# NHM Biodiversity Report

## Evaluating the impact of biodiversity interventions: a pilot study within the Cairngorms National Park

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# Summary

Far Ralia is an area of the Cairngormss National Park. At present, it is managed mostly for grouse (with deer stalking, limited sheep grazing, and heather burning) with some small patches of planted birch that is not used commercially. Restoration of the area will include the planting of 851ha of native trees, regeneration of peatlands, and natural succession of open grounds. This document presents a pilot study, where we predict the Biodiversity Intactness Index (BII) of the area as it stands now and the expected BII over time under the current restoration plans. **We conclude that the regeneration program planned at Far Ralia will, in a period of 75 or so years, return biodiversity to the level of a resilient and functioning ecosystem, surpassing the safe Planetary Boundary reaching a high of 94%**; and even within 30 years will deliver a surprisingly significant increase in biodiversity of nearly 21 percentage points.

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# The business case for nature

Earth is changing quickly in response to human activities. Biodiversity loss is one of the clearest warning signs that we are facing a planetary emergency.

Nature loss poses a major risk to businesses, with an estimated USD$44 trillion of economic value threatened by biodiversity declines and ecosystem collapse – equal to over half of the world's total GDP (World Economic Forum, 2021). At the same time, moving to nature-positive investments offers opportunity.

To date, there have been two major difficulties that make it hard for companies to think about biodiversity loss:

1. How to measure something as complex as biodiversity (there is no simple, granular, and universal biodiversity metric)
2. How to use that evidence to inform management decisions

**The NHM's work on Biodiversity Indicators offers solutions to both these problems.**

Biodiversity indicators are important tools for understanding, monitoring, and communicating biodiversity changes and for tracking our progress towards goals. At the NHM, we can supply estimates of a key biodiversity indicator – the **Biodiversity Intactness Index (BII)** – using the most comprehensive evidence base of its kind alongside robust, peer-reviewed methodology.

# The Biodiversity Intactness Index (BII)

The PREDICTS (Projecting Responses of Ecological Diversity In Changing Terrestrial Systems) project has gathered biodiversity data from ecological studies conducted around the world. This data includes around 58,000 species, encompassing not only birds and mammals, the groups most often used in biodiversity indicators, but also plants, fungi, and insects.

These studies have allowed us to infer a baseline of the number and diversity of species at near-undisturbed sites, and then to compare this baseline with biodiversity at sites with high human activity. While each of these studies looked at distinct species groups in different areas using different sampling methods, we account for this variation in our statistical analysis.

**The PREDICTS database is the most absolute of its kind and allows us to supply evidence-based assessments of the Biodiversity Intactness Index (BII) using robust, peer-reviewed methodology.** The BII is an estimated percentage of the original number of species and their abundance that remain in any given area, despite human impacts.

The BII is an intuitive summary of local biodiversity and an indicator for granular and global biodiversity targets. **Unlike other biodiversity indicators, we can project how BII will change in response to future management decisions.** This can help businesses evaluate different management strategies and opportunities.

To this end the BII has been included as an indicator within the post-2020 **"Global Biodiversity Framework"** and been reported within the recent **"Living Planet Report 2022"** and the **"IPBES: Global Assessment Report on Biodiversity and Ecosystem Services"**. Scientific publications from the PREDICTS project can be accessed here.

# Using the BII in a planetary boundary framework

*The planetary boundary framework aims to describe a set of nine boundaries within which humanity can continue to thrive. Only if we stay within these boundaries are we likely to avoid the major shocks to our lives that will occur due to the climate and biodiversity crisis.*

BII is an indicator of the 'health' of nature, with a value between 0 and 100%. A BII value of 100% is what we would expect to see if an area is unimpacted by humans – it still supports only native species at their natural abundances. Such environments are incredibly rare, especially in the UK – even ancient woodlands have suffered some human impacts, either through direct actions such as tree planting and harvesting, or indirectly through impacts on the surrounding landscape. 100% is not always a suitable target - but it helps to put our existing BII - and our plans to increase BII – into context.

This table describes what a BII percentage means in broad terms, using a planetary boundary framework. Within this framework, if the BII of an area is less than 90% then it is below what we consider a *safe space* for humanity. Crossing this boundary increases the risk that the area – and the biodiversity living there – will no longer be able to provide the key environmental benefits that we need to survive (e.g., clean air and water, food, and fuel), so substantial human intervention may be needed to make the area habitable and productive.

Table 1: Interpreting BII values

| BII | Interpretation |
|---|---|
| 100% | Biodiversity intact. |
| ≥ 90% | The area has enough biodiversity to be a resilient and functioning ecosystem. |
| < 90% | Biodiversity loss means ecosystems may function less well and less reliably. |
| ≤ 30% | The area's biodiversity has been depleted and the ecosystem could be at risk of collapse. |

# Brief methods

The BII is derived from combining two models. The first model is how human activity has influenced the total abundance of species in any one area. The second model analyses how similar each site's ecological community is to the near-undisturbed sites (this is known as the compositional similarity and includes what original species are present and what species are dominant).

Next, we combine each of these models with maps of human pressures, including land use change and intensification, human population growth, and landscape simplification. This produces new maps of how abundance and compositional similarity are affected by human pressures. Bringing these two maps together then gives us the BII: the percentage of the original ecological community that remains across an area.

If the relationship between biodiversity and human activity does not change, stacking the human driver data from multiple years allows biodiversity projections to be made through history and into the future.

For this work, we have classified the current and future maps of land use and management intensity in Far Ralia according to the PREDICTS land-use and intensity classification. We have then produced estimates of BII through time with and without restoration activity (See Detailed Methods below). We report the modelling predictions precisely, however, we accept that the modelling of any large data over long time-periods will inevitably involve uncertainty.

# Results: Average BII over time for Far Ralia

**Far Ralia's BII is currently just below 52%.** When land is restored – either using active planting schemes or passive abandonment – biodiversity is allowed the time and space to recover. Full recovery can take decades. To our knowledge, we have predicted BII at Far Ralia for the first time over three coarse time steps - short term (<30 years after restoration), medium term (30-75 years after restoration), and long term (>75 years after restoration). Based on the planned planting and regeneration scheme and the subsequent improvements in local biodiversity over time, **BII will recover to a mark of 94% in the long term**. This increase in BII over time is demonstrated in the figure and table below.

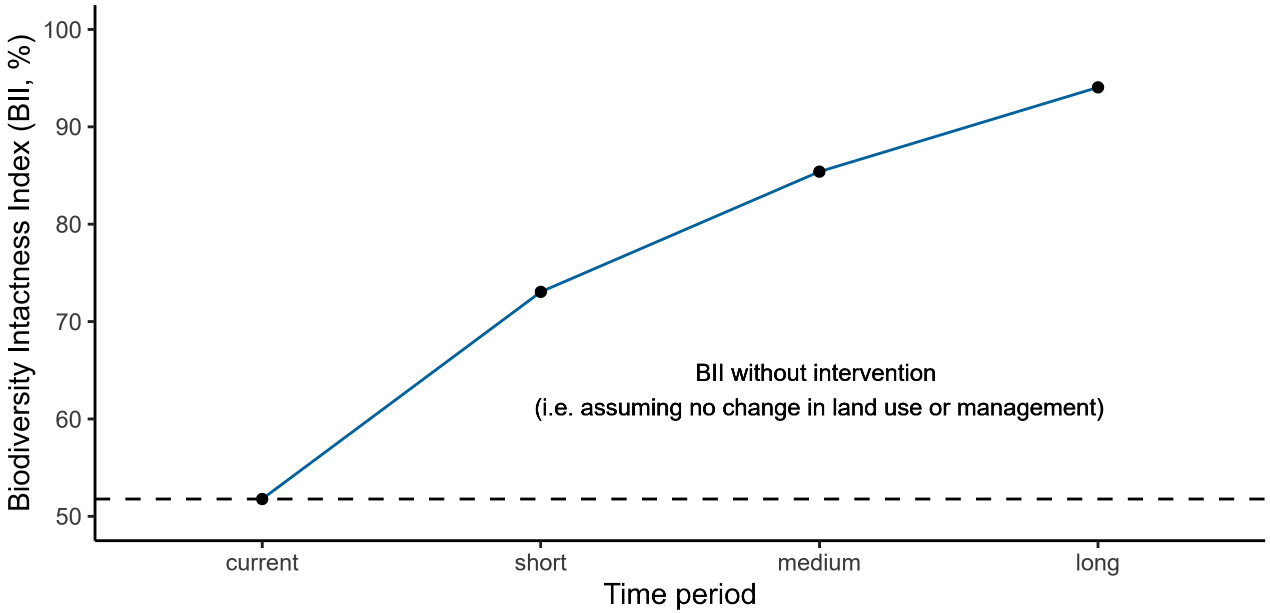



Figure 1: Change in Biodiversity Intactness Index (%) over time after planting scheme compared to no intervention (dashed line)

Table 2: BII for Far Ralia, rounded to two decimal places

| Time period | BII (%) |
|---|---|
| current | 51.78 |
| short | 73.05 |
| medium | 85.39 |
| long | 94.06 |


"These planned changes should really increase the area's Biodiversity Intactness Index, meaning Far Ralia can expect strengthened resilience and ecosystem-service security…certainly a successful outcome for the regeneration plan!"
Biodiversity expert, Prof. Andy Purvis

# Spatial and temporal variation in BII

The planned tree planting and peat-regeneration is expected to increase BII significantly and for the betterment of Far Ralia. **The area will have enough biodiversity to be a resilient and functioning ecosystem, with a thriving biodiversity.**

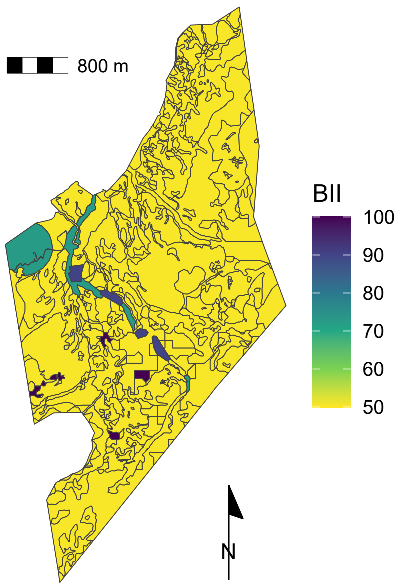
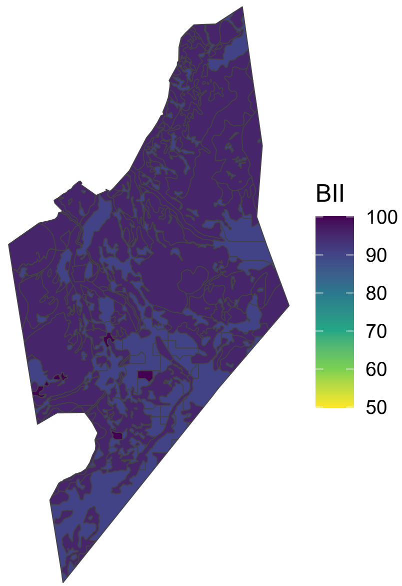
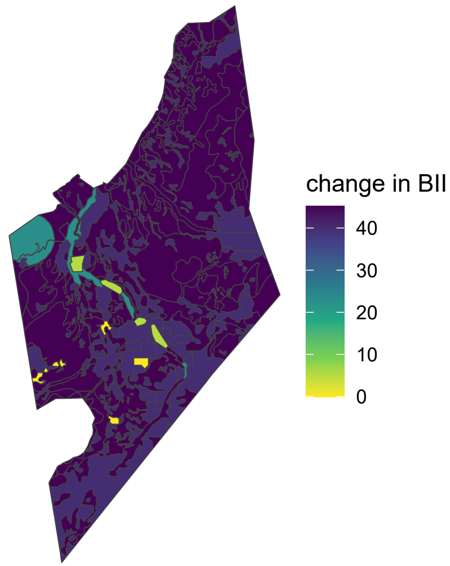



Fig 2a: Average BII at the current time = 51.78 %




: Average BII 75 years after current day = 94.06 %




2c: Change in BII after 75 years, relative to the current day = 42.28 percentage points

# Final Summary

**These results should be considered wonderful news. The planting strategy is expected to deliver meaningful results in the short, medium, and long term. Taking a habitat reduced in expected biodiversity and turning it into a thriving ecosystem, well within the safe planetary boundary.**

- How would more conservative areas within Far Ralia respond to different tree planting combinations?
- How would biodiversity respond to different management plans (i.e., grouse moors)?
- How would the impact of the regeneration plan on BII respond over granular time scales (i.e., every 5 years)?

Further work would allow us to answer these questions and enhance the power of the regeneration plan. By curating existing data, sourcing in woodland/management-practice specific data, and add in other pressure variables we would be able to assess how biodiversity would respond to various regeneration interventions. See "Future work" for more details.

| Time period | Biodiversity recovered? |
| --- | --- |
| Short term (<30 years) | After less than three decades, BII will have already improved by over 21%. |
| Medium term (30-75 years) | At this time, BII will be over 33% higher than it is today, and already surpassing the level where we would expect biodiversity to be a resilient and functioning ecosystem. |
| Long term (75+ years) | Far Ralia's BII is expected to increase to 94% after 75 years. This exceeds the planetary boundary threshold (90%), indicating the area has enough biodiversity to be a resilient and functioning ecosystem. This is an incredibly positive result. |


“The results of this ambitious regenerative plan highlight just how well nature can recover, when it is given space, time, and support!”
Lead analyst, Dr Adriana De Palma

# Additional Information

# Assigning land uses to PREDICTS categories

We were provided with a shape file outlining the planting scheme that has been designed for Far Ralia. Areas where planting is planned is currently being managed for grouse, with heather burning, some deer stalking, and limited sheep grazing. We have mapped the land-use information from Far Ralia onto land-use categories within the PREDICTS database. For more information on PREDICTS categories, see Hudson et al (2014)[2].

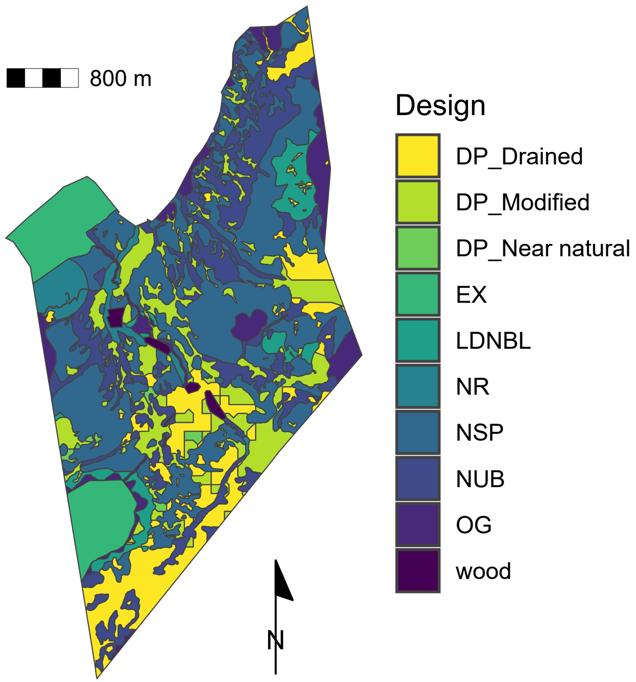



Figure 3. Land use and planting plans for Far Ralia

Table 3: Translating Far Ralia land uses into PREDICTS categories

| Map Abbreviation | Meaning | Current PREDICTS Category | Future PREDICTS Category | Notes |
|---|---|---|---|---|
| DP | Deep Peat | YSV intense | YSV/ISV minimal | Drained and Modified Deep Peat will be restored and will be allowed to recover over short, medium, and long-term projections |
| EX | Other Land | NA | NA | Exclude from analysis |
| NUB | Native Upland Birch | YSV intense | YSV/ISV/MSV minimal | Will be allowed to 'mature' over short, medium, and long-term projections |
| wood | Existing woodland | ISV minimal | MSV minimal | Approx 30 years old, being left to recover naturally |
| NSP | Native Scots Pine | YSV intense | YSV/ISV/MSV minimal | Will be allowed to 'mature' over short, medium, and long-term projections |
| OG | Open Ground | YSV intense | YSV/ISV/MSV minimal | This is partially managed land, now unused and will be left to recover naturally |
| NR | Natural Regeneration | YSV minimal | YSV/ISV/MSV minimal | Approx 5 years old, left to recover naturally, will be allowed to 'mature' over short, medium, and long-term projections |
| LDNBL | Low-Density Native Broadleaf | YSV intense | YSV/ISV/MSV minimal | Will be allowed to 'mature' over short, medium, and long-term projections |

# Assumptions

There are also some general assumptions of PREDICTS methodology and BII that should be considered when interpreting results.

- In our modelling, we assume that human pressures (e.g., land use change and intensification, human population growth and landscape simplification) have caused the differences we see in biodiversity within each study. However, these are not the only drivers of biodiversity change.
- We assume that the species at sites with minimally disturbed plants are like species in a pristine area as truly untouched environments are rare.
- We also assume that all species found in these minimally disturbed sites are naturally present. But this is not always true as some of these species may be invasive. Usually, the PREDICTS database cannot identify which species present are native or invasive. However, we have performed sensitivity analyses using information on species' native status.
- Because representative long-term data do not exist, we do not have true baseline sites with which we can make biodiversity comparisons.
- While our data are more geographically representative than other biodiversity databases, there are still some geographical gaps in the data used to calculate the BII.

# Future work

There are several areas where additional work could improve the accuracy of the outputs shown here.

1. While we have used the most extensive dataset of its kind to underpin our estimates of biodiversity responses to land-use change, the land-use categories are coarse and could be refined. For instance, by re-curating the data we have and collating new data if necessary on biodiversity in different woodland types, we would be able to assess whether biodiversity recovery over time varies with woodland type. Gathering more data would also allow us to assess biodiversity responses to grouse moors and associated management practices more specifically. Working with a more refined categorisation of land uses will also more accurately reflect the spatial variation in BII (See Figure 2).
2. The biodiversity models can be adapted to assess biodiversity change more accurately in temperate woodland systems and to predict biodiversity recovery every five years up to 100 years (rather than assessing recovery only over coarse time steps as we have done here.)
3. More refined models can include added pressure variables that may play a part in shaping biodiversity and its change over time.
4. Additional analyses can look to assess complementary biodiversity indicators, for example, endangered species. Habitat loss and creation plays a significant role in driving or halting species loss.
5. Future work can supply the uncertainty around the BII estimates. All predictions - no matter the method - come with uncertainty. For some predictions, we have more confidence than others (depending on the amount of underlying data and the amount of variation in that data). Supplying uncertainty will allow for informed decision-making and can also highlight areas where further data collection is necessary.
6. Finally, we would always recommend the gold standard approach to biodiversity reporting. This involves on-the-ground monitoring of biodiversity, to check recovery progress over time and integrate data into the modelling. Over time, the models will become better and better at predicting biodiversity for this specific area.

# Leveraging biodiversity indicators for business

Biodiversity indicators are important tools for summarising and communicating complex biodiversity data. The BII can be adopted by businesses to:

- Map BII across regions of interests
- Reports of intactness and uniqueness of a region's biodiversity
- Infer how BII has changed over recent years in areas of interest
- Project changes in biodiversity under future land use and management
- Model and project impacts of land usage and other pressures on biodiversity as a whole or groups
- Compare dimensions of biodiversity e.g., taxonomic, functional, and phylogenetic diversity
- Compare biodiversity impacts of crops
- Screen policy options for biodiversity consequences
- Develop goal-seeking scenarios while integrating with economic models to achieve biodiversity
- Evaluate the likely impact of specific management decisions aimed at increasing biodiversity

The analysis was done using the R Statistical language (v4.2.1; R Core Team, 2022) on Windows Server x64, using the packages ggspatial (v1.1.6), purrr (v0.3.5), tidyterra (v0.3.1), terra (v1.6.17), gt (v0.8.0), deckhand (v0.0.9), report (v0.5.5), here (v1.0.1), tibble (v3.1.8), ggplot2 (v3.4.0), forcats (v0.5.2), stringr (v1.4.1), tidyverse (v1.3.2), dplyr (v1.0.10), tidyr (v1.2.1) and readr (v2.1.3).

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2. Lawrence N. Hudson et al., “The PREDICTS Database: A Global Database of How Local Terrestrial Biodiversity Responds to Human Impacts,” *Ecology and Evolution* 4, no. 24 (2014): 4701–35, https://doi.org/https://doi.org/10.1002/ece3.1303.↩