 2007).

Like the Spey, the Dee suffers from flooding related to heavy rain and melting snows. Major floods have been recorded in 1769,

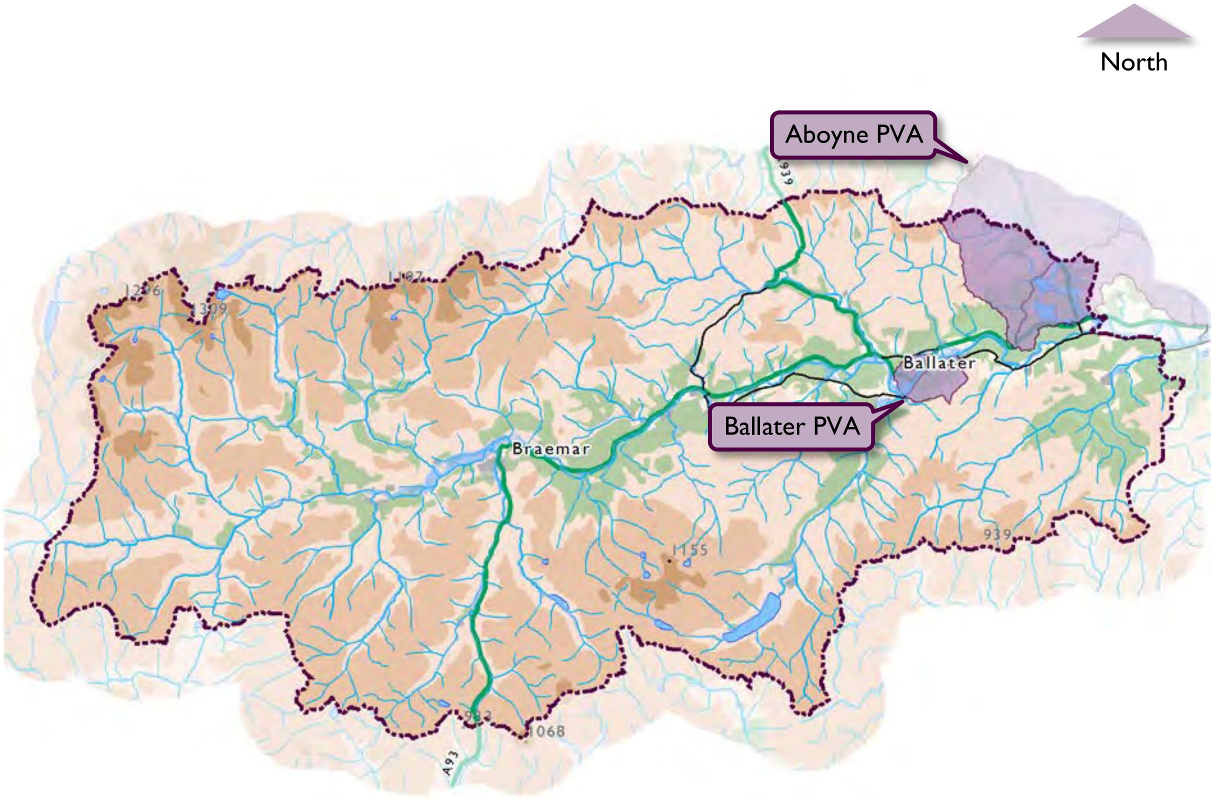


Figure 39 River Dee PVAs in the River Dee catchment area within the Cairngorms National Park and indicative river flooding extent (medium probability 1 in 200 years).

1829 (the Great Muckle Spate), 1920 and 1956 (the Cairngorm Flood) (Dee Catchment Partnership, 2007). In 2008, surface run-off entered the Netherly Guesthouse in Ballater and in 2014 the town's caravan park and a number of roads were closed due to flooding (Scottish Environment Protection Agency, 2015).

On 30th December 2015, flooding caused by Storm Frank inflicted significant damage to businesses and property around Braemar and Ballater. Infrastructure was also heavily impacted on, with part of the A93 between Ballater and Braemar washed away and the Invercauld Bridge near Braemar closed. On the 7th - 8th January 2016 further heavy rain falling on already very saturated ground caused further localised flooding.

The Dee catchment contains two PVAs that fall within or across the National Park boundary (**Figures 40** to **42**), namely:

- Aboyne (PVA 06/20); and
- Ballater (PVA 06/22).

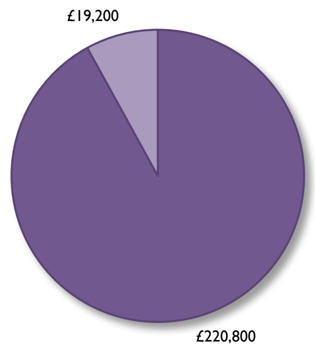


Figure 40 Annual average damages in Aboyne PVA (PVA 06/20).

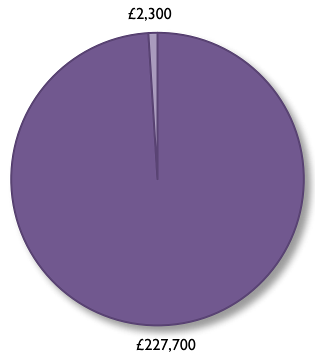


Figure 41 Annual average damages in Ballater PVA (PVA 06/22).

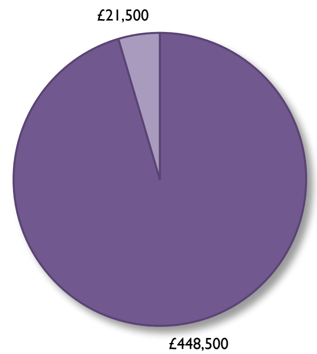


Figure 42 Annual average damages of all National Park PVAs in Dee Catchment area.

River flooding   Surface water flooding

(Source: Scottish Environment Protection Agency, 2015).

The former is only partly within the boundary, with the majority of the population and the associated risk located outwith. As one of the National Park's main settlements, the PVA around Ballater therefore offers most concern. The estimated average annual cost of damage here is £230,000, 99% of which is associated with river flooding. The majority of estimated damages are due to flooding to non-residential properties (80%), although more significantly, the fire station is located in an area which has a medium likelihood of flooding (Scottish Environment Protection Agency, 2015).

River Don

Rising in the peat flat beneath Druim na Feithe, and in the shadow of Glen Avon, the River Don flows 135km east to the sea in Aberdeen. It's Scotland's 6th largest river, draining a catchment of around 1,300km^2.

The Don catchment contains one PVA that falls across the National Park boundary, namely Heugh-Head (PVA 06/14) (**Figure 44**). There was a surface water flood in August 2006 affecting Strathdon, Waterside and Bellabeg when water ponded in low points of the road, with heavy rainfall and steep sloping fields to the south resulting in significant amounts of flood water. On 7th - 8th January 2016, following Storm Frank, heavy rain falling on already very saturated ground caused damage, particularly around Inverurie, where small watercourses responded quickly to the rainfall. Most of the PVA's estimated annual average damages, which equate to £95,000, are associated with river flooding (92%) (**Figure 43**) and mostly affect residential properties (60%) (Scottish Environment Protection Agency, 2015).

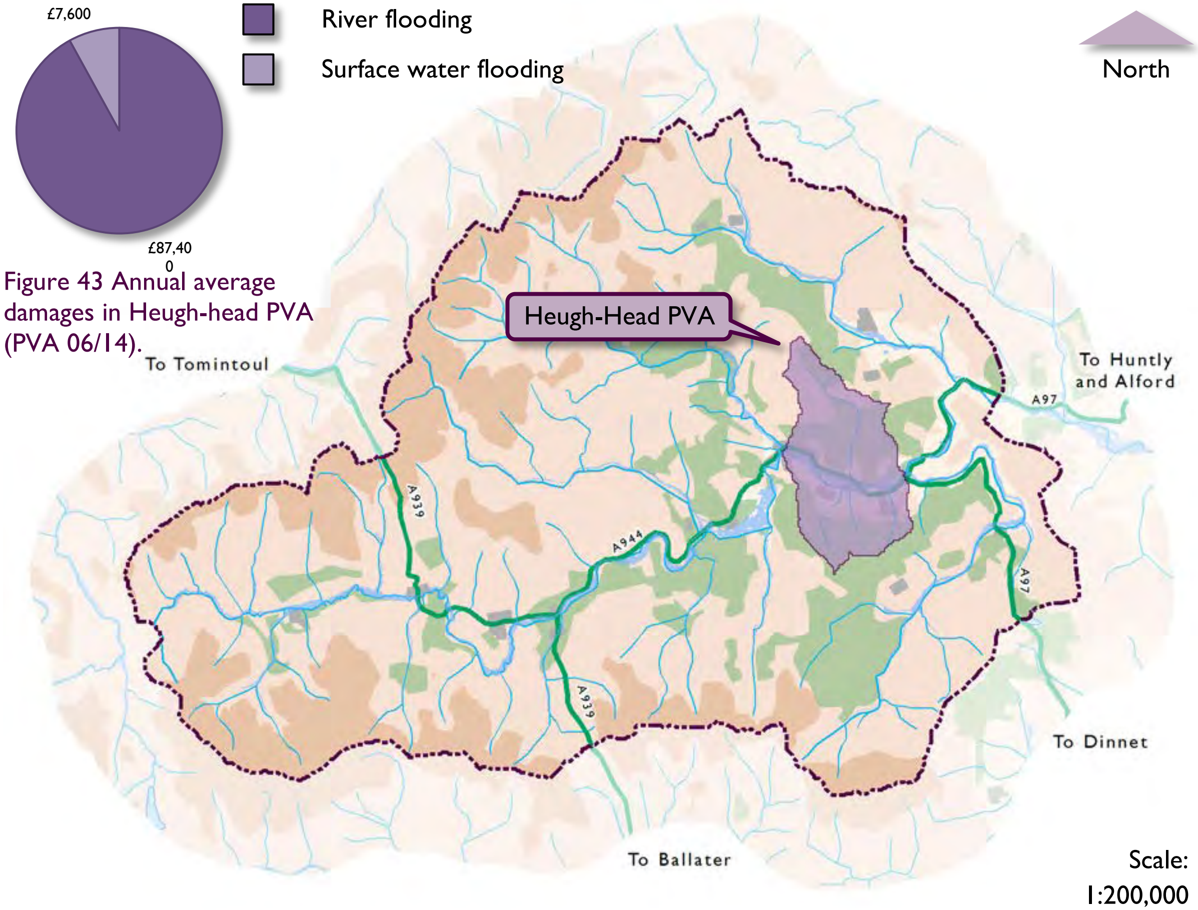


Figure 43 Annual average damages in Heugh-head PVA (PVA 06/14).

Figure 44 Heugh-Head PVA (PVA 06/14) and indicative river flooding extent (medium probability 1 in 200 years) in the River Don catchment area within the Cairngorms National Park.

River Tay

The River Tay has the largest catchment area and is the longest river in Scotland, with many of its headwaters lying within the Cairngorms National Park (**Figure 46**). It covers an area of 5,088km^2 and is around 190km in length. More water flows through the River Tay than any other river in the United Kingdom. The main tributaries include the River Garry, River Tummel, River Lyon, River Braan, River Isla and River Almond. The largest lochs in the River Tay catchment include Loch Ericht, Loch Rannoch and Loch Tay (Scottish Environmental Protection Agency, 2015).

The Tay catchment contains one PVA that falls across the National Park boundary, namely Blair Atholl (PVA 08/01). A number of river floods have been recorded in this area. These include:

- 13 June 1931: Evacuation was required as River Garry flooded near Blair Atholl, the railway was also affected.
- July 1916: Evacuation was required as River Garry flooded near Blair Atholl, the railway was also flooded.

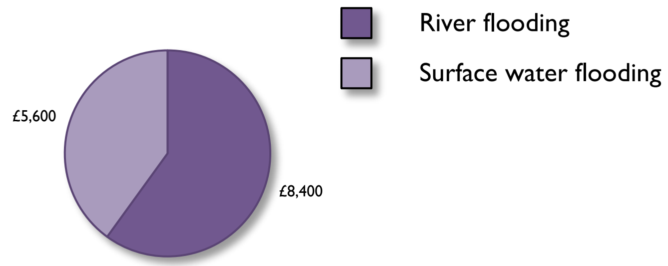


Figure 45 Annual average damages in Blair Atholl PVA (PVA 08/01).

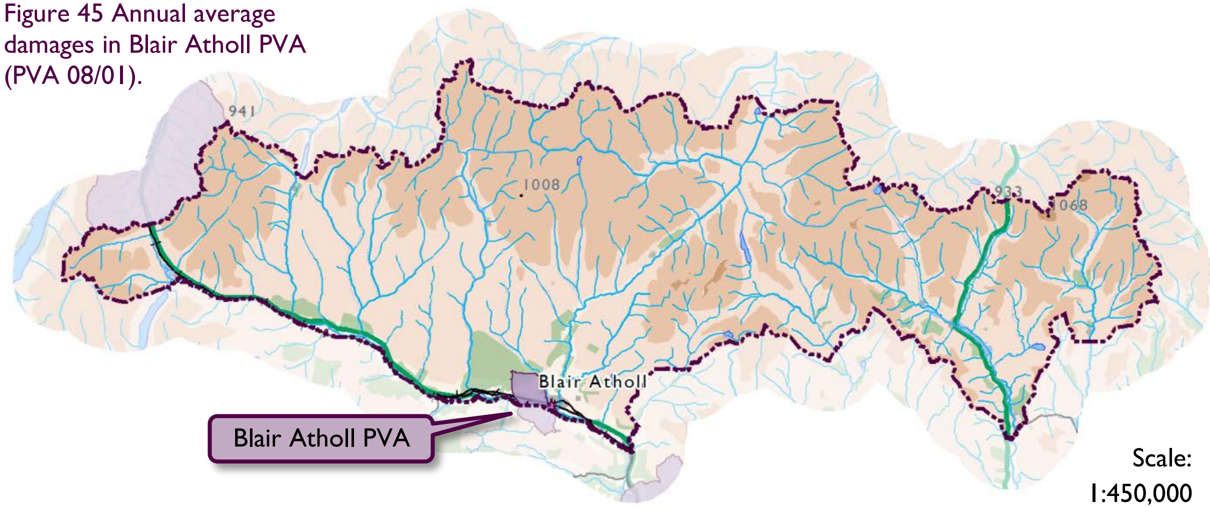


Figure 46 River Tay PVAs in the River Tay catchment area within the Cairngorms National Park and indicative river flooding extent (medium probability 1 in 200 years).

Blair Atholl continues to be at risk of flooding from the Garry Burn and from surface water. The risk of flooding to people, property, as well as to community facilities, utilities, the transport network, designated sites and agricultural land is presented in **Figure 45**.

Currently there is relatively low confidence in SEPA's river flood hazard maps due to limitations arising from the data used and techniques applied in the national modelling. The number of properties at risk of flooding in the Blair Atholl area is likely to be underestimated (Scottish Environmental Protection Agency, 2015).

Key Messages

Water quality within the National Park is relatively high, however, monitoring indicates that recent years have seen an increase in the proportion of water bodies falling out of the high classification for overall status and water quality. The situation was particularly poor in 2013, which saw a large increase in the number of waterbodies falling into lower classifications.

AMAX data from the Spey and Dee indicates a general trend for higher annual maximum instantaneous peak flows over the time they were monitored, indicating an increase in floodrisk in these catchments.

There is not enough capacity in the water and sewage treatment works that serve the National Park to meet the projected level of housing growth for the Plan period.

There are nine Potentially Vulnerable Areas (PVAs) within the National Park. The estimated total average annual cost of damage in these areas is £1,071,000.

Inter-relationships with other topics

- Topic 1: Climatic Factors 88
- Topic 2: Air 97
- Topic 4: Soil 129
- Topic 6: Biodiversity, Fauna and Flora 148
- Topic 7: Landscape and Cultural Heritage 221
- Topic 8: Population and Human Health 250

Topic 4: Soil

> *"Soil is a resource of common interest… and failure to protect it will undermine sustainability and long term competitiveness in Europe."*
>
> Commission of the European Communities (2006).

Soils cover most of the natural world, forming the foundation of all terrestrial ecosystems and services. They support key processes in biomass production and mass exchange with atmospheric and hydrological systems. Nearly all of the food, fuel and fibres used by humans are produced in soil. Soil is also essential for water and ecosystem health. It is second only to the oceans as a carbon sink, with an important role in the potential slowing of carbon change. Soil functions depend on a multitude of soil organisms, which makes soil an important part of our biodiversity (Joint Research Centre, 2012).

Although soils are a continually evolving, living and dynamic medium responding to external pressures and management, some activities such as development or pollution can mean their recovery or reformation cannot take place within human timescales. This means soils are a finite and essentially non-renewable resource (Scottish Government, 2009).

Land Capability for Agriculture

Although it is estimated that Agriculture contributed about £688 million to the Scottish economy in 2014 (Scottish Government, 2015), it is difficult to value the direct financial contribution that healthy soils make to our economy. But it is now widely acknowledged that the sustainable management of soils, and the protection of soils' ability to deliver a wide range of environmental and ecological services, is essential to achieving sustainable economic growth.

Land Capability Classification for Agriculture mapping provides detailed information on soil, climate and relief for those involved in the management of land use and resources. The classification ranks land from 1 to 7 on the basis of its potential productivity and cropping flexibility determined by the extent to which its physical characteristics (soil, climate and relief) impose long term restrictions on its agricultural use. Land classified from 1 to 3.1 is considered to be prime agricultural land, while land classified as 3.2 to 7 is considered to be non-prime (Soil Survey of Scotland Staff, 1981).

There are no areas of prime agricultural land within the Cairngorms National Park, although there are areas of land in Strath Spey and Deeside within the 3.2 classification (around 1.2% of the National Park's total area), which denotes non-prime land that is limited by moderate climatic factors and may yield a moderate range of crops, with average production, but potentially high yields of barley, oats and grass. Most land within the National Park is classified as 6 or 7 (around 73%), which denote areas of 'rough grazing only' and 'very limited agricultural value' respectively.

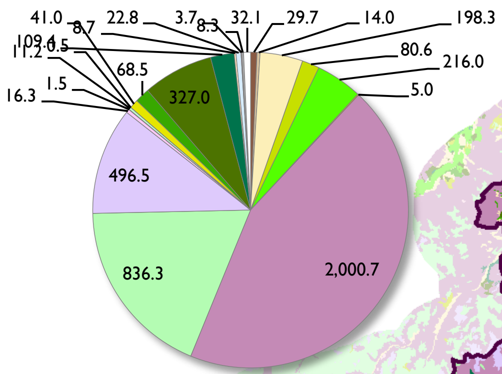


Figure 47 Land use classification by area (km²) in the Cairngorms National Park (Soil Survey of Scotland Staff, 1981).

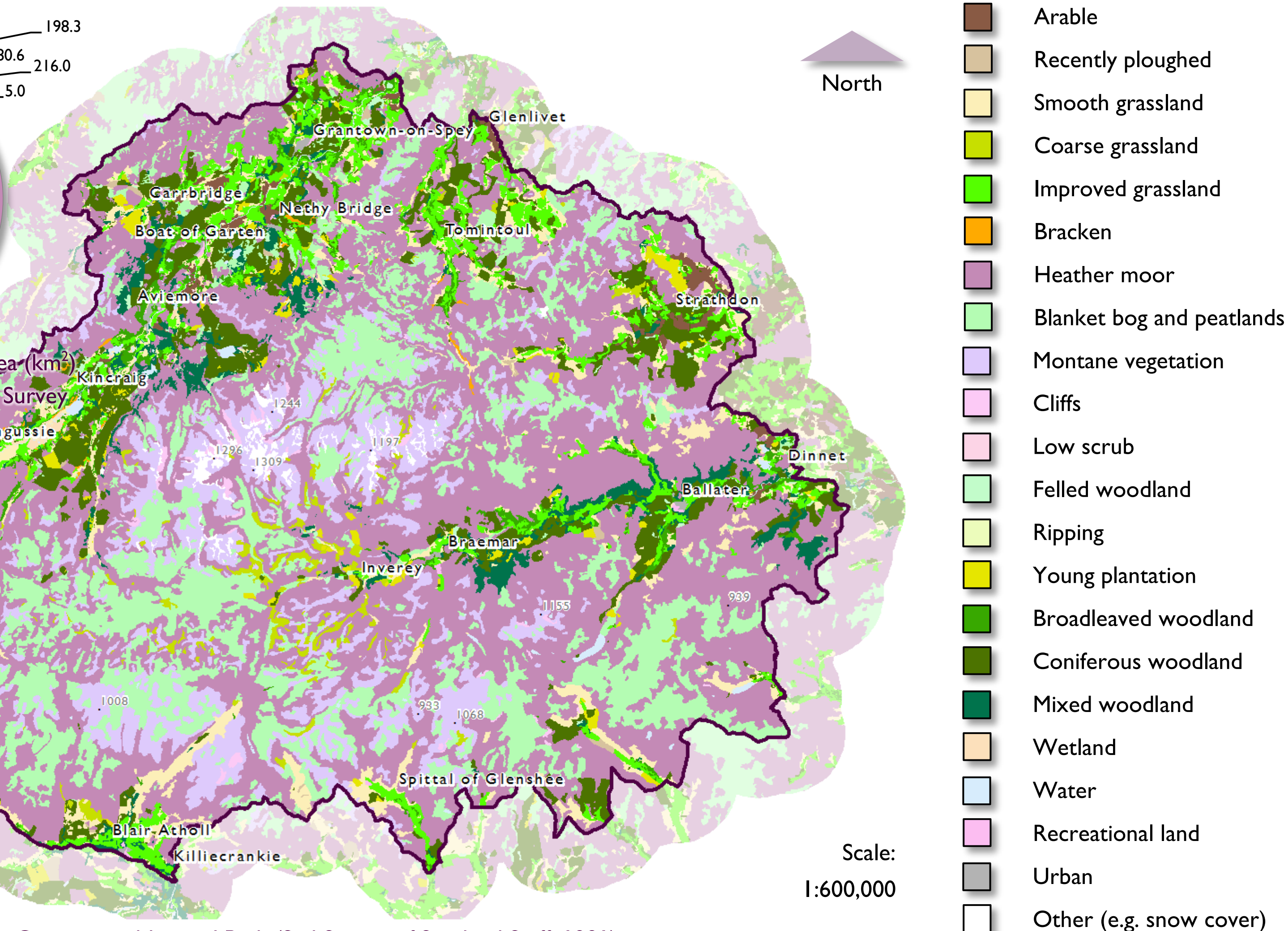


Figure 48 Landuse Classifications in the Cairngorms National Park (Soil Survey of Scotland Staff, 1981).

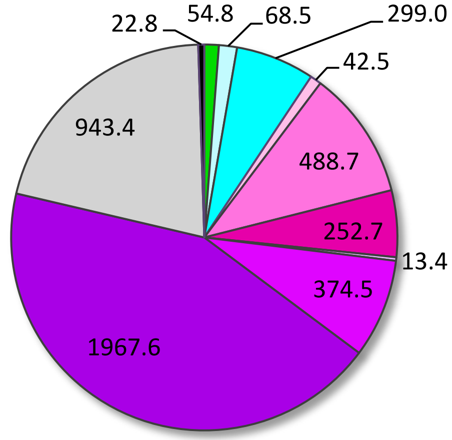


Figure 49 Agricultural land classification by area (km[2]) in the Cairngorms National Park (Soil Survey of Scotland Staff, 1981).

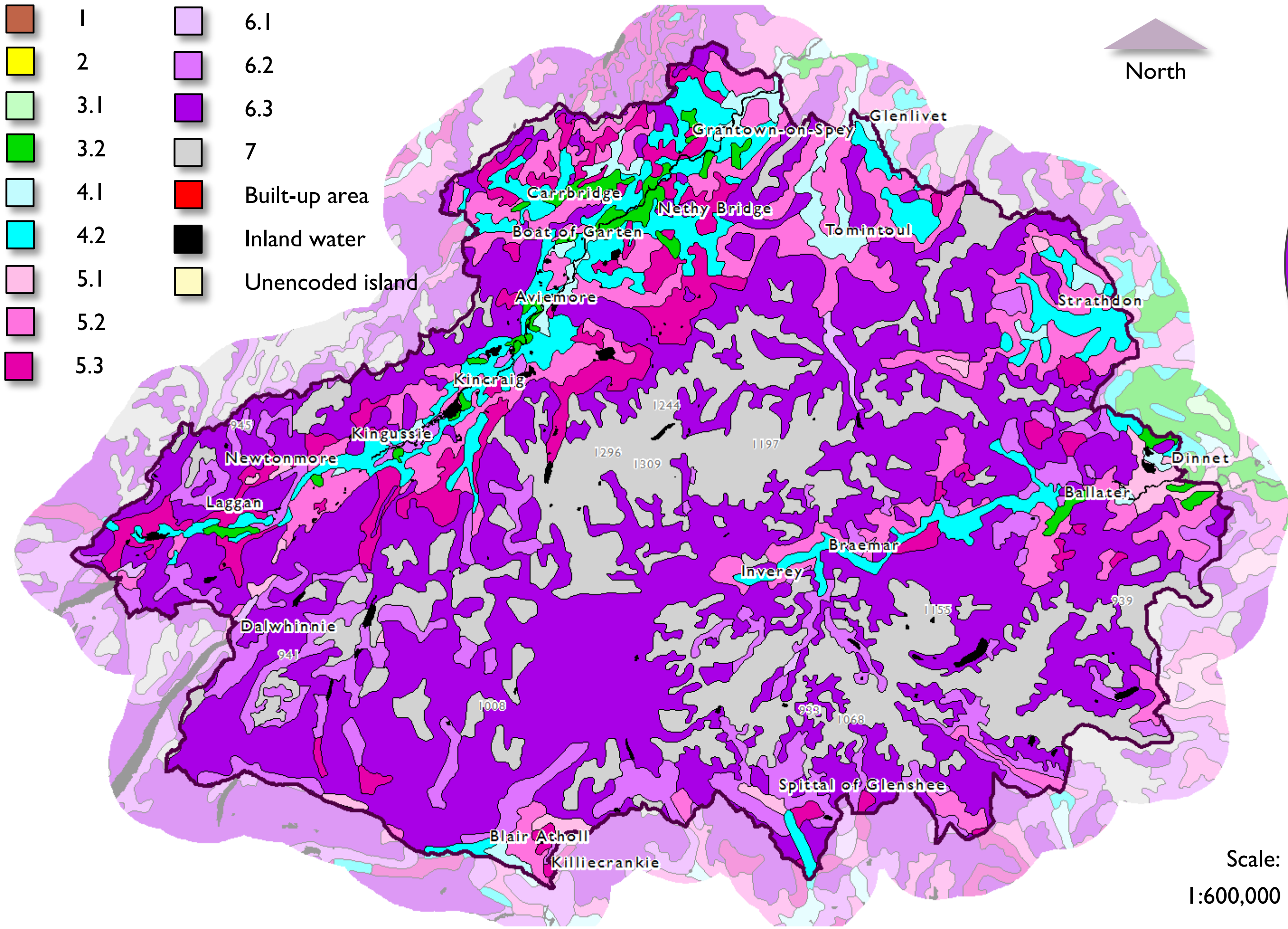


Figure 50 Agricultural land classification in the Cairngorms National Park (Soil Survey of Scotland Staff, 1981).

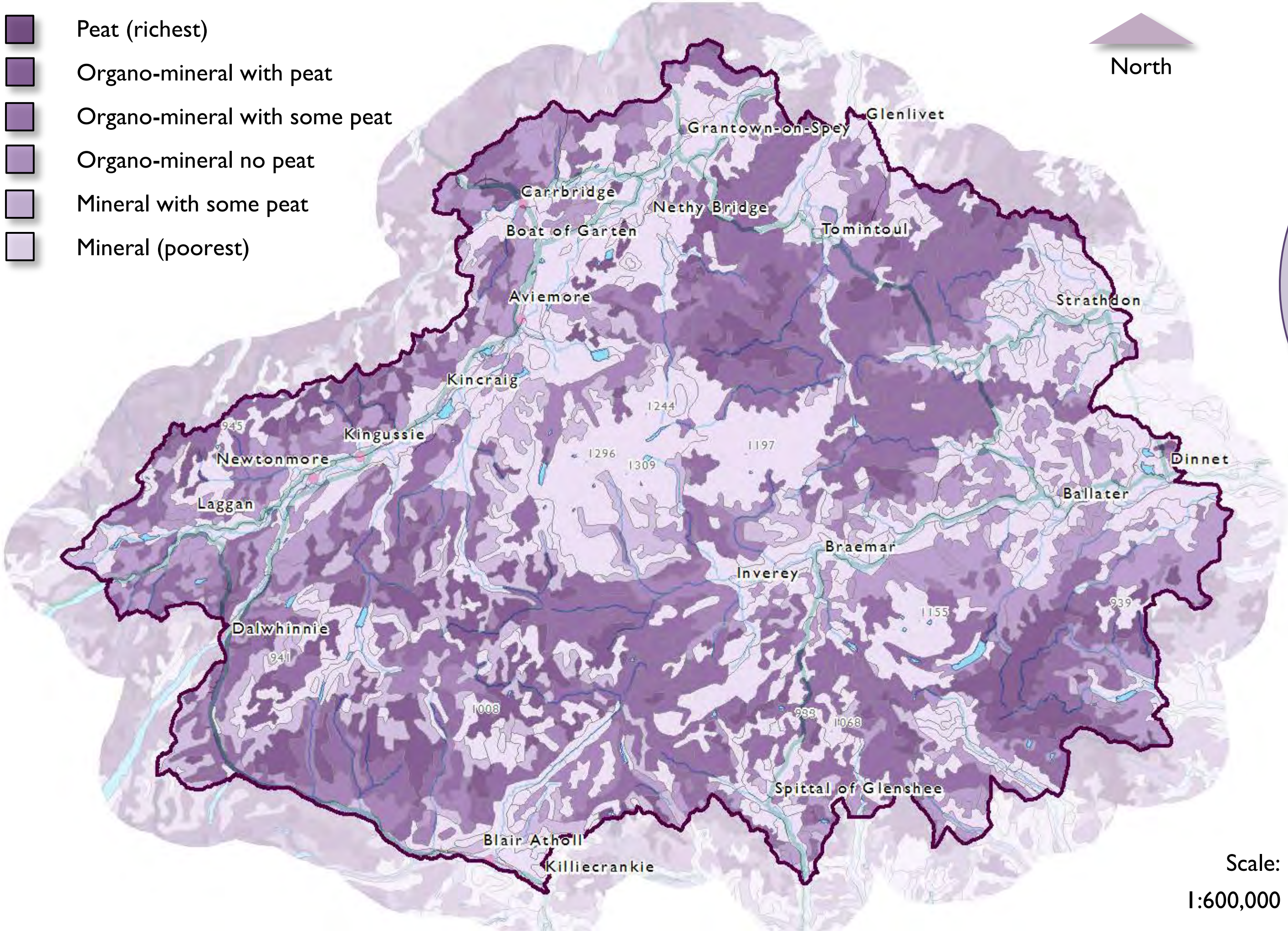
Organic Matter

Soil organic matter is a universal constituent of soils and plays a vital role in contributing to a range of soil functions. Organic carbon is the dominant component of soil organic matter (around 50%), so management of soil has important wider consequences in the context of greenhouse gas emissions and climate change. Soil organic matter also contains a wide range of nutrients (e.g. nitrogen, phosphorus) and trace elements that are essential for plant growth and health. The presence of soil organic matter is a critical indicator of soil quality and is required to deliver many of the vital functions of soil including its ability to provide nutrients, ameliorate the inputs of wastes and pollutants, contribute to the formation of good physical conditions, improve water storage and provide a habitat for microbial populations (Rees *et al.* 2011).

The soils of the Cairngorms National Park are particularly rich in soil organic matter because the cool, moist climate encourages the retention of decomposed organic materials, with peatlands containing the largest quantities of soil organic matter (**Figure 51**, **Figure 52** and **Figure 53**). These soils are important global reserves of soil carbon.

The organic matter content of soils is at risk from a range of pressures, with land use change and climate change being of particular importance. The pressures affect the incorporation, cycling and breakdown of organic matter in the soil through alteration of soil conditions populations (Rees *et al.* 2011). The major pathway of loss of organic matter from soils is by carbon dioxide (CO_2) emission to the atmosphere via soil respiration, but other greenhouse gases can also be emitted as a result of soil organic matter decomposition, for example methane (CH_4) and nitrous oxide (N_2O) (Scottish Executive, 2007). In addition, carbon compounds can be released from soil into water, for example dissolved organic carbon and particulate organic carbon (Buckingham *et al.* 2008; Dinsmore *et al.* 2010). Other processes can also influence the amount of organic matter loss, such as soil erosion (Bilotta et al. 2007). Although most CO_2 is returned to soils as a consequence of the photosynthetic activity of plants, the net exchange (the difference between gains and losses) of carbon from land surfaces may still be large (*Rees et al.* 2011).

Climate is important in determining the equilibrium soil organic matter content. Temperature and rainfall influence both the input of organic matter via photosynthesis (e.g. litter and root inputs), and its subsequent decomposition through microbial activity, with resultant release of greenhouse gases and dissolved organic carbon, along with nutrients and trace elements. Thus any change in climate, for example increased rainfall and/ or increased temperature, is likely to change the rate at which organic matter is lost or accumulated in Scottish soils (Rees *et al.* 2011).



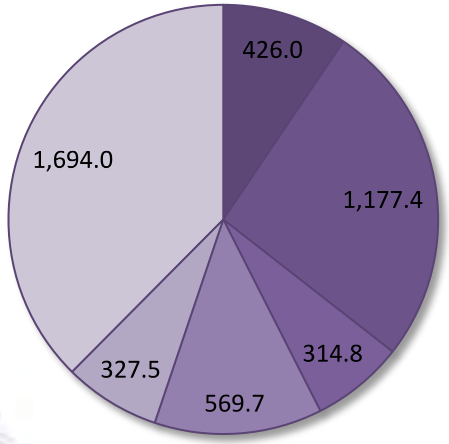


Figure 51 Carbon richness of soil by area (km^2) in the Cairngorms National Park (Scottish Natural Heritage, 2012).

Figure 52 Carbon Richness of Soil (Scottish Natural Heritage, 2012).

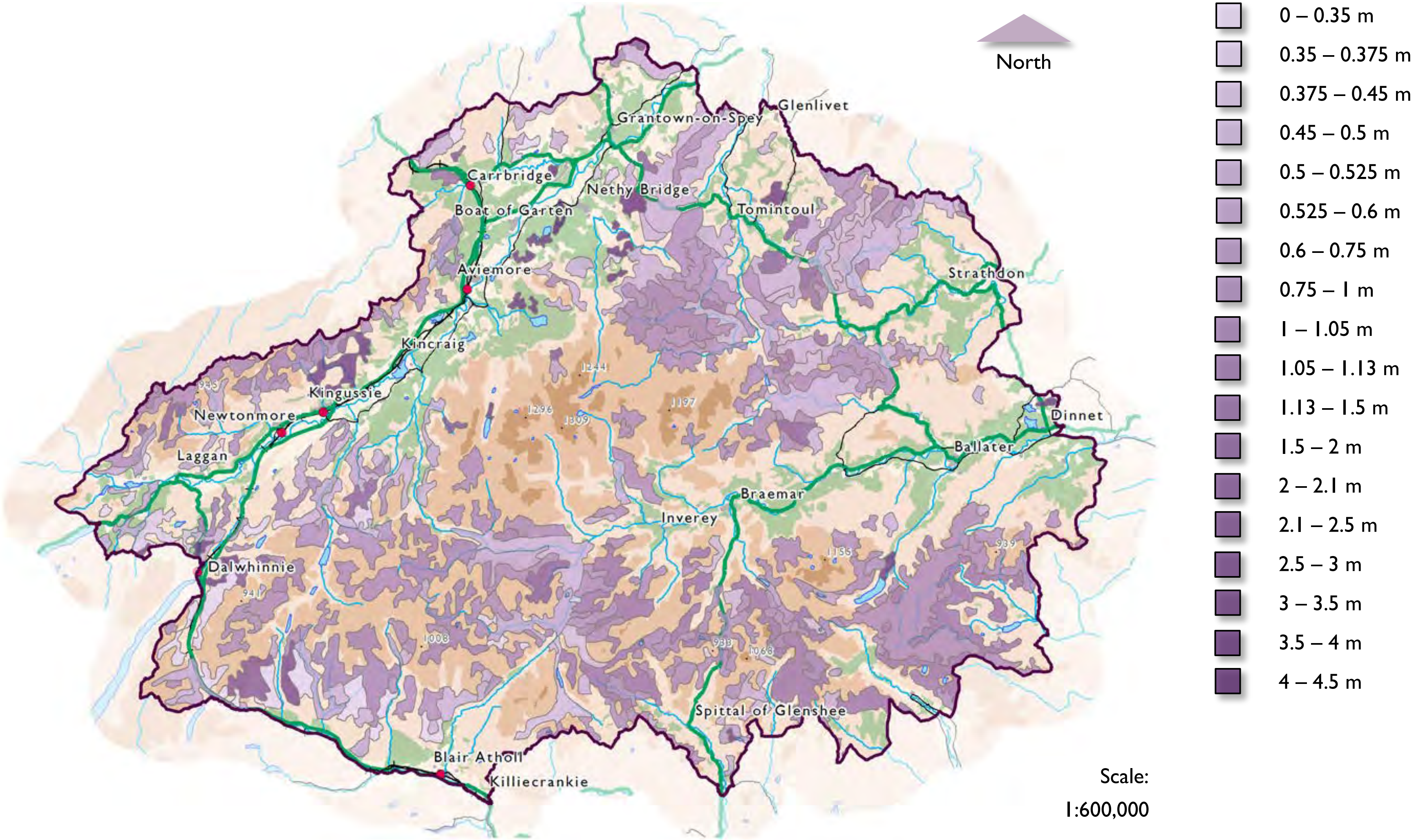


Figure 53 Depth of peat in the Cairngorms National Park (Soil Survey of Scotland Staff, 1981).

There is a particular concern regarding the sensitivity of soil organic matter to changes in climate. Projected climate change in the Cairngorms National Park, with warmer and drier summers and wetter winters, threatens to increase losses of soil organic matter (see **Topic 1: Climatic Factors**, p. 88). Another concern is that extreme weather events such as heavy rainfall could contribute to significant losses of organic matter through soil erosion (Rees *et al.* 2011).

Issues caused by climate change may be compounded by unsustainable land use activities such as those related to agriculture, forestry practices, recreation / game management, peat exploitation and development. Many of the Cairngorms National Park's most organic rich soils are located on its moorlands, large areas of which are managed for game. Deer can cause compaction and erosion and it is necessary to maintain the deer population at a sustainable level. Grouse shooting requires management of the moorland habitat such that a good balance of young heather is available for forage. This is normally done by burning (muirburn), typically in patches which are burnt every 10–20 years. Carefully managed heather moorland should aim to retain soil organic matter and the soil carbon balance over time but poorly managed burning can result in losses. There is evidence of soil organic matter loss following burning though the evidence base is scant (Rees *et al.* 2011).

The consequences of organic soil loss are potentially serious since it provides a number of important ecosystem services, such as:

- Providing the basis for food and biomass production
- Controlling and regulating environmental interactions
- Storing carbon and maintaining the balance of gases in the air
- Providing valued habitats and sustaining biodiversity
- Preserving cultural and archaeological heritage; and
- Providing raw materials.

Contamination

Soil contamination can come in many forms and from many sources. However, not all are of concern within the Cairngorms National Park. While contamination from metals, organic chemicals, radioactive substances and pathogens may exist within National Park boundary, they are not of an order that is likely to cause significant harm to the environment and can therefore be scoped out of the assessment.

Because of its potential effects on habitat and biodiversity, soil acidification is however of significance to the National Park. Typically, this pollution originates from gaseous emissions of sulphur dioxide and oxides of nitrogen, which are dissolved in rainwater to form sulphuric and nitric acids which subsequently are deposited on soil, causing soil acidification. Excess nitrogen deposition can also lead to soil eutrophication.

Acidification and eutrophication impacts are often greatest in upland areas as a result of high rainfall and are exacerbated by predominantly poorly-buffered and nutrient-poor soils and the greater sensitivity of locally adapted biodiversity to a change in soil conditions. However, lowland soils, especially those associated with ecosystems of high conservation value, may also be affected by acidification and eutrophication. In addition, fertiliser application in excess of crop nutrient requirements can result in acidification and eutrophication of agricultural and forestry soils (Cundill *et al*. 2011).

Acidification can impact on soil nutrient cycling, causing critical load exceedance and a reduction in the ability of soils to filter contaminants. Further nitrogen additions are also less readily retained in ecosystems where the critical load for nitrogen is exceeded, resulting in 'nitrogen' saturation' (Aber *et al*. 1989; Agren & Bosatta, 1988).

Contaminates may therefore more readily enter water bodies, the acidification of which has been linked with soil acidification in Scotland (Helliwell *et al*. 2001). The impacts of soil acidification on both the biological and chemical quality of water has been observed in the Cairngorms (Soulsby *et al.* 1997). See **Topic 3: Water** (p. 101) for further details.

Soil Erosion

Soil erosion by water or wind is a natural process where soil particles become detached and are transported within the landscape. Features of soil erosion may be found throughout the Cairngorms National Park (**Figure 54**). For example, landslides and debris flows are a relatively common occurrence on many of the National Park's hill slopes, which have been over-steepened by glaciation (Ballantyne, 1986, 2004). The rate of soil loss via erosion and the incidence of landslides can be increased by removing the vegetation cover that protects the soil (e.g. ploughing to grow crops, deforestation) or by engineering works. Tillage erosion also leads to the redistribution of soil downslope (Lilly *et al.* 2011).

The erosion of upland organic (peat) soils is also prevalent in some parts of the National Park, and in particular the Monadhliath Mountains, the southern part of which fall within its boundary. The mechanisms that lead to erosion in these soils are not fully understood although historic overgrazing by sheep and deer may be a contributory factor. There is also evidence that changes in climate over many years may be partly responsible for the development of gully systems in these areas (Lilly *et al*. 2009).

Landslides (in the form of debris flows) have occurred in clusters over the last 7,000 years which may be related to climatic factors such as the frequency of extreme rainfall events, for example, although deforestation is also likely to be an important factor. Debris flows in the Lairig Ghru appear to occur with a return period of around 20 years, with each episode of debris flow activity thought to be linked to intense rain storms (Baird & Lewis, 1957; Innes, 1982; Luckman, 1992). Landslide and debris flow activity is reported to have increased over the last 200–500 years (Innes, 1985; Ballantyne, 2004) and it is thought that localised extreme rainfall was the major contributing factor to the

Scottish landslides in 2004 (Winter *et al.* 2005). Triggering of peat slides is also commonly attributed to intense rainfall events (Dykes & Warburton, 2008).

Climate change (see **Topic 1: Climatic Factors**, p. 88) is therefore likely to lead to an increase in the frequency of landslides and in the intensity of soil erosion (Ballantyne, 2004; Winter *et al.* 2005).

One of the most important factors in the protection of soils from erosion is vegetation cover, as roots bind soil particles together and plants protect soil from direct raindrop impact, as well as disrupting overland flow. Where vegetation cover is sparse, or soils are bare, the incidence of landslides and soil erosion (by wind and water) is greater.

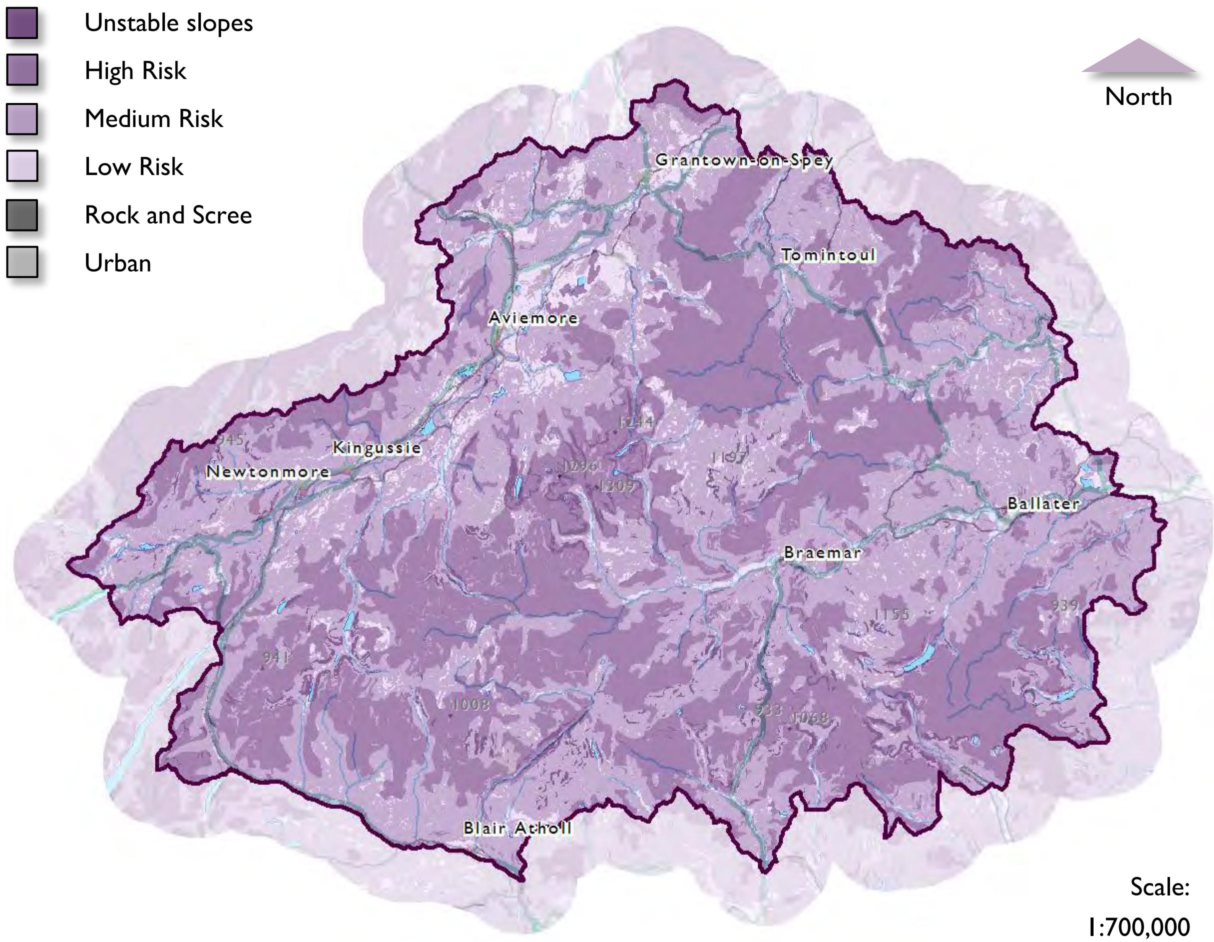


Figure 54 Soil erosion risk within Cairngorms National Park.

In some upland areas of the Cairngorms National Park, heavy grazing by sheep and deer has caused a decline in heather cover which has then been replaced by tussock forming grasses with poorer soil binding abilities. However, one difficulty in establishing links between soil erosion (in particular, the erosion of peat) and grazing is that historic stocking densities, which are generally unknown, may have had more influence on the risk of erosion than current stocking densities. Also, both sheep and deer will preferentially graze specific areas, resulting in localised areas experiencing greater grazing pressures and an increased risk of erosion (Lilly *et al.* 2011).

In the Cairngorms National Park, estates and upland farms have commonly used burning as a means of controlling vegetation structure and improved heathland productivity. This can cause issues when too much vegetation is removed. Severe burning may even make the surface organic layer of the soil water resistant, resulting in greater run-off and greater potential for soil erosion and landslides (Lilly *et al.* 2011).

With an area around 600 km^2 of forest cover, soil erosion originating from forestry activities is also a consideration for the National Park. While in most instances, tree cover has a positive effect on soil erosion, providing vegetation cover and binding soils, certain activities may cause issues. For example, the bed of new drainage ditches can be scoured and run-off during harvesting can remove the loosened soil (Lilly *et al.* 2011).

Due to the National Park's popularity as a visitor and tourist destination, the effects of recreation must also be given consideration. Hill walking and mountain biking on some hill and upland areas can cause erosion and lead to the extension of paths across sensitive environments where natural regeneration of the vegetation is slow. These areas then become vulnerable to continued erosion (Lilly *et al.* 2011).

Key Messages

The Cairngorms National Park does not contain any mapped areas of Prime Agricultural Land; it does however have large areas of Carbon Rich soils, which perform important ecosystem services, particularly as a carbon sink. Soil erosion, both natural and through inappropriate land management techniques place many of these soils at risk.

There is little evidence of soil contamination within the National Park, however inappropriate agricultural practices may lead to instances, which in turn may have a negative effect on water quality.

The NPPP may have an effect on soil quality, particularly through its influence on the level and distribution of development within the National Park.

Inter-relationships with other topics

- Topic 1: Climatic Factors 88
- Topic 3: Water 101
- Topic 5: Material Assets 129
- Topic 6: Biodiversity, Fauna and Flora 148
- Topic 7: Landscape and Cultural Heritage 221
- Topic 8: Population and Human Health 250