Executive Summary

In the face of an escalating climate emergency, our planet is confronting a pivotal moment that demands urgent and decisive action to mitigate its devastating consequences. Alongside climate research, scientists have also drawn attention to major declines in biodiversity and the serious consequences of this for ecosystem function, evolutionary processes, and the health, well being and economic value derived from rich and diverse natural systems.

Although Scotland is renowned for its wonderful wildlife, it is still one of the most nature depleted countries in the world and experiencing major declines in biodiversity: the 2019 Scottish State of Nature report found that 49% of Scottish species have decreased in abundance in the last two decades. This gloomy state of affairs and its consequences are recognised by governments and decision-makers and momentum is growing for actions to address the interlinked climate and nature emergency.

To address the urgent issue of biodiversity loss within Loch Lomond and the Trossachs National Park, a comprehensive and ambitious new strategy, Future Nature has been launched. This strategy serves as both a commitment and a call to action, aiming to collaborate with partners in order to achieve an inspiring vision: a resilient nature-rich National Park, where abundant wildlife and a healthy natural environment provide a wealth of benefits through an extensive, well-connected living network.

In support of this strategy, Ecosulis were commissioned to i) develop a monitoring framework and dashboard of indicators to track progress towards the Future Nature vision, and ii) establish a baseline review of the State of Nature in the National Park using a selection of indicators. The purpose of these reports was to provide a robust framework enabling the assessment of key outcomes related to the Future Nature Strategy and set a vital reference point that future progress and evaluations can be measured against. Together, these reports serve as essential tools for informed decision-making and strategic planning within Loch Lomond and the Trossachs National Park.

Within the context of the State of Nature in Loch Lomond and the Trossachs National Park, the reports shed light on the disparity between the current ecological conditions and the aspirations for a thriving and resilient natural environment. By comparing the park's performance to the rest of Scotland and considering data from the past few years, the reports highlight that although the park may be performing relatively well compared to some benchmarks, it still falls significantly short of the ambitious goals set for a National Park. Recognising the concept of shifting baselines is crucial as it prompts us to recalibrate our conservation goals and reevaluate what we consider as good ecological conditions. In the context of Loch Lomond and the Trossachs National Park, shifting baselines can distort our perception of what constitutes success in conservation.

These reports also highlight the existence of data gaps that hinder an up-to-date baseline assessment of the State of Nature. In particular, key data gaps exist in woodland, peatland analysis, herbivore impact and long-term species monitoring, where open-source national datasets are inconsistently updated and lack contemporary data.

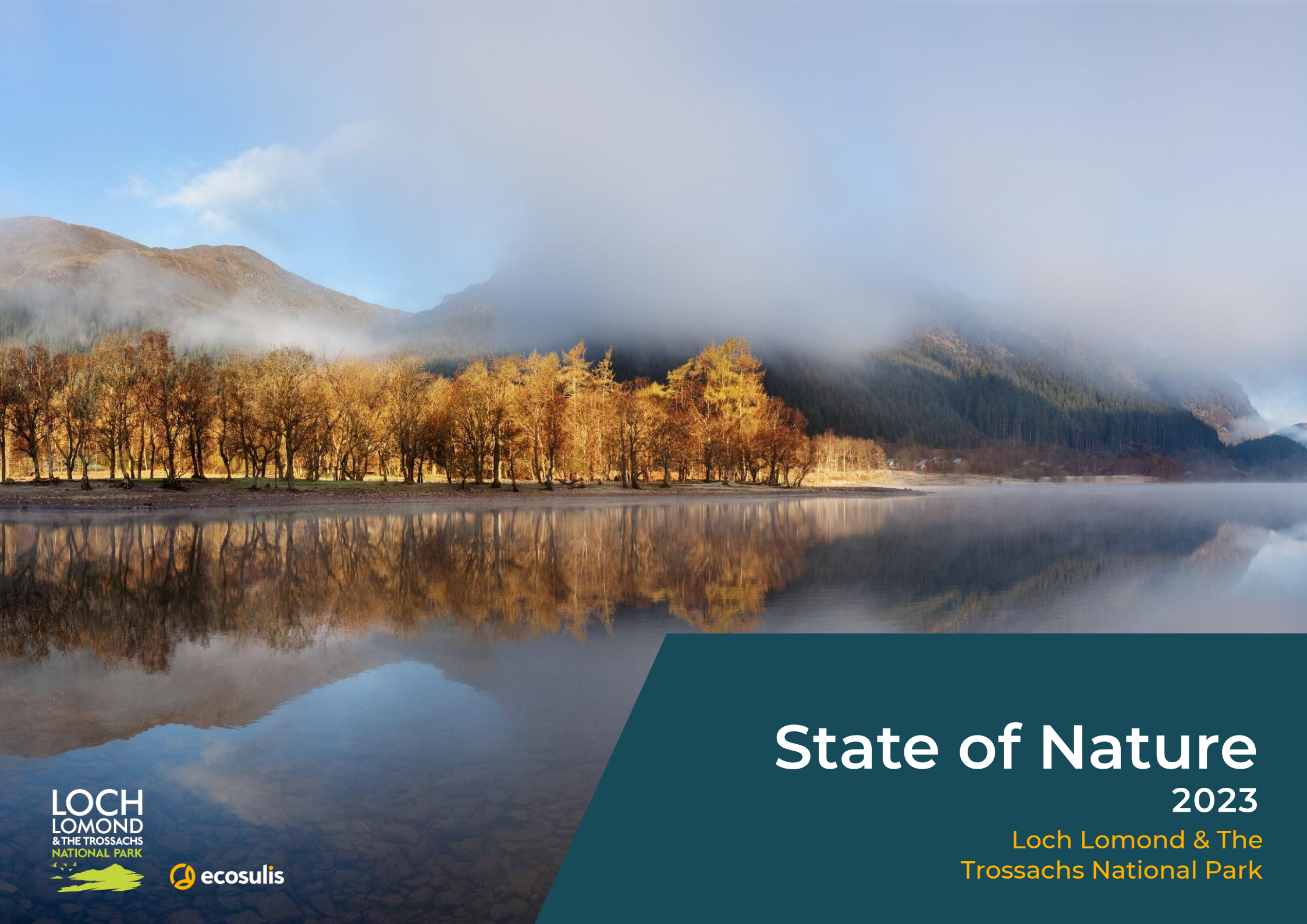
Although there is a high level of detail in the available woodland data, it is outdated and requires updating to ensure accurate monitoring. The data gaps in peatland arise from uncertainties regarding the location and quality of the available data, making it challenging to verify the measured indicators against actual peatland areas. Data compilation to reduce uncertainties in location and condition of peatland would enable a fuller understanding of the overall peatland condition in the National Park. Additionally, long-term monitoring scheme species data only extends until 2011 and at relatively low sampling effort, as provided by the National Park. Acquiring more recent data would enable a more up-to-date evaluation of the park's important species.

For next steps and monitoring, it's recommended to:

i. Prioritise indicators with data availability, as highlighted in the Future Nature Indicators report, for inclusion on a working dashboard. Indicators with out-of-date data can be included on the dashboard but it would be good to establish an infrastructure that allows for easy updates as data gaps are filled.

ii. Use the State of Nature report as a 'lag' report to be updated every 5-10 years and to establish context and summarise any progress.

iii. Prioritise sub-outcomes with data gaps and strategise the best ways to fill these data gaps to enable a more up-to-date indicator assessment.



State of Nature

2023

Loch Lomond & The Trossachs National Park

LOCH LOMOND & THE TROSSACHS NATIONAL PARK

ecosulis

Contents

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Version 1 .0 | May 2023

Introduction

This report was commissioned by Loch Lomond and The Trossachs National Park Authority in February 2023 to produce a report to assess the current State of Nature within the National Park and act as health check of how the National park is faring. As one of Scotland's most treasured landscapes, the park encompasses a diverse range of habitats, including expansive lochs, rugged mountains, moorlands and ancient woodland. This report strives to foster a comprehensive overview of the park's natural environment and nature recovery efforts, inspire conservation action and guide collective initiatives to ensure long-term preservation and recovery of this landscape.

This report combines Loch Lomond and The Trossachs National Park Authority data with openly available data to assess the State of Nature of the National Park. To achieve this, key elements of the National Park's natural environment are reviewed in turn. The elements applied here are derived from key outcomes defined by the National Park's *Future Nature Strategy*. These elements span the National Park's woodland to its peatland and wetlands, as well as assessing species and sites which are of importance to the National Park.

Where relevant and where data allows, comparisons are made between the National Park and wider Scotland. Assessing the State of Nature against Scotland is useful for understanding the broader context of the park's ecological state. However, despite its reputation for abundant wildlife, Scotland is already facing significant challenges in terms of biodiversity loss. Therefore, it is crucial to view Scotland as a depleted baseline, acknowledge the concept of shifting baselines and setting ambitious goals that go beyond the current conditions to ensure thriving and resilient nature within Loch Lomond and The Trossachs National Park.

Land Cover Change

Land cover change has significant impacts on biodiversity and ecosystem functioning. 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. Conversely, sustainable land use practices, such as reforestation or the restoration of wetlands, can enhance ecosystem functioning and support human livelihoods. Understanding land cover change at a National and LLTNP scale helps contextualise the state of nature in the park with the wider landscape.

Here, Space Intelligence Land Cover data[1] has been reviewed to provide a high-level insight into and measure of drivers of land cover change within Loch Lomond and the Trossachs National Park, and then situate this within the wider context of Scotland.

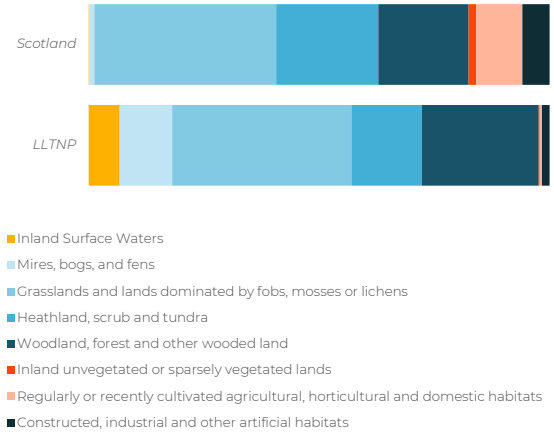
Land Cover in the National Park

To contextualise land cover change, proportional land cover in the National Park, in comparison to wider Scotland was assessed. This highlights the proportionally greater presence of inland surface water, woodland, and mire, bog, and fen habitats within the National Park than in wider Scotland, emerging from the Park's vast network of lochs and rivers and swathes of woodland.

Similarly, cultivated agricultural, horticultural, and domestic habitats, and constructed or industrial artificial habitats are proportionally much less present in the National Park than they are in wider Scotland.

This illustrates the degree to which – at a broad level – heavily modified habitats are less dominant within the National Park, emphasising its importance as a natural landscape within Scotland.

Land Cover by EUNIS Habitat Class, 2020
(Space Intelligence data)

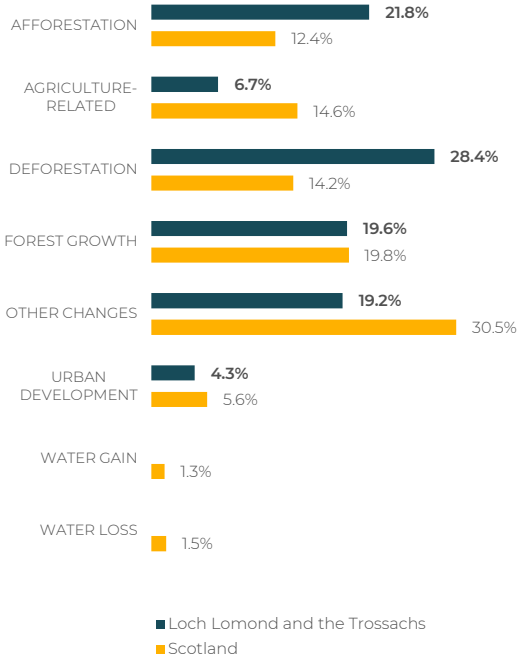


Drivers of Land Cover Change

Comparison of drivers of land cover change (2019-2020) between Loch Lomond and the Trossachs National Park and Scotland was produced from Space Intelligence Land Cover Change data. This comparison highlights two drivers of land cover change that are more prevalent in the National Park than wider-Scotland: (i) afforestation, and (ii) deforestation. Forest-related land cover changes – including forest growth – are dominant in the National Park, representing a total of 69.8 % of land cover change occurring between 2019 and 2020.

Forest growth has been identified as a driver of land cover change which exerts a broadly equal impact on the National Park as it does in Scotland. When considering the prevalence of afforestation and deforestation in the National Park, this indicates that woodland is driven more through active management, whether afforestation or deforestation, than woodland in wider Scotland.

Drivers of Land Cover Change, 2019-2020:
Scotland and Loch Lomond and the Trossachs

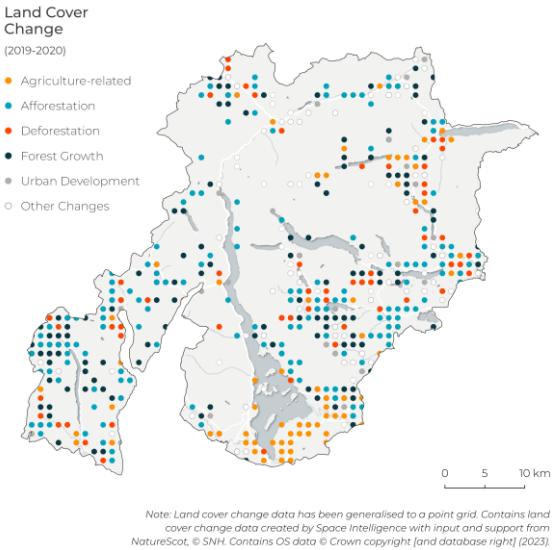


Agricultural-related, urban development, and other changes represent drivers of land cover change which are less prevalent in the National Park than in wider Scotland. No detail is provided on the definition of the 'other changes' class within the data, however, it may comprise changes in land cover which do not meet any of the rules applied to assign specific land cover change types.

Water gain and water loss are drivers of land cover change which have been identified as having a presence in Scotland, but do not directly drive land cover change in the National Park.

The spatial distribution of these drivers of land cover change within the National Park are mapped (*below*) to visualise spatial trends within the data. Several trends emerge from this:

1. the high concentration of agriculture-related land cover changes in the area to the south of Loch Lomond,
2. the limited presence of identified land cover changes in the upland areas near the centre and to the north of the National Park.



Note: Land cover change data has been generalised to a point grid. Contains land cover change data created by Space Intelligence with input and support from NatureScot, © SNH. Contains OS data © Crown copyright [and database right] (2023).

This landcover analysis highlights the standing of woodland and forestry in the National Park's natural environment, with woodland-related changes dominating land cover changes within the park.

Long-Term Changes

To provide longer-term insights into land cover changes within the National Park, European Environment Agency (EAA) data[2] was investigated. This data represents land cover changes observed between 2012 and 2018.

This data highlights two core drivers of land cover change within the National Park throughout the period 2012 to 2018. Firstly, the most significant (by area) land cover change was '*Coniferous Forest to Transitional Woodland-Shrub*', which comprised 74.6 % (or 2,896 ha) of land cover change within the National Park. Secondly, '*Transitional Woodland-Shrub to Coniferous Forest*', which represented 21.4 % (or 829 ha) of land cover change within the National Park.

Other land use changes include: '*Mixed Forest to Transitional Woodland Shrub*' (2.4 % or 92 ha), '*Mineral Extraction Site to Water Body*' (0.6 % or 23 ha), '*Coniferous Forest to Mineral Extraction Site*' (0.4 % or 17 ha), '*Pasture to Construction Site*' (0.1 % or 5.3 ha), and '*Pasture to Industrial or Commercial Units*' (0.1 % or 5.1 ha).

This reflects the trends and patterns also presented within the Space Intelligence Land Cover data, whereby forest-related land cover changes are dominant. In fact, these forest-related changes represent over 95 % of land cover change (by area) in the EEA data, considerably higher than the 69.8 % recorded in Space Intelligence data. This should not be interpreted to mean that forest-related land cover changes have fallen in the period 2019-2020 in comparison to 2012-2018. Rather, it is more likely to be an outcome of the different methods applied in developing and characteristics (e.g., spatial resolution) of each dataset.

Key Findings

1. The National Park contains a greater proportion of inland surface water, woodland, and bog habitats but a smaller proportion of heavily modified habitats compared to the rest of Scotland.

2. Afforestation and deforestation are significant drivers of land-use change within the National Park throughout the period 2012 to 2020.
3. Much of the land use change seen between 2019 and 2020 occurred in the lowland areas in south of the park.

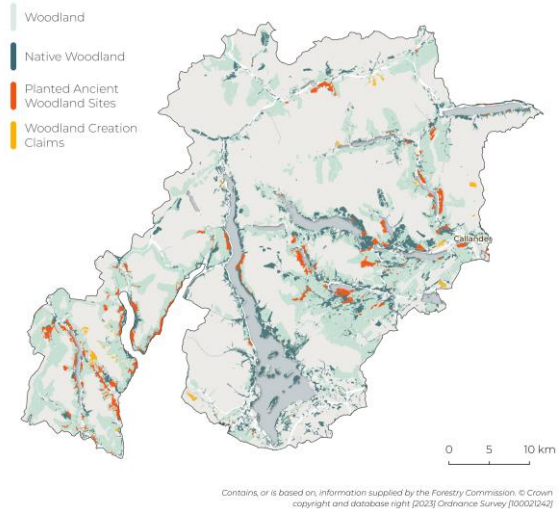
References

[1] Space Intelligence with input and support from NatureScot, 2021. *Scotland Habitat and Land cover map – 2020*, *Scotland Habitat and Land cover map – 2020*, *Scotland Land cover change map – 2019-2020*.

[2] European Environment Agency, 2020. *Corine Land Cover Change (CHA) 2012 – 2018*. Produced by the European Environment Agency under the framework of the Copernicus programme.

Woodland

Woodlands are valuable ecosystems that offer shelter and sustenance to numerous species, while also providing critical ecosystem services like carbon sequestration and flood prevention. Indeed, as stated by the National Park's 2019 Trees and Woodland Strategy[1], the Park is home to temperate rainforests and ancient Caledonian pine forests. These woodlands form a crucial habitat within Loch Lomond and The Trossachs National Park and are also priority habitats for protection and enhancement within Scotland. The influence of the Park's woodlands is illustrated by the dominance of woodland and forestry-related land cover change. This, however, only provides a surface-level overview of woodlands and forests in the National Park. To examine these woodlands in more detail, we apply openly available data.



Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right [2023] Ordnance Survey [100021242]

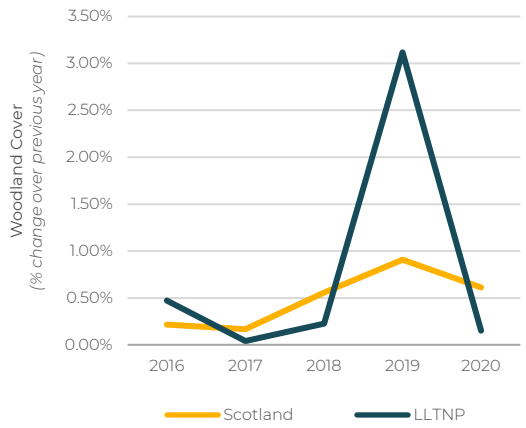
Here, we look at the distribution and quantity of both native woodland and planted ancient woodland sites within the National Park. This applies National Forest Inventory[2] and Native Woodland Survey of Scotland data[3] which map locations of both native and planted ancient woodland sites. This is supplemented by data provided by the National Park Authority which describes the location of woodland creation claims within the National Park.

Planted ancient woodland sites (PAWS) describes sites which are recorded as ancient woodland, but canopy cover is currently non-native. Finally, woodland creation claims refer to locations of planting which have received funding under the Scottish Government's Forestry Grant Scheme[4] which seeks to facilitate the creation of new woodland and associated benefits.

Though a limited indicator of woodland – or habitat – quality, woodland cover provides insights into certain ecosystem services provided by the National Park's woodland stock.

Comparing the total extent of woodland cover across both the National Park and Scotland, from 2015 through to 2020. This comparison illustrates that total woodland coverage, as assessed by the National Forest Inventory, has increased consistently at both scales from 2016 to 2020. Average (mean) woodland expansion calculated over this period is 0.49 % for Scotland and 0.80 % for the National Park. Plotting the data reveals that this is in large part due to the increase in forest cover within the National Park between 2018 and 2019.

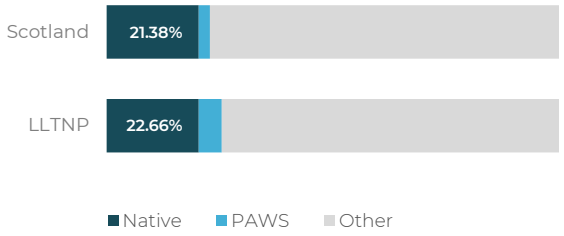
Total Woodland Cover Change (%)
(National Forest Inventory data)



Native Woodland Survey of Scotland data was reviewed to review the status of native woodland within the National Park. It is important to note that this data was produced in 2014, though it is still considered the best data representing native woodland within the National Park. This data was supplemented with – more recent – 2020 National Forest Inventory data from which values relating to the total extent of woodland were derived.

Native woodland here is considered as woodland which has a percentage native value of 50 % of greater in Native Woodland Survey of Scotland data. This threshold was then used to extract a value from Native Woodland Survey of Scotland data for total native woodland, both within the National Park and across Scotland.

Proportional Woodland Type
NFI (2020) and NWSS (2014) data

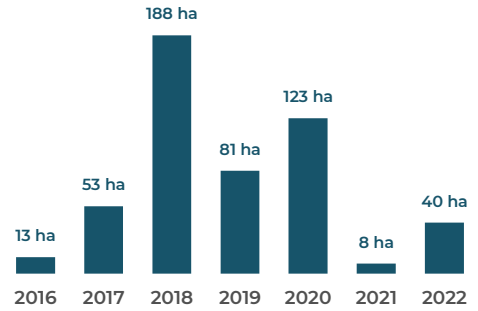


This highlights that the proportion of the total area of woodland within the National Park is broadly similar between Scotland and the National Park, though the value is slightly greater in the National Park. However, whilst PAWS represents 2.6 % of woodland across Scotland, it represents 5.7 % of woodland within the National Park.

This indicates that there is potential for forestry management of PAWS woodland to improve the condition of the National Park's ancient woodland and enhance the woodland network. This forms a core target defined in the National Park's Trees and Woodland Strategy[1] which prioritises PAWS woodland as opportunities for creating landscape-scale woodland networks.

Woodland creation claims supported by the Forestry Grant Scheme and located within the National Park have averaged 72 ha per year from 2016 to 2022. National Forest Inventory data (2020) has recorded 1,520,410 ha of woodland throughout Scotland, with 44,227 ha of woodland creation claims. This indicates that 300 m^2 of woodland creation claims have been granted per ha of existing woodland. In contrast, this value for the National Park only is 90 m^2. This indicates that, while woodland cover changes are more pronounced in the National Park than nationally, the impact of woodland creation claims on these changes in landcover is currently likely to be less within the National Park than nationally.

Total Area of Woodland Creation Claims
(Scottish Forestry data)



Data source: Scottish Forestry, 2022. *FGS Woodland Creation – Claims.*

Key Findings & Conclusions

1. The National Park's woodland cover has - on average – increased annually by 0.31 percentage points more than woodland across Scotland.
2. Native woodland cover within the National Park is slightly greater than it is across Scotland, though the proportion of PAWS land within the National Park is approximately twice as large as in Scotland.

Analysis of land cover data covering the period 2012-2020 highlights the significance of forest-related land cover changes (e.g., afforestation, deforestation, and forest growth) within the National Park. This is perhaps a factor of the extent of the National Park's woodland, but may also hint at the dynamic, changing nature of woodland habitats throughout the National Park. Analysis of National Forest Inventory data, indicates that – for the period 2016-2020 – the National Park's woodland cover is increasing at a faster rate than national woodland cover.

National Forest Inventory data (produced by the Forestry Commission), shows that as a proportion of total woodland, Planted Ancient Woodland Sites (PAWS) represent 5.7 % of woodland within the National Park, as opposed to 2.6 % nationally. This suggests that plantation woodland may represent a proportionally larger threat within the National Park than nationally.

Assessments of woodland are limited by data availability. Scottish Forestry's NWSS data was applied in the analysis towards this report. While the data is useful for understanding the condition and composition of woodland throughout the National Park and represents the most recent comparable data, it was published in 2014.

To mitigate this, the report also draws upon more recently published National Forest Inventory data. However, this data does not provide the level of detail available in NWSS data with regards to the condition and species composition of woodlands. This lack of contemporary woodland condition data represents a key data gap encountered in production of this report.

References

[1] Loch Lomond and the Trossachs National Park Authority, 2019. *Trees and Woodland Strategy: 2019 – 2039.*

[2] Forestry Commission, 2021. *National Forest Inventory: 2015 – 2020.*

[3] Scottish Forestry, 2014. *Native Woodland Survey of Scotland.*

[4] Scottish Forestry, 2022. *FGS Woodland Creation – Claims.*

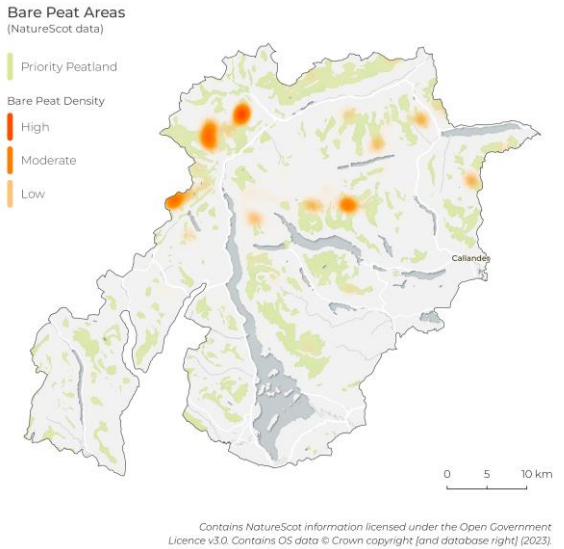
Peatland

Peatlands are an internationally important habitat and a key part of the Scottish landscape, covering more than 20% of the country. In good condition they also form a crucial carbon sink. However, degraded peatlands may emit more CO_2 than they remove. With 80% of Scottish peats considered degraded, peatland restoration is a key aim of the Scottish Government's Climate Change Plan 2018-2032[1].

Here, we first apply NatureScot mapping to review the status of bare peatland within the Nation and contextualise this on a Scotland-wide scale. Next, we assess the health of peatlands within the National Park by assessing levels of vegetation cover of areas of priority peatland (as mapped by NatureScot, applying data produced by the James Hutton Institute[2]). This was undertaken by applying the Normalised Difference Vegetation Index (NDVI). This index uses both near-infrared – which is strongly reflected by vegetation – and red light –absorbed by vegetation – imagery bands. Calculating the difference between the two provides a value ranging from -1 to 1, where -1 is highly likely to be water, and 1 is highly likely to be dense, leafy vegetation.

Bare Peatland

Areas of bare peatland throughout Scotland have been mapped by NatureScot[3] through analysis of 2018 Sentinel-2 imagery. A visualisation displaying this data represented as a heat map showing density of distinct areas of bare peat is provided in the *top left*. This data highlights 0.31 km^2 of peatland within the National Park which may be considered exposed due to low vegetation cover, this represents 0.11 % of the 296 km^2 of priority peatland identified within the National Park. In contrast, throughout Scotland, NatureScot mapping has identified 18,604 km^2 of priority peatland, with 0.18 % of this value – or 33.8 km^2 considered as bare peatland. This indicates that when considering the degree to which peatland is exposed, peatland within the National Park is in better condition than peatland across Scotland.



Contains NatureScot information licensed under the Open Government Licence v3.0. Contains OS data © Crown copyright [and database right] (2023).

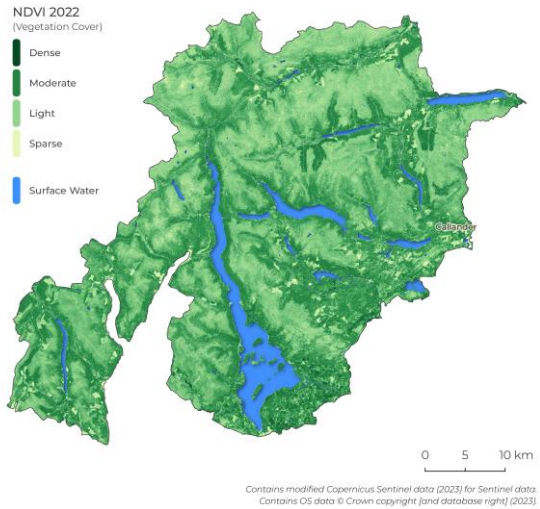
Vegetated Peat NDVI Analysis

Bare peatland data produced by NatureScot represents a single point in time. To indicate areas of bare peatland in 2022 and therefore potential trends, additional analysis was undertaken using Sentinel-2 images captured in 2022. This analysis required several processing stages.

First, a series of images were downloaded for 2022. Two images were downloaded for each month between April and September, for Sentinel-2 tiles which intersect the National Park. Images with the lowest cloud cover which matched the input search parameters were retrieved. Each Sentinel-2 image was then processed to mask clouds, cloud shadows, snow, and unclassified cells within the scene classification data (SCL) associated with each Sentinel-2 image.

Next, NDVI was calculated for each of the masked Sentinel-2 images, with the output NDVI images being stacked by the year represented by the data. This aimed to minimise

variations between single images. Those associated with climate conditions at the time of image capture, for example. This stack of images was then combined to give a single NDVI image for the year, where values of each cell represented the maximum value for that cell within the raster stack. NDVI, as calculated for 2022, is shown below.



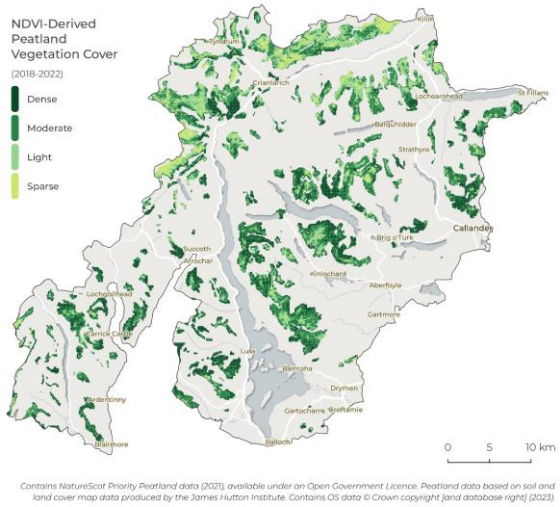
Contains modified Copernicus Sentinel data (2023) for Sentinel data. Contains OS data © Crown copyright [and database right] (2023).

While applying maximum aggregation produced a more cohesive output, it is more sensitive to noise and outliers in the input imagery. In this instance, this produces an overestimation of NDVI values in the output NDVI composite image. Consequently, the NDVI values used to classify *dense*, *high*, *moderate*, and *light* have been derived from standard classification values and adjusted – in reference to satellite imagery and habitat mapping – to compensate for this overestimation of NDVI values.

This analysis produced a classification to categorise areas of priority peatland by modelled vegetation cover. Classes applied here were 'light', 'moderate', 'high', and 'dense'.

This indicates that areas of peatland in the northern region of the National Park are the least vegetated This correlates with NatureScot analysis which highlights area of peatland of concern due to exposure from low vegetation cover predominantly to the north of the National Park.

In contrast, areas of peatland towards the fringes of woodland, in particular to the east of Loch Lomond are indicated as being the most vegetated through this analysis.



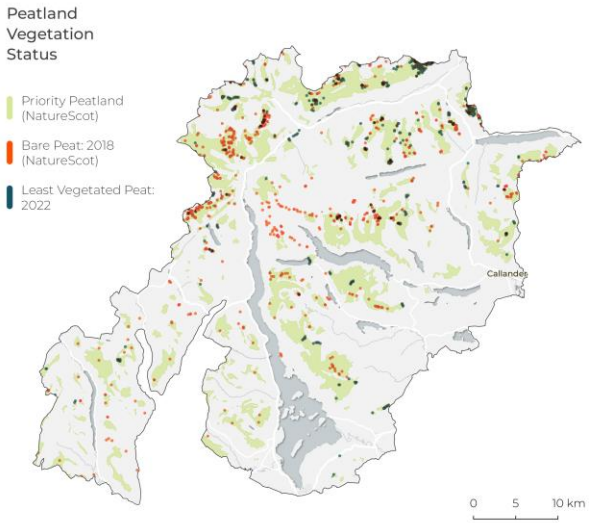
Contains NatureScot Priority Peatland data (2021), available under an Open Government Licence. Peatland data based on soil and land cover map data produced by the James Hutton Institute. Contains OS data © Crown copyright [and database right] (2023).

Priority peatland data applied here is a predictive model of the likelihood of peatland presence in a given area, modelled using existing soil and vegetation data. In contrast, NDVI data is much higher resolution, with a 10 m cell size. This may explain the presence of higher vegetation coverage of peatland along the margins of mapped priority peatland areas. Several areas of mapped priority peatland are shown to be almost entirely covered in denser vegetation however: a large area to the north of Loch Katrine, for example.

Indicative 2018-2022 Comparison

Here, NatureScot bare peat modelling (2018) are presented alongside the least vegetated peat NDVI analysis (2022) undertaken as part of this report.

It is important to state that any patterns or trends identified by this comparison are indicative. This is a result of the differing methods and workflows applied to generate the 2018 and 2022 datasets. For example, 2018 data was produced using machine learning techniques encompassing 23 indices (including NDVI), whereas under the scope of this report, 2022 data has been produced using a simplified method considering NDVI only. The figure below shows areas of bare peat as identified by the 2018 analysis (orange) and the 2022 analysis (blue).



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Mapping areas of bare peatland (2018 analysis) against areas of least vegetated peatland (2022 analysis) indicates that areas of bare and least vegetated peatlands have remained within the northern expanses of the National Park within the 2018-2022 period.

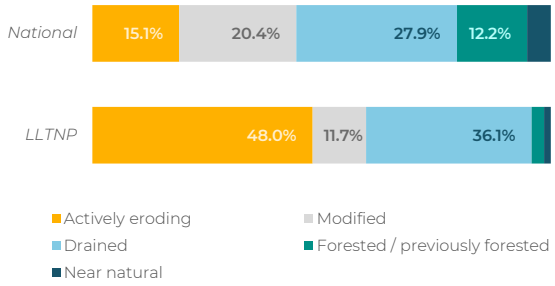
Least vegetated peatland analysis (2022) is also limited to priority peatland areas, whereas the bare peatland analysis (2018) includes non-priority peatland.

Peatland Depth

Data relating to peatland depth has been produced by NatureScot.[5] The data represents sampled peat depth gathered from a range of peatland project sites located throughout Scotland. Each sample point also contains an assessment of condition of peatland at each sample point.

Here, we extract sample points where peat depth is greater than 0 cm and review condition assessments for each remaining point. Sample points where condition was described as 'Not provided' were also omitted from the analysis; a total of 1 point in the National Park and 11,430 throughout Scotland.

Peatland Sample Condition Status



Data source: NatureScot, 2022. Peatland Action – peat depth. Contains NatureScot information licensed under the Open Government Licence v3.0.

Review of this data highlights that peatland sampled within the National Park is more likely to be actively eroding or drained than peatland sampled nationally. While 1.4 % of peatland sampled within the National Park was recorded as being in a near natural condition, this value was 4.1 % for peatland nationally. This indicates that key pressures faced by peatland within the National Park are drainage and active erosion. Drained peatland shown in the peatland depth data is concentrated in peatland north of Buchanan Smithy, and north Inveranan. Actively eroding peatland is located predominantly in the northern expanses of the National Park.

Key Findings and Conclusions

1. Least vegetated peat is located within the north of the National Park, with more densely vegetated peat being in southern regions – often near areas of existing woodland.
2. Several large blocks of priority peatland classed as highly vegetated are present within the National Park, north of Loch Katrine and southwest of Crianlarich, for example.
3. The ratio of bare peatland to priority peatland within the National Park is 0.11 %, 0.07 percentage points below the Scotland-wide ratio.
4. Indicative comparison between areas of least vegetated peatland (2022 analysis) and areas of bare peatland (2018 analysis), suggests that exposed peatland has remained concentrated within the northern regions of the National Park throughout the period 2018-2022.
5. Key pressures faced by the National Park's peatland are active erosion and drainage. These pressures are present more acutely within the National Park than throughout Scotland.

A review of data representing the degree to which peat is vegetated indicates that areas of potentially exposed peat area focused within the northern expanses of the National Park. This has been observed to be the case in both 2018 and 2022.

A review of peatland depth survey data gathered by NatureScot reveals detail on the condition of peatland within the National Park and allows comparisons to be made with peatland nationally, throughout Scotland. This data highlights active erosion and drainage as key challenges experienced by the National Park's peatland. The degree to which these challenges are experienced within the National Park is also much greater than the degree to which they are faced nationally. For example, 48 % of surveyed peatland within the National Park was classed as 'actively eroding', in comparison to 15 % nationally.

Several data gaps have been identified here. Gathering of data to fill these gaps would enable a fuller understanding of the condition of peatland within the National Park to be developed. These data gaps relate to: (i) the location of areas of peatland, and (ii) the condition of this peatland.

Peatland extent data is produced by NatureScot and derived from mapping undertaken by NatureScot and the James Hutton Institute in 2016. While this represents the best available peatland extent data, it is currently seven years old and shows areas of where peatland is predicted to be located, rather than actual peatland locations. Peatland condition data relating to bare peat and peatland depth is available. Bare peat data provides insights into areas of exposed peatland within the National Park, however as the data represents a single point in time – 2018 – the ability to draw trends and longer-term insights from this data is limited.

References

[1] Scottish Government, 2018. *Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3).*

[2] NatureScot (derived from data produced by the James Hutton Institute), 2021. *Priority Peatland (Scotland).*

[3] NatureScot, 2022. *Bare peat in Scotland from Sentinel 2.*

[4] European Union Copernicus Programme. Sentinel-2 data acquired via Copernicus Open Access Hub.

[5] NatureScot, 2022. *Peatland Action - Peat depth.*

Water Network

Freshwater health is a key indicator of a healthy ecosystem and can be significantly impacted by surrounding land use and management. For example, nutrient inputs to arable land and soil erosion are two parameters related to land use which greatly influence water quality.

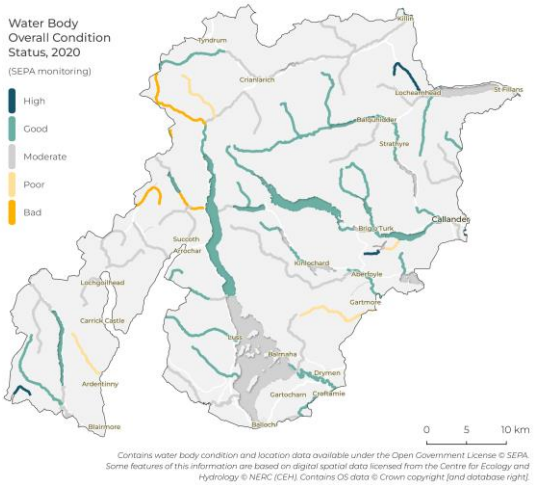
Comprising sea lochs and upland streams, the water network of the National Park is vast and expansive, with the surface area of Loch Lomond the largest of any in Scotland.

Here, we firstly review overall condition data, as assessed by SEPA, for each year between 2007 to 2020, and at both the Scotland-wide and National Park scale. Secondly, fish barrier condition data, also assessed by SEPA, is reviewed across the same period and spatial scales.

Overall Condition

Overall condition status of river and loch water bodies in the Loch Lomond and the Trossachs National Park for 2020 is shown (left).

This highlights that lochs within the National Park are in moderate or good condition, with most water bodies being in moderate condition or higher. In addition, several river waterbodies are in a high overall condition, these are all described in SEPA data as non-heavily modified surface waterbodies. River waterbodies in 'bad' condition are confined to the River Leven (Inveruglas Water, Dubh Eas) and Loch Fyne Coastal (Kinglas Water, Allt na Lairige) catchments to the northwest of Loch Lomond. These waterbodies are also all classified in SEPA data as being heavily modified, due to their usage as water storage for hydropower generation. This indicates a potential driver of 'bad' overall waterbody status in the National Park.



Contains water body condition and location data available under the Open Government License © SEPA. Some features of this information are based on digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH). Contains OS data © Crown copyright [and database right].

In addition, the '*Drunkie Burn (Loch Drunkie sluice to Loch Venachar)*' records a 'Poor' overall water quality status for 2022. Information provided by SEPA[1] indicates that this is due to the waterbody being heavily modified for drinking water supply and the impact of this modification on the waterbody's ecological function. It is understood that opportunities to restore the ecological function of these heavily modified waterbodies may be constrained by their primary functions.

However, three river waterbodies not classed as 'heavily modified' are of 'Poor' overall condition status. These river waterbodies are (1) Kelty Water, (2) Allt Fionn Ghlinne/Sput Ban/Allt Oss, and (3) River Finart. Drivers of these condition statuses at each of these river waterbodies are presented *overleaf*. This indicates that each of these three waterbodies scores poor or lower for the 'Overall ecology' parameter.

Investigating further reveals that in Kelty Water, the 'Biological elements' and 'Fish ecology' parameters both assessed as 'Poor' are responsible for this status classification. Both Allt Fionn Ghlinne/Sput Ban/Allt Oss, and

River Finart have been assessed as 'Poor' due to their hydromorphology.

Hydromorphology relates to the physical characteristics of the waterbody, for example the degree to which the waterbody has been straightened or channelised, water flows and levels, or the presence of structures which may act as barriers to the movement of fish.

Parameters Scoring Poor or Lower for River Water Bodies in Poor or Bad Overall Condition
Loch Lomond and The Trossachs (2020)

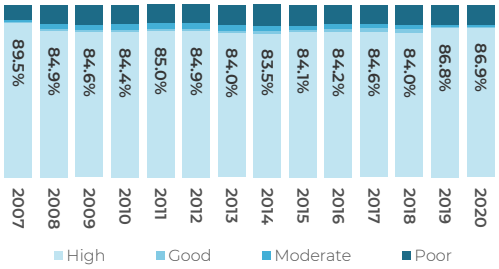
Kelty Water	Allt Fionn Ghlinne/Sput Ban/Allt Oss	River Finart
Overall ecology:	Overall ecology:	Overall ecology:
Biological elements	Hydromorphology	Hydromorphology
Fish ecology		

Data source: Scottish Environmental Protection Agency, 2023, *Water Classification Hub: Overall status.*

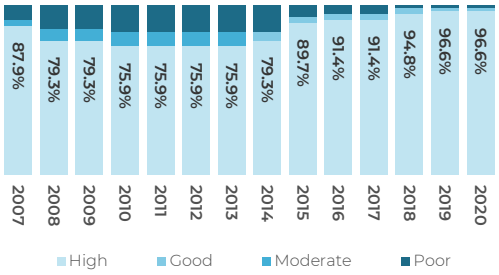
Connectivity

To build a picture of connectivity within the National Park's water network, a comparison of SEPA-monitored water bodies and their assessed value for fish barrier condition both across Scotland and Loch Lomond and the Trossachs National Park[2] is shown *overleaf*. This highlights that while Scotland wide fish barrier condition status has remained broadly consistent from 2007 to 2020, this status for water bodies within the National Park have been much more variable.

Water Bodies by Proportion in Each Fish Barriers Condition Class:
Scotland (2007 - 2020)



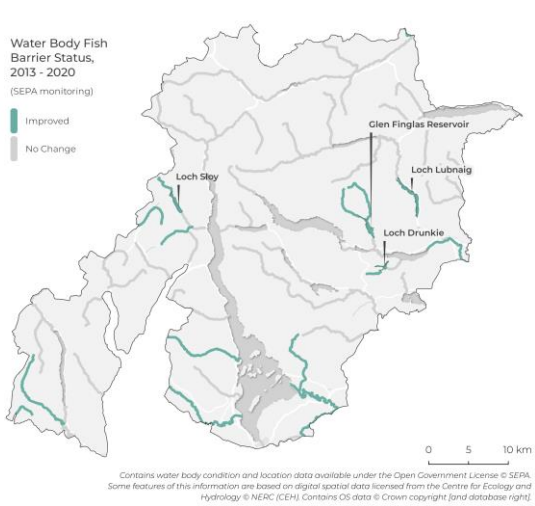
Water Bodies by Proportion in Each Fish Barriers Condition Class:
Loch Lomond and The Trossachs (2007 - 2020)



Data source: Scottish Environmental Protection Agency, 2023, *Water Classification Hub: Fish barrier status.*

This variability is defined by two key trends. First, a decline from 2007 to 2010 – also reflected in the Scotland-wide data, albeit with a smaller decline, and second, a marked upturn in assessed condition between 2014 and 2020, most notably a 10.4 % increase between 2014 and 2015. It is also worth noting that while this increase was observed in the National Park, it was not reflected in the Scotland-wide data.

To visualise and further explore the upturn in fish barrier condition identified in the comparison between Scotland-wide and National Park scale data, GIS analysis was undertaken to identify river and loch waterbody features which had recorded an improved condition between 2013 and 2020. The results of this are shown *below,* illustrating the four loch and 14 river waterbodies which improved in assessed fish barrier condition between 2013 and 2020.



Key Findings and Conclusions

1. Water body condition in terms of presence of fish barriers initially lagged behind national-level condition, before recovering and improving to a standard above national-level condition in 2020.
2. All river and loch waterbodies classed by SEPA as having a 'bad' overall status within the National Park are heavily modified river water bodies used as water storage for hydropower generation.

Review of SEPA data indicates that most waterbodies within the National Park which are assessed as either 'bad' or 'poor', are assessed as such due to the degree to which the waterbodies have been modified. Purposes of modification within the National Park are twofold: (i) hydropower generation and (ii) water extraction.

Further to these heavily modified water bodies, the hydromorphology (i.e., physical characteristics), and biological quality of waterbodies within the National Park are key limiting factors.

The analysis presented here also highlights that every loch waterbody within the National Park recorded an overall status of 'Moderate' or higher in 2020, with all occurrences of 'Poor' or 'Bad' overall waterbody status found in riverine waterbodies. This may suggest an opportunity to prioritise restoration of river habitats,

SEPA condition data has been used due to the broad range of parameters considered in waterbody assessment and both the spatial and temporal completeness of the data. However, it is worth noting here that this is only a single framework for assessing and understanding water quality.

References

[1] Scottish Environmental Protection Agency, 2023, *SEPA Data Publication: River and loch classifications*.

[2] Scottish Environmental Protection Agency, 2023, *Water Classification Hub: Fish Barrier status*.

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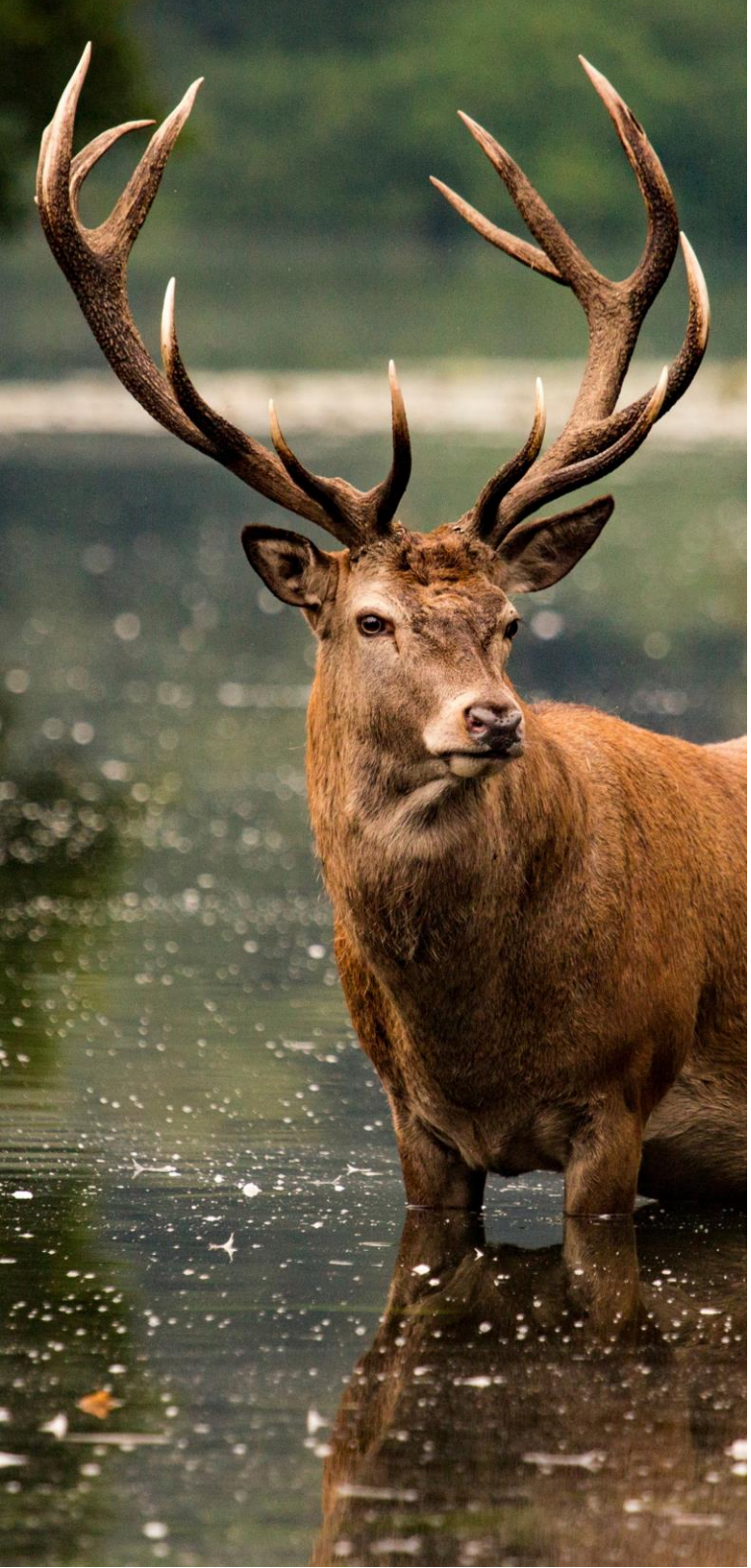


Herbivores

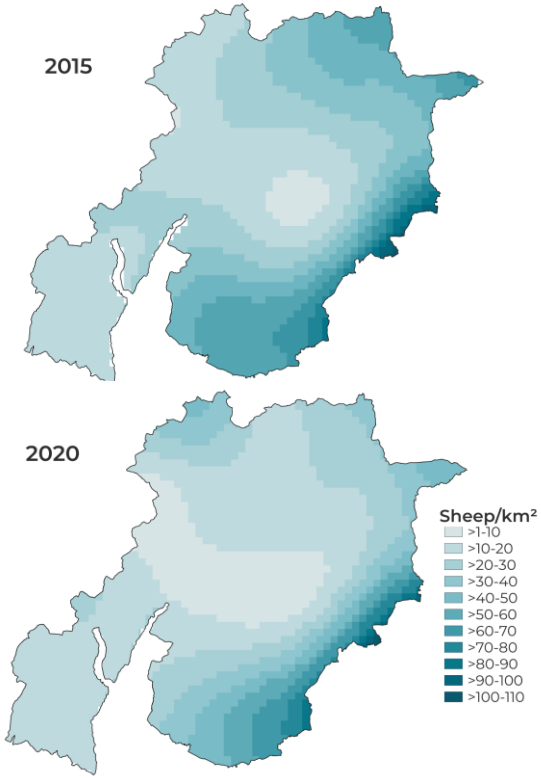
The most widespread pressure to the condition of native woodlands is excessive herbivore impact. Herbivores, namely sheep and deer are widespread across the National Park and are an integral part of the area's cultural and natural heritage. However, in some areas there are unsustainable levels of grazing pressure which can lead to the loss of ground flora species, simplified woodland structure without shrubs or climbing species, reduced tree cover, and soil erosion. By monitoring herbivore densities and impacts, and implementing appropriate management strategies, reduced pressure in some areas will allow for the widespread natural recovery and expansion of native woodlands, as well as protecting fragile peat soils.

Here we look at deer and sheep density estimates (per km^2) across the National Park over time using APHA Sheep and Goat inventory data and NatureScot deer census data.[1] We also use the Native Woodland Survey of Scotland (NWSS 2014) and Scotland Natural Heritage (SNH) [2] and upland habitat impact assessment (HIA)[3] data to assess the levels and distribution of herbivore impact.

Sheep

The distribution density of sheep in the National Park reduced over the five-year period, from an average winter sheep density of 30 sheep/km^2 in 2015 to 24 sheep/km^2 in 2020. This is compared to an average of 48 sheep/km^2 across Scotland in 2020 (APHA).

Distribution and density of sheep across the National Park in 2015 and 2020
(LDDG, APHA))



Deer

Deer populations in the National Park are monitored and managed by NatureScot and monitored/managed sustainably through local Deer Management Groups, with objectives seeking a mosaic of deer densities allowing different deer management objectives. Standardised data collection methods by NatureScot provide a snapshot of populations in key areas across the National Park. Area specific surveys by deer management groups show

Glenartney has a much higher average deer density but in most areas the number of deer has remained stable over time. For comparison, the national estimated mean deer density on open-hill ground in the Highlands and Islands was 9.35 deer per km^2 in 2019.

Average red deer density from survey areas each year in the National Park

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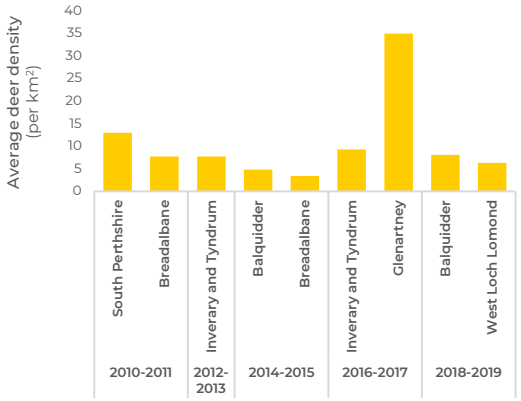
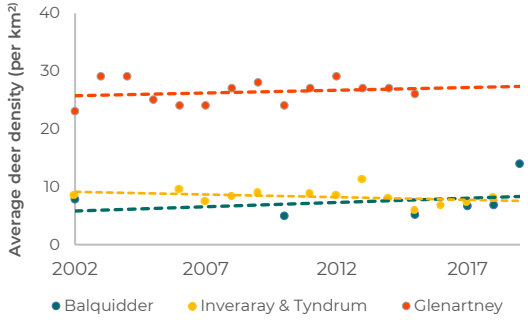


Average red deer density in 3 key areas

Densities estimated from deer management groups (2002 - 2019)

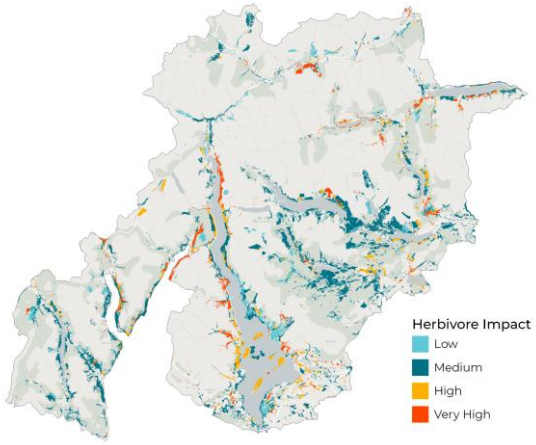


Herbivore Impact

Woodland

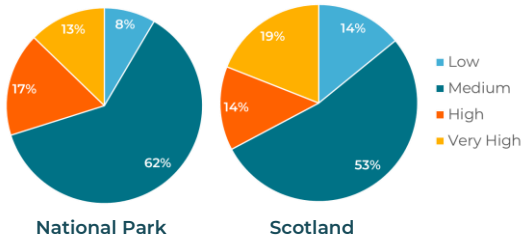
The most widespread threat to the condition of native woods is excessive herbivore impact, largely due to deer. The Native Woodland Survey of Scotland (NWSS, 2014) data on herbivore impact was assessed to indicate the levels and distribution of herbivore impact on native and nearly-native woodland. The overall impact of herbivores on woodland is based on visual estimates of the extent of browsing, bark stripping/fraying on trees and shrubs, the extent of any visible ground disturbance caused by herbivores and an assessment of the canopy fragmentation. This is on a scale of 'low' impact to 'very high' impact, with a low or medium level of herbivore impact required for sustainable woodland ecosystems and a low level of impact necessary for natural regeneration. These data are likely out-of-date; however it provides an insight into the areas in the National Park that have had pressure from high herbivore impact or might be less likely to naturally regenerate.

Levels and distribution of herbivore impact on a woodland (NWSS, 2014)



Only 8% of the native and nearly-native woodland assessed in the National Park was in the 'Low' impact category. At low, natural grazing densities, wild herbivores play an integral functional role in ecosystem processes such as enhancing carbon capture and storage, so this is the ideal level for optimum long-term woodland condition. Overall, 30% if the of the National Park could be at unsustainable levels of grazing (High and Very High impact), which is a similar level to the rest of Scotland at 33%. Research suggests that unfenced native woodlands can naturally regenerate if deer densities are below the threshold of 4-5 large deer or 25 roe deer per km^2. [4]

Levels of herbivore impact for native and nearly-native woodland in the National Park compared to Scotland (NWSS 2014)



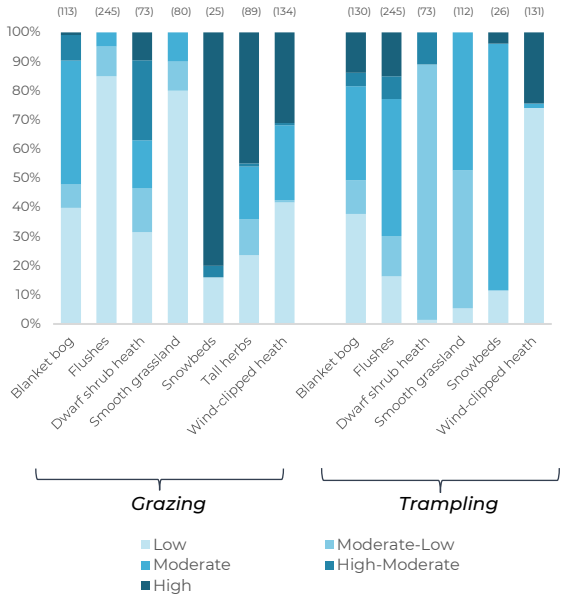
Upland

The National Park's mountains and moorlands are largely managed for hill sheep and cattle grazing, as well as habitats for deer. Habitats include blanket bog, upland heathland, upland flushes, montane heaths and calcareous grassland which support a wide range of priority species.

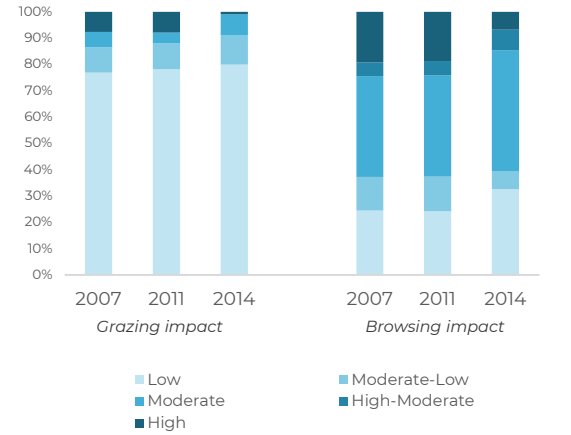
Here, we assess the Scottish Natural Heritage HIA surveys for the National Park from 2006 until 2014. This data provides a snapshot of the impacts of sheep and deer grazing in the upland habitats of the National Park. The data shows that snow-beds, tall-herbs and wind-clipped heath are most susceptible to high impacts of herbivore

grazing and wind-clipped heath the most susceptible to high levels of trampling.

Herbivore grazing and trampling impacts for upland protected areas
Data collected 2006-2014



Three key habitats (flushes, tall herbs and wind-clipped heath) had impact assessments repeated over a seven year period (in years 2007, 2011 and 2014). These repeated surveys show that grazing impact in these habitats reduced gradually over this time period which could be reflective of the reduced sheep grazing and deer management in the National Park (figure to the right). The National Park is working closely with local land managers and Deer Management Groups in the National Park, to improve the condition of designated sites by increasing pressure on herbivore numbers, which in turn is reducing pressure on upland habitats.



Key Findings and Conclusions

1. Sheep grazing density reduced by 6 sheep per km2 between 2015 and 2020.
2. Deer population densities in most areas of the National Park are relatively stable due to ongoing management.
3. Deer densities in some areas of the National Park are likely too high for sustainable woodland ecosystems. Grazing impact on woodland in National Park compared to Scotland is similar, with 30% and 33% of woodland experiencing unsustainable levels of herbivore impact, respectively.
4. Of the upland habitats assessed, snowbeds were most highly impacted by sheep and deer grazing, while wind-clipped heath is most highly impacted by trampling.

The significance of large herbivore grazing for biodiversity is widely acknowledged, yet there remains a contentious debate surrounding the appropriate densities of wild large herbivores and the natural levels of grazing and browsing intensity. The state of herbivores in Loch Lomond and The Trossachs National Park reflects the broader context of historical losses and intense pressure experienced by large herbivore populations. Compared to the historic landscapes, current ecosystems exhibit dramatically simplified faunas due to the massive historical losses of large herbivores.

While sheep densities have shown a decrease between 2015 and 2020, and deer populations are managed and maintained at relatively stable levels within the park, determining the natural levels of large herbivore biomass is challenging due to shifting baselines and the influence of cultural perspectives on wildlife management decisions.

In Mesolithic Britain, the estimated large herbivore biomass was around 4000kg/km^2. However, it is crucial to note that the distribution of herbivores in the past was heavily influenced by the presence of predators, which played a role in preventing overgrazing and determining the extent of woodland areas. In the absence of predators in the modern UK landscape, unfenced native woodlands appear to regenerate naturally if there are fewer than 4-5 large deer or fewer than 25 roe deer per km^2. However, when deer and livestock populations exceed these thresholds, overgrazing can lead to habitat degradation and impede the restoration of native vegetation. This impact is evident and remains a threat in certain areas of the park where the level of herbivore impact on woodland, and other habitats, is high.

Achieving a balance in deer population and implementing effective deer management strategies, such as culling or reintroducing the “landscape of fear” concept, are contentious issues that elicit varying opinions among stakeholders. These decisions are crucial for mitigating overgrazing and promoting the regeneration of native vegetation in the National Park.

It is important to note that the most recent assessment of herbivore impact on woodlands and uplands within the national park dates back to 2014. Consequently, there is a potential for changes in herbivore impact over the past

eight years. Without up-to-date impact data, herbivore densities can be used as a proxy indicator for gauging vegetation pressure and the potential for natural regeneration. While this approach provides some insights, it is imperative to conduct more recent assessments to ensure accurate and comprehensive understanding of the current state of herbivore impact in the National Park.

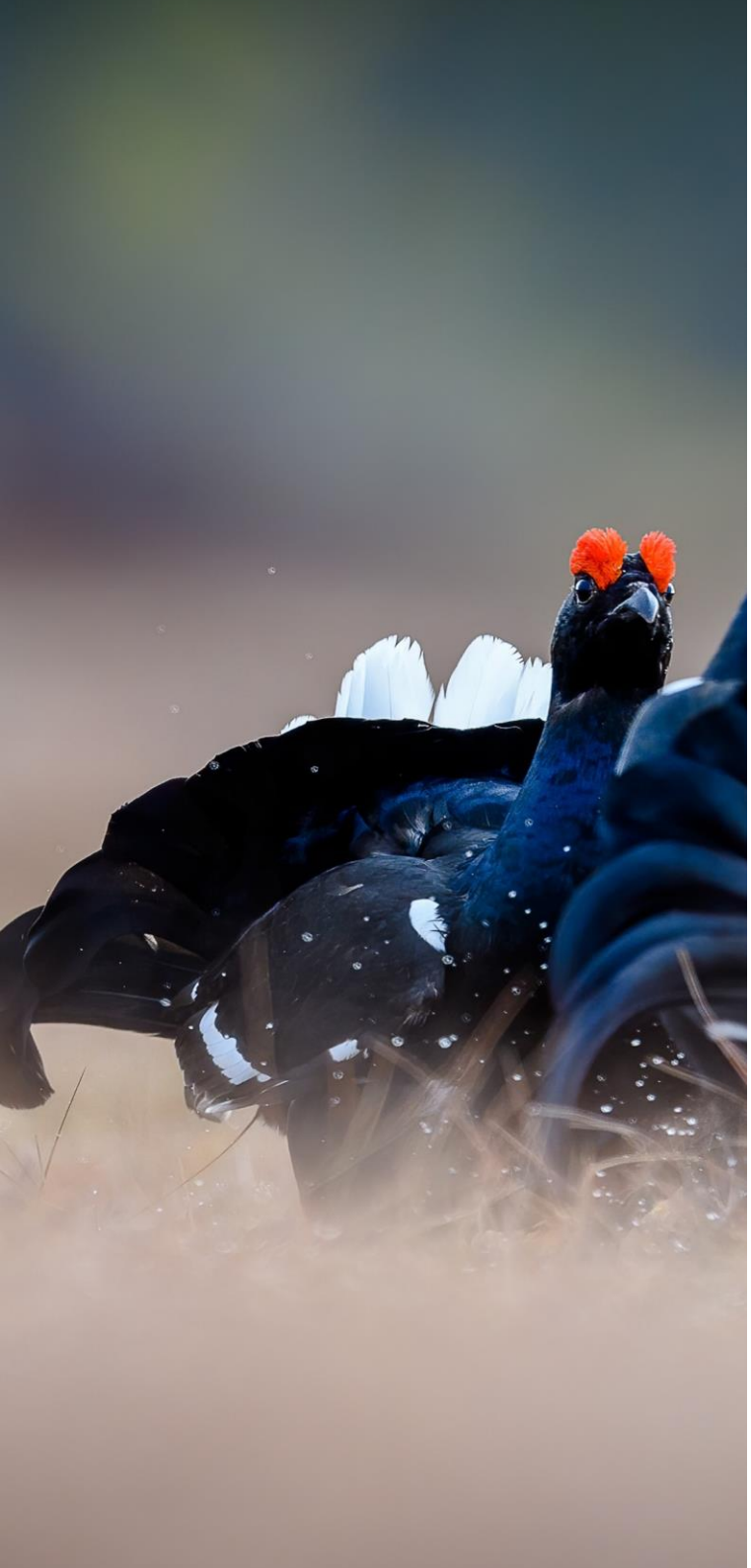
References

[1] Livestock Demographic Data Group (LDDG/APHA), *Sheep population and holding density raster (2015 & 2020)* NatureScot Deer Census, 2022. Red Deer Count Information

[2] Scottish Forestry, 2014. *Native Woodland Survey of Scotland*.

[3] NatureScot, 2018. *Upland Habitat Impact Assessment surveys*

[4] Watson et al., 2009. *A review of the threshold densities for which wild deer in England above which negative impacts may occur.* Deer Initiative Research Report.



Important Species

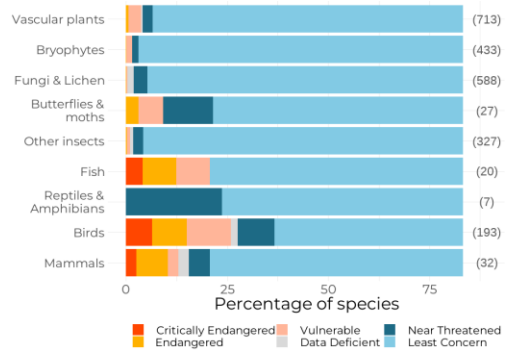
The National Park is home to a huge variety of important species that play vital roles in ecosystem functions and processes. Some of the most notable species in the park include the Scottish wildcat, red squirrel, beaver, golden eagle, osprey, and otter. These species are not only important for their ecological value but also have cultural significance in Scotland. Certain species found within the park are considered rare and threatened, underscoring the need for urgent conservation measures to safeguard their persistence. These species furthermore serve as valuable bioindicators of the park's health and the efficacy of conservation initiatives in the region. Consequently, the preservation and protection of the diverse assemblage of species in National Park is essential to maintain the integrity of this unique region.

IUCN Red List Assessment

Here we break down the IUCN GB Red List assessments for species recorded in the National Park for the species groups which have been assessed against the GB Red list by JNCC. Each taxonomic group has been categorised by the proportion of species in each IUCN red list category. The GB Red lists provides a more nuanced understanding (compared to the IUCN Global red list) of the conservation status of species in Great Britain and captures variations in the distribution and abundance of species.

While this data provides valuable insights, it is important to consider that it may not fully represent the conservation status of all species in the National Park. The recorded observations might be biased towards more common species, and rarer species may be underrepresented. Therefore, the actual proportion of threatened species might be higher than indicated. Nevertheless, the 2340 species assessed using the GB red list provides a valuable snapshot of the conservation status of the species in the park and a representative benchmark for future comparison.

Great Britain Red List Assessment (JNCC) by Taxonomic Group for Species Recorded within the National Park
(NBN Atlas, 2000-2023)



Threatened species = (CR + EN +VU) / total number assessed – DD

Of the 2340 species recorded and assessed within the National Park with sufficient data available, 120 (5.2%) are formally classified as threatened and therefore at risk of extinction from Great Britain.

Otter, small heath butterfly, Scotch Argus butterfly, white-fronted goose and black grouse are examples of species threatened in Scotland and are occupants of the National Park.

By implementing effective nature recovery measures, the National Park can play a key role in helping improve the conservation status of threatened species and prevent further declines.

Bird & Butterfly Abundance

Indices of abundance are vital for monitoring the population status of a species group and measuring responses to changes in climate and land-use.

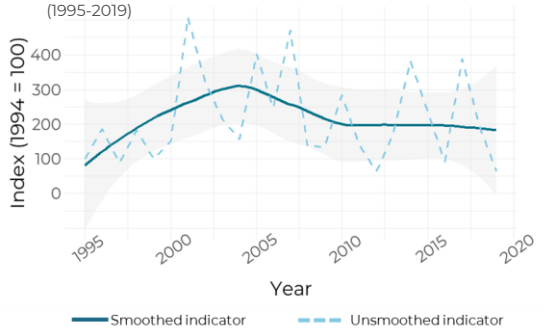
Birds

Here, we combined the abundance trends for 90 breeding bird species in the National Park. We used the BTO/JNCC/RSPB Breeding Bird annual survey data (an established long-term monitoring scheme)[1] and methods similar to NatureScot, to calculate the geometric mean species' relative abundance indices. Overall, since 1995 the abundance indicator has been broadly stable between 1995 and 2020.

It's important to note, that due to relatively small spatial scale and sampling effort, the trend could be biased by more abundant common species and potentially limit resolution and reliability of species trends. Due to the small sample size, the confidence intervals are wide for most species.

Species which have shown strong inclines in the National Park in recent years include black cap and chiffchaff. The swift however has showed a slight decline. These trends are in correlation with Scotland-wide trends (BTO). In Scotland, meadow pipit, chaffinch and oystercatcher populations have shown a slight decline in abundance since 1995, however in the National Park, numbers have shown a slight increase.

Trends in overall abundance for breeding birds in the National Park.
(1995-2019)



Butterflies

The UK Butterfly Monitoring Scheme (UKBMS) has carried out count surveys across the National Park, with three main long-term monitoring sites. (i) Glen Ogle (2008-2011) (ii) Aberfoyle (2009 – 2013) and (iii) Cashel (1998-2007) (NGN Atlas).[2]

In Glen Ogle, 14 species were recorded with dark green fritillary, green veined white, ringlet and small pearl bordered fritillary being the most abundant species. In Aberfoyle, 13 species were recorded with ringlet, peacock, green-veined white and orange tip as the most abundant. And in Cashel, 19 species were recorded: a stronghold for small pearl bordered fritillary, small heath, and meadow brown.

Status of Priority Species

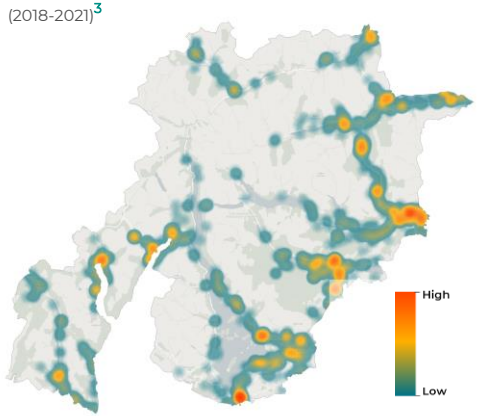
The National Park prioritises the maintenance of healthy ecosystems and biodiversity, while also focusing targeted efforts towards the conservation of key species facing declining populations or at risk. Four key 'flagship' species have been indentified by the National Park that can gauge the health and are representative of threatened habitats in the park.

- Red Squirrel (woodland)
- Black Grouse (upland)
- Brown Trout (freshwater)
- Gannet (marine)

Red Squirrel

Protecting and recovering the red squirrel population is a priority for the National Park. Red squirrels are sensitive to habitat fragmentation and disturbance, making them excellent indicators of the health and connectivity of woodland habitats. Unfortunately, in recent decades, the red squirrel population in the UK has been threatened by the introduction of the non-native grey squirrel, which competes with the red squirrel for resources and also carries a virus lethal to red squirrels. The National Park woodland areas area an important stronghold area for the red squirrel.

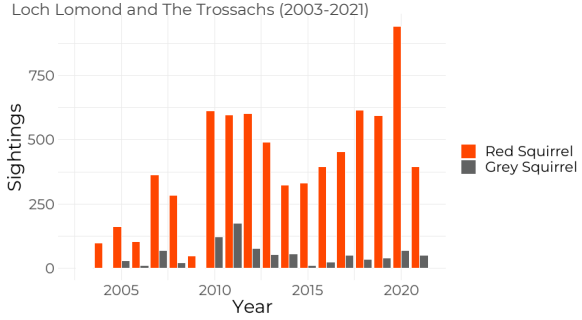
Red squirrel distribution density
(2018-2021)[3]



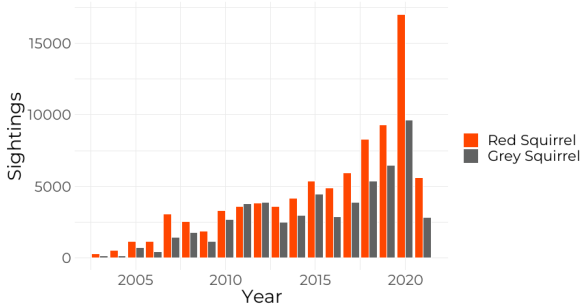
There are ongoing conservation efforts, such as the Saving Scotland's Red Squirrels project, which aims to protect and increase the red squirrel population in Scotland by controlling the spread of grey squirrels and improving woodland management practices to enhance the quality and extent of red squirrel habitat. As well as the increasing pine marten population, the National Park is now almost a red only zone and has seen an increase in red squirrel sightings in the Scottish Squirrel Database over recent years. This is reflected in a much higher ratio of red to grey squirrels in the National Park compared to Scotland (figures on following page).

While the conservation efforts in the National Park have shown encouraging results for red squirrel populations, it is important to consider the limitations of the data used, which relies on the 'Scottish Squirrel Database', a citizen science initiative. While citizen science data provides extensive coverage, it may be subject to biases and variations in sampling effort. Therefore, interpreting the findings with caution is advised highlighting the need for more robust and standardised monitoring approaches.

Sightings of Red and Grey squirrels
Loch Lomond and The Trossachs (2003-2021)



Sightings of Red and Grey squirrels
Scotland (2003-2021)



Black Grouse

Black grouse are a priority species for the National Park and considered an indicator of the health and diversity of upland heathland ecosystems, which are home to many other species. The black grouse population in Scotland and globally has been in decline for decades due to habitat loss, overgrazing leading to loss of key plant foods (heather, bilberry, birch scrub), fragmentation, drainage of mores and predation. The black grouse is now classified as a UK red-listed species, with an estimated population of around 4800 breeding pairs (RSPB).

In Loch Lomond & the Trossachs National Park, black grouse populations have also declined over the years. However, several projects have been implemented to aid in habitat and population recovery. Data were collected to monitor population levels in the Argyll and Bute area as part of the Black Grouse Recovery project between 2002 and 2011 to prioritise areas for black grouse conservation. The survey work showed that black grouse numbers were at a critical level and required urgent conservation action.

Black grouse recorded in the National Park compared to across Argyll and Bute
Maximum number of hens and males attending leks recorded by the Argyll and Bute black grouse recovery project, 2003 – 2011 [5]

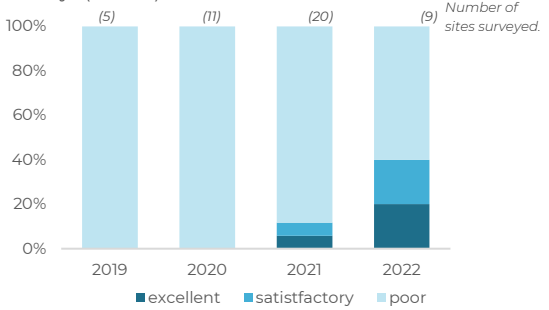
In 2012, the Loch Lomond and Trossachs National Park Authority initiated a collaborative project with six farms and estates, covering an area of 8,000 hectares from Callander to Loch Earn, aimed at conserving and increasing the black grouse population in the area. The project was funded with a £720k grant from the Scottish Rural Development Programme, and implemented native woodland creation, moorland management and changed hill grazing to promote heather regeneration, and targeted predator control. This project is being monitored by the RSPB. In 2018, eight males were recorded, 2019 only two males were recorded but at the end of 2020, 29 black grouse were spotted on Drumardoch Estate. Despite this recent positive progress on Drumadoch Estate, the lack of spatially and temporally consistent data collection makes it challenging

to accuratley evaluate the braoder trends and impacts of the conservation efforts on black the National Park's black grouse populations.

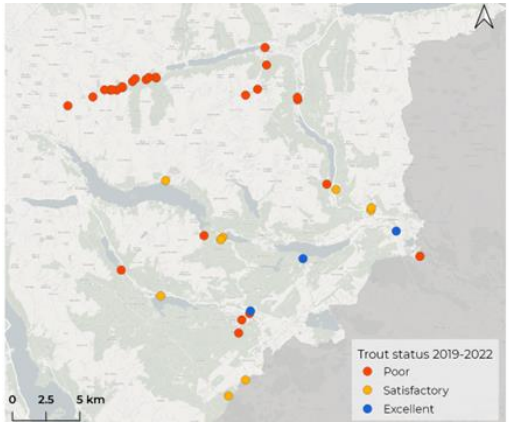
Brown Trout

Brown trout are a UK BAP priority species which live in fast-flowing, stony and gravelly river and lakes. It is a predatory species which feeds on insect larvae and small fish, as well as insects indicative of high water-quality such as mayflies and damselflies. This, and species' sensitivity to low oxygenation make its presence a useful indicator of high water-quality. The species is also economically important within the park bringing in tourists who come to fish for brown trout. It is present in many of the lochs and rivers within the park, such as Loch Katrine which is well known for its large brown trout. Due to its reliance on cold water habitats to survive, climate change is a particular threat to the species and the cool rivers and lochs of Scotland are likely to form an important refuge for this species. Data from the National Park's last four seasons of electrofishing show that only three out of the 45 sites are classified as 'excellent' status for trout. However, the electrofishing surveys in 2021 and 2022 identified satisfactory and excellent trout status locations, as opposed to only poor status identified in 2019 and 2020.

Status of trout populations
Based on trout density from electrofishing surveys (LLNPA)



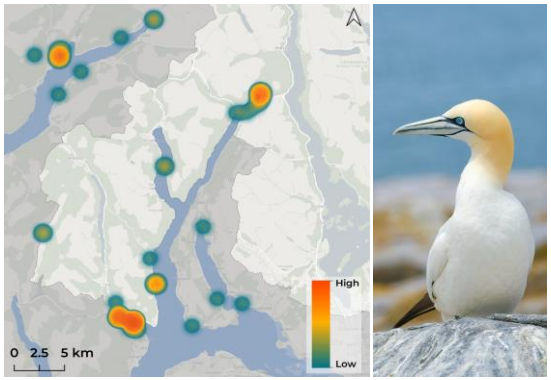
Status distribution of trout populations
Based on trout density from LLTNP electrofishing, 2019-2022 [6]



Gannet

One of Britain's largest seabirds, Gannets are top predators in marine ecosystems and excellent indicators of the health of our seas. This species is classified as 'amber' under the Fifth Birds of Conservation Concern in the United Kingdom due to its international importance as a breeding site for this species. In fact, Scotland is home to around 60% of Europe's gannets and from February onwards they return to key breeding sites around the coast and feeding grounds in the Lochs around Argyll (Holy Loch and Ardgarten). Hotspots for citizen science gannet sightings indicate marine ecosystem health and productivity in these areas. However, without consistent surveys, it becomes challenging to ascertain population size and overall significance of gannet

Sightings of gannets in and around the National Park
(eBird, 2016 - 2022)



Drivers of Change

The changes in abundance and occupancy of terrestrial species in the National Park have been caused by a wide range of drivers of change acting on species' populations and the environments they live in. It is important to consider shifting baselines when assessing these changes, as our perception of what is considered "normal" or "natural" can shift over time due to lack of historic knowledge, potentially leading to underestimations of the ecological changes that have occurred.

Land-use Change

Changes in land use in the past few generations, particularly for agriculture, forestry, and urbanisation, have a significant impact on the environment. This can result in the loss and fragmentation of habitats, leading to a negative impact on animal populations.

Climate Change

Climate change can alter habitat conditions and affect the timing of seasonal events such as breeding, migration, and hibernation, which can in turn affect animal populations. In the National Park. For example, the cold-associated pearl-

bordered fritillary butterfly (UK BAP priority species) was rediscovered around Loch Katrine and relies on violets as a host plant for its larvae. However, changes in temperature and rainfall patterns can affect the timing of the emergence of violets in the National Park, which can negatively impact the survival and reproduction of the species.

Invasive Species

Invasive non-native species are a threat to the National Park's biodiversity as they can outcompete native species for resources and space. The National Park is taking measures to concentrate on the control of grey squirrel and North American mink, which has beneficial impacts on the red squirrel and water vole.

Water Quality

Water quality is a critical factor that affects the health and well-being of various species in the park. High levels of pollutants, such as agricultural runoff, sewage, and industrial waste, can harm aquatic life, including salmon and trout populations. In addition, poor water quality can negatively impact the habitat and food sources of water voles, which are highly sensitive to changes in their environment.

The recent translocation of beavers to Loch Lomond will bring a wide range of benefits for biodiversity in the nature reserve and the wider National Park from creating ponds and wetlands where other species can thrive, to helping natural floodplain functioning and improving water quality.

Key Findings and Conclusions

1. Overall breeding bird abundance trends from 1995 until 2019 indicate stability but data limitations and biases should be considered.
2. The butterfly monitoring scheme has recorded a total of 21 butterfly species, but more recent survey data is needed to assess population trends of these species.
3. The red squirrel population is threatened by competition with the non-native grey squirrel, but conservation efforts, such as the Saving Scotland's Red Squirrels project, have shown positive results in the National Park.
4. Black grouse populations have declined, but collaborative projects and habitat management initiatives have been implemented to aid in population recovery.
5. Recent electrofishing surveys of brown trout have shown improvements in trout status in some locations, but continued monitoring is needed to see long term change.
6. There are several gannet hotspots around the National Park lochs indicating marine ecosystem health, but data gaps make it difficult to gauge long term population trends.

Loch Lomond an the Trossachs National Park is home to a huge variety of important species that play vital roles in ecosystem functions and processes. These species are not only important for their ecological value but also have cultural significance in Scotland. Certain species found within the park are assessed as rare and threatened in GB, underscoring the need for urgent conservation measures to aid population recovery. While the provided species analysis does highlight some positive aspects of key species in the National Park, reflective of ongoing conservation initiatives in the park, it is important to consider the concept of 'shifting baseline syndrome'. This poses a challenge, due to the tendency of individuals to normalise current species abundance and diversity and underestimate historical declines or changes in ecosystems.

Despite this, ongoing monitoring programs and targeted conservation initiatives, such as those focused on red squirrels and black grouse, are demonstrating positive outcomes. Nevertheless, there is still work to be done. By continuing to address the drivers of change, including land-use alterations, climate impacts, invasive species, and water quality, the National Park can continue to protect and restore habitats and species, ensuring their persistence and contributing to the overall health of the park's ecosystems.

Addressing data limitations is also crucial for a comprehensive understanding of the ecological dynamics of the park. A notable limitation is the spatial and temporal coverage of some data feeds. Some species data (such as the BTO bird data) is limited due to a small number of BTO squares relative to the park's size. And species data provided by the National Park only cover observations up until 2011, which may not capture the effects of more recent conservation initiatives. For future state of nature assessments, it will be important to address data limitations to ensure a more accurate reflection of the park's ecological changes.

References

[1] JNCC, 2023, *Conservation Designations for UK taxa*

[2] BTO/JNCC/RSPB partnership, 2023, *records accessed through NBN Atlas website*

[3] UK Butterfly Monitoring Scheme (UKBMS). *Records accessed through NBN Atlas website*

[4] Scottish Wildlife Trust, 2023. *The Scottish Squirrel Database. Occurrence dataset accessed through the NBNAtlas*

[5] RSPB, SNH, FCS, 2011, *Black grouse annual lek surveys in Argyll & Bute. Records accessed through NBN Atlas website*

[6] LLTNPA, 2019-2022, *brown trout status*

Invasive and Non-Native Species

An alien species is a type of organism that exists beyond its typical historical or current range, and its presence and expansion pose a threat to ecosystems. Within the National Park, there are various invasive non-native species (INNS), including those that affect riparian and aquatic environments, which can have a significant negative impact on the ecology, environment, and economy. Some examples of these INNS within the National Park are Japanese knotweed, Himalayan balsam, and rhododendron.

Here, the National Park's INNS monitored sites data is applied to understand the status of terrestrial INNS. This is supplemented with SEPA monitoring data, which classifies waterbodies based on their alien species status. Subsequently, the following interpretation is divided between both terrestrial and aquatic INNS data.

Terrestrial INNS

Invasive and non-native species (INNS) monitoring data supplied by the National Park Authority was assessed to indicate trends for monitored INNS. This data is collected by the National Park Authority and describes terrestrial INNS. Records in the monitoring data were firstly grouped, by site, species, and monitoring status. Next, records with no species name or status recorded were removed.

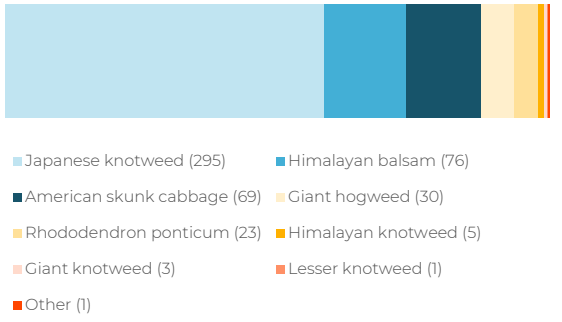
To understand key INNS of concern in the National Park, each species within the INNS monitoring data was extracted and the count of sites where each of these species is monitored calculated. This indicates that Japanese knotweed is the most commonly occurring INNS at monitored sites (295 occurrences), followed by Himalayan balsam (76 occurrences) and American skunk cabbage (69 occurrences).

Remaining records were then plotted (overleaf) to show the proportion of sites which fall into each status class, by species. This indicates that (i) giant hogweed, (ii) giant knotweed, (iii) Himalayan balsam, or (iv) Japanese knotweed populations are increasing at some monitored sites.

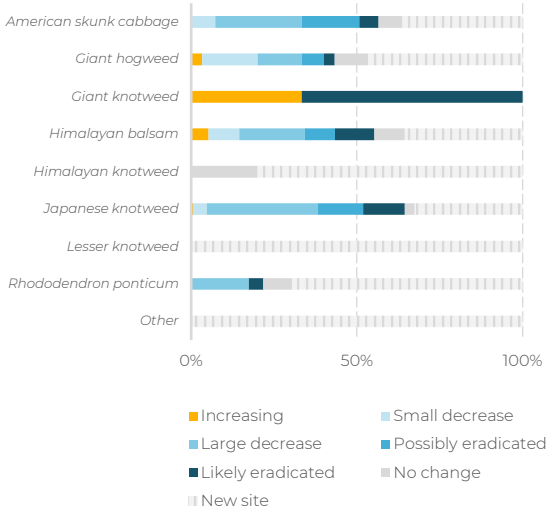
However, it should be noted that for each of these four species, a much larger proportion of monitored sites have recorded a decline in these species. In addition, Giant knotweed is likely to have been eradicated from the two out of the three sites where it is monitored.

All INNS observed at monitored sites, except for Giant knotweed, have a large proportion of new sites where the species are being monitored. This may reflect either an increasing abundance of the species, and/or an increase in monitoring and control effort undertaken by the National Park Authority. Rhododendron, in particular, records the largest proportion of new monitoring sites, of all species with a presence at more than 20 monitored sites.

Count of Monitored Sites by INNS
Loch Lomond and the Trossachs National Park



INNS Status at Monitored Sites
Loch Lomond and the Trossachs National Park

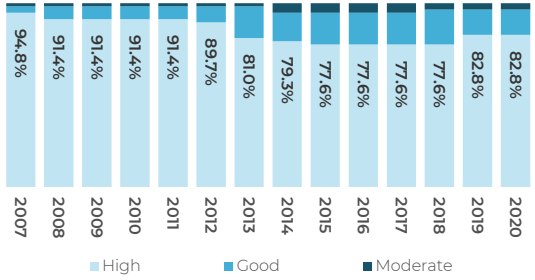


Aquatic INNS

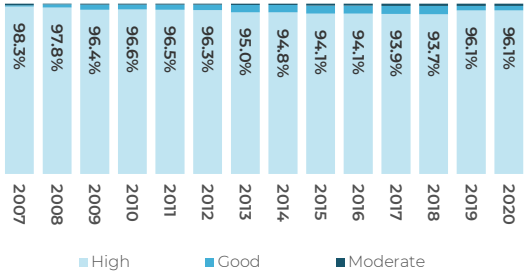
SEPA Alien Species annual water body condition class data (available from 2007 – 2020) was applied to supplement the National Park Authority's terrestrial INNS data. To achieve this, polygon areas of loch and river water bodies represented within SEPA's condition assessments were obtained from SEPA's *Environmental Data publication* platform[1], and a list of water bodies located within the National Park extracted from this data. Table data containing Alien Species condition for each water body monitored by SEPA was then retrieved from the SEPA Water Classification Hub[2].

The list of water bodies located within the National Park was then used to identify the alien species condition (as assessed by SEPA) of water bodies in (a) Scotland, and (b) the Loch Lomond and the Trossachs National Park.

Water Bodies by Proportion in Each Alien Species Condition Class:
Loch Lomond and The Trossachs (2007 - 2020)



Water Bodies by Proportion in Each Alien Species Condition Class:
Scotland (2007 - 2020)



Data source: Scottish Environmental Protection Agency, 2023, *Water Classification Hub: Alien species status.*

Review of this data at the Scotland-wide and National Park scales indicates that alien species condition of monitored loch and river water bodies within the National Park generally follows historic trends recorded throughout wider Scotland. The proportion of river and loch water bodies classed as being 'high' condition within the National Park is, however, lower than the Scotland-wide proportion. This may reflect the relative proximity of the National Park to Scotland's major population centres.

Notably, in 2007, nationally, 98.3 % of river and loch water bodies were classed as 'High' condition for alien species, with this value being 94.8 % for water bodies within the National Park. Following a period of decline between 2011 and 2014 – particularly acute in the National Park – the proportion of water bodies classed as 'High' recovered to 96.1 % nationally by 2020, whereas in the National Park the 2020 value is 82.8 %.

Key Findings and Conclusions

1. Japanese knotweed is the most commonly occurring INNS in the park's terrestrial habitats, being found at 259 monitored sites. Himalayan balsam and American skunk cabbage are also significant INNS.
2. 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%.
3. Of the most frequently occurring INNS, rhododendron has the greatest proportion of new monitoring sites, indicating it is of increasing concern within the National Park.

Terrestrial INNS are recorded at NPA-monitored sites, INNS show generally declining trends. Japanese knotweed was identified as the most prolific INNS at these monitored sites. Himalayan balsam and American skunk cabbage are also significant INNS within these monitored sites. However, amongst newly monitored sites, rhododendron is present.

These monitored sites represent a small proportion the overall National Park. This highlights a data gap with regards to INNS – in particular terrestrial INNS – outside of these monitored sites. However, developments in data are being made which may enable this to be assessed. For example, the Environmental Information Data Centre have recently published rhododendron habitat suitability data for Scotland (Environmental Information Data Centre, 2023).[3]

Aquatic INNS throughout the National Park and Scotland are monitored by SEPA. Comparison between the alien species status of waterbodies between the National Park and Scotland indicates that waterbodies within the National

Park experience a lower alien species status than waterbodies throughout Scotland. However, the proportion of waterbodies classed as having a 'high' alien species status has increased from 2015 to 2020. This suggests that aquatic INNS exert a more acute pressure on the National Park's water networks than is the case nationally, though recent interventions may be having a positive impact.

References

[1] Scottish Environmental Protection Agency, 2023, *SEPA Data Publication: River and loch classifications.*

[2] Scottish Environmental Protection Agency, 2023, *Water Classification Hub: Alien species status.*

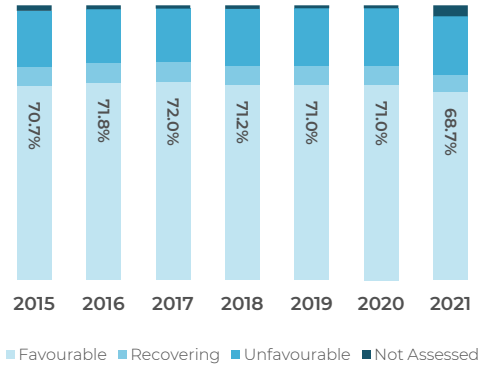
[3] Environmental Information Data Centre, 2023. *Habitat suitability maps for Rhododendron ponticum across Scotland as reservoir host for Phytophthora*.

Important Sites

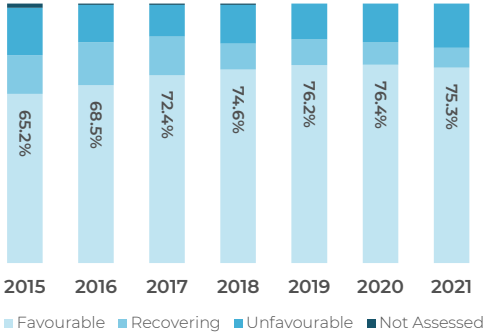
Within the National Park, specific regions are classified as having significant conservation importance due to the presence of rare species and distinctive habitats. These areas act as crucial ecological "stepping stones," preserving source populations that can spread to neighbouring lands. The condition of important sites can serve as indicators of wider ecological health and biodiversity trends in the surrounding landscape.

Here, we apply Scottish Natural Heritage (SNH) data – accessed via the Scottish Environment Protection Agency (SEPA) Protected Nature Sites portal to assess the condition of designated sites within the National Park. Comparisons of designated sites by condition status each year from 2015 to 2021 at both the Scotland, and National Park scales are also given (*below* and *right*).

Designated Sites by Proportion in Each Condition Class:
Scotland (2015 - 2021)



Designated Sites by Proportion in Each Condition Class:
Loch Lomond and The Trossachs (2015 - 2021)



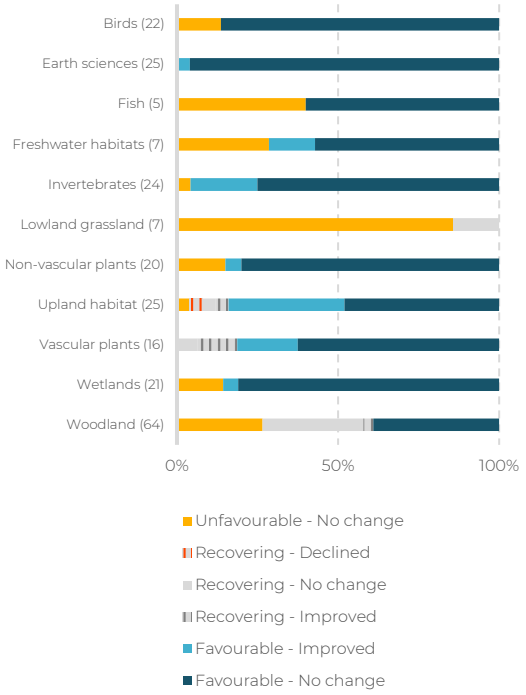
Data source: Scottish Environmental Protection Agency, 2022. Protected Nature Sites: Overall condition.

This indicates that designated sites classed as 'Favourable' condition across Scotland have remained consistently between 68 % to 72 % of the total from 2015 to 2021. In comparison, designated sites classed as 'Favourable' condition across Loch Lomond and the Trossachs National Park increased steadily from 2015 to 2020. Though a slight decline in this value was observed from 2020 to 2021, it has moved from being 5.5 % behind the Scotland-wide value in 2015, to being consistently above 5 % between 2019 to 2021. The decline in sites with favourable condition observed between 2020 and 2021 within the National Park, was also reflected in the Scotland-wide data.

To explore trends in designated site condition within the National Park further, SEPA SSSI feature condition status was retrieved from the SEPA *Protected Nature Sites* hub and joined to SSSI extent GIS data available from *data.gov.uk* [1]. This allowed a list of SSSIs which intersect the National Park to be extracted and reviewed here. A breakdown of SSSI feature designation types by their condition within the National Park is shown *overleaf*.

This highlights that upland habitat feature designations have recorded the largest proportion of features which have improved to a favourable condition from 2015 to 2021. Similarly, earth sciences were all recorded as being in 'favourable' condition between 2015 and 2021. While vascular plants feature designations have recorded no features in unfavourable condition in both 2015 and 2021.

SSSI Status by Feature Designation Type
Loch Lomond and the Trossachs National Park



Data source: Scottish Environmental Protection Agency, 2022. Protected Nature Sites: Overall condition.

Features designated for lowland grassland hold the highest proportion of features in a condition assessed as unfavourable, with over 80 % being recorded as being in an unfavourable condition in both 2015 and 2021.

Key Findings and Conclusions

1. The percentage of designated sites in 'favourable' condition in the park increased between 2015 and 2021 and is now above the national average.
2. When considering the Park's SSSIs, the greatest improvement in condition was observed for upland habitat features.
3. Lowland grassland had the highest proportion of features in unfavourable condition while no earth science or vascular plant features were classified as 'unfavourable'.

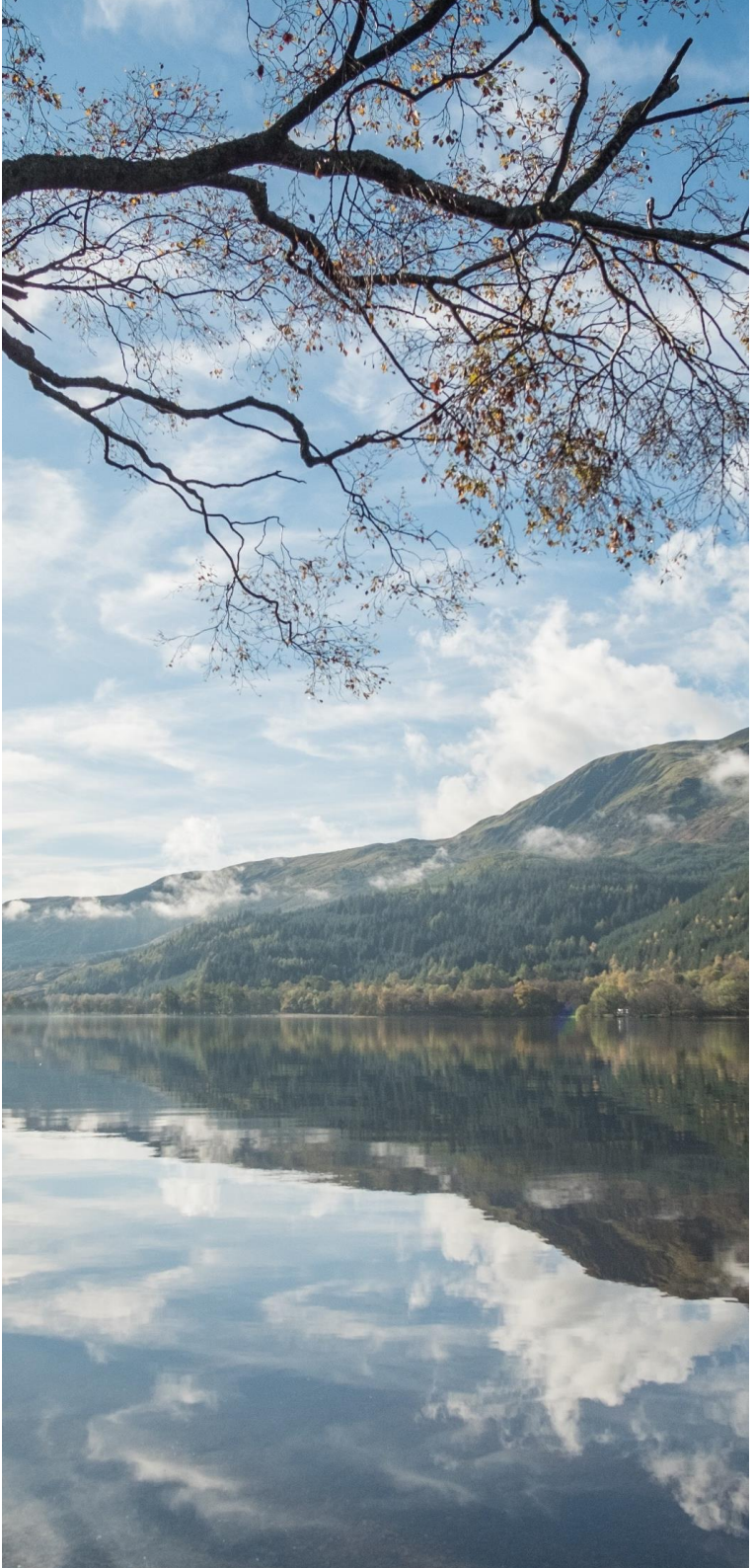
Reviewing the condition status of designated sites across Scotland illustrates positive long-term trends within the National Park. In the period 2015 to 2021, the proportion of designated sites in a favourable condition throughout Scotland remained relatively constant at around 70 %. In contrast the value for this figure was 65 % in 2015, increasing to 75 % in 2021. This shows illustrates an increase in condition of these important sites from below the national average in 2015 to exceeding the national average in 2021. This increase has occurred despite a decline in the average national condition of these designated sites.

Future State of Nature assessments may wish to consider additional sites beyond those designated as important sites by legislation (e.g., SSSIs).

References

[1] NatureScot, 2023. *Sites of Special Scientific Interest (Scotland).*

[2] Scottish Environmental Protection Agency, 2022. *Protected Nature Sites: Overall condition.*



Conclusion

This report has presented a range of datasets and analyses designed to assess the State of Nature within the National Park. These have been applied to a series of dimensions identified as being core elements of the National Park's natural environment. To contextualise and situate indicators within the bigger picture, where possible, indicators have been compared to either the Scotland-wide scale, and / or through time. This has highlighted both areas of concern and areas of success.

Dimensions which present challenges to the State of Nature within the National Park include Invasive and Non-Native Species (INNS) – in particular Japanese knotweed and rhododendron, peatland erosion and drainage, and deer grazing pressure – in particular within wooded areas.

Black grouse populations have also declined, though the impact of programmes introduced to support the recovery of these populations may not have been captured in the monitoring data. The impact of INNS management undertaken on sites monitored by the NPA is also highlighted, with INNS population in decline at the majority of these sites.

Several dimensions highlight areas of success within the National Park. The condition of important designated sites has recovered in the last seven years, from a point of lagging behind the national average in 2015 to exceeding it in 2021. Data also shows that red squirrel populations within the National Park have responded positively to conservation programmes.

The report has also highlighted a series of data gaps which have limited the ability to draw meaningful conclusions on the State of Nature in relation to several key dimensions. For example, data relating to the composition and condition of woodland is limited, with the best available data being the 2014 Native Woodland Survey of Scotland (NatureScot).

Although some indicators show positive improvements within the park in comparison to the rest of Scotland, it is important to emphasise that Scotland has undergone significant biodiversity losses in recent years, and so, provides a relatively depleted baselineShifting baselines refers to the gradual shift in perception of what is considered natural or acceptable due to changing ecological conditions. Therefore, while the comparison to Scotland provides a broader perspective, it is important to set ambitious conservation goals that aim to surpass previous baselines and restore biodiversity and ecosystem health to levels far beyond we are seeing in the modern UK landscape.