Tranquillity Mapping in the Lake District

Report prepared for Friends of the Lake District by

Wildland Research Limited

And

Lune Geographic

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Contents

[Cover photo by Wendy Stirrup]

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Glossary

Acoustic Complexity Index (ACI)
A metric used to quantify the complexity of biological sounds in an environment, often associated with biodiversity and natural soundscapes.

Anthrophony
Human-generated sounds within a soundscape, including speech, vehicles, and machinery.

Bootstrapping (Monte Carlo Simulation)
A statistical technique that uses repeated random sampling to assess uncertainty in model outputs, often applied in sensitivity analysis.

Buffer Zones
Fixed-radius areas around features (e.g., roads) used in spatial modelling to represent zones of influence, such as noise disturbance.

Contributors
Landscape features that enhance tranquillity, such as open water, native woodland, and open fell.

Detractors
Features that reduce tranquillity, including roads, urban areas, buildings, noise, and recreational congestion.

Dempster-Shafer Theory
A mathematical framework for modelling uncertainty and combining evidence, used here to quantify public perceptions of tranquillity.

Eco-acoustics
The study of environmental sounds to understand ecological processes and human impacts on natural soundscapes.

Geophony
Sounds generated by non-biological natural processes, such as wind or rain.

GIS (Geographical Information System)
A system for capturing, storing, and analysing spatial data, used extensively for tranquillity mapping.

Jack-knifing Analysis
A sensitivity analysis method that recalculates model outputs while omitting one criterion at a time to assess its influence.

LEQt (Equivalent Continuous Sound Level)
A standard acoustic metric representing average sound energy over time, expressed in decibels (dB).

Map-Me
A web-based participatory mapping tool allowing users to identify tranquil and non-tranquil areas using a “spray can” interface.

Multi-Criteria Evaluation (MCE)
A spatial modelling technique that combines multiple weighted factors to produce composite maps, such as tranquillity indices.

Naismith's Rule
A formula for estimating walking time based on distance and elevation, used to model remoteness.

Normalized Difference Soundscape Index (NDSI)
An acoustic index estimating the ratio of anthropogenic to biological sounds in a soundscape.

Openness
A measure of topographic enclosure, indicating the proportion of visible sky from a given location.

Paper2GIS
A participatory mapping tool that converts hand-drawn annotations on paper maps into georeferenced digital data.

PGIS (Participatory GIS)
An approach that integrates public input into spatial analysis, capturing local perceptions and experiences.

Remoteness
A measure of isolation from roads or public transport, often associated with higher tranquillity.

Soundscape
The acoustic environment of a location, including natural and human-made sounds.

Strava Heatmap
A dataset derived from GPS activity tracking, used as a proxy for recreational intensity and visitor presence.

Tranquillity Index
A composite measure combining contributors and detractors to represent overall tranquillity across a landscape.

Viewshed Analysis
A GIS technique that determines visibility of features from a given point, used to assess visual intrusion.

Executive Summary

This report presents a comprehensive approach to mapping and monitoring tranquillity within the Lake District National Park (LDNP), a key cultural ecosystem service central to the park's character and World Heritage status. Tranquillity contributes to visitor experience, health, and biodiversity but faces increasing pressures from development, over-tourism, and recreational activity.

The project aims are to:

- Develop a high-resolution tranquillity map for the LDNP using spatial modelling of contributors (e.g., open water, native woodland) and detractors (e.g., roads, settlements, noise).
- Validate findings through Participatory GIS (PGIS) using tools such as Map-Me and Paper2GIS to capture public perceptions.
- Incorporate acoustic monitoring and case studies to provide a rich understanding of tranquillity dynamics.
- Establish a repeatable monitoring framework for long-term use.

Key findings are:

- Most tranquil areas are concentrated in remote high fells and isolated valleys, while least tranquil zones align with major transport corridors and tourist hubs.
- PGIS results closely match modelled outputs, confirming strong public consensus on tranquil and disturbed areas.
- Acoustic monitoring highlights the potential impact of multiple sources of traffic and recreational noise on perceived tranquillity.
- Case studies reveal seasonal and spatial variability, with tranquillity often compromised in popular locations during peak periods.

The report makes certain key recommendations which include:

- Policy Actions: Embed tranquillity indicators in planning frameworks that prioritize noise and light control and support sustainable transport solutions.
- Planning Guidance: Use mapped data to inform the development of planning policies/guidance, guide development management decisions, and inform management plans, visitor management and other strategies and associated decision-making. Repeat mapping and "what if?" analysis can inform decision-making prior to developments or other planned changes taking place.
- Monitoring: The establishment of long-term monitoring in LDNP can establish a baseline for existing impacts on tranquillity in the park, inform the development of management strategies to mitigate this, and provide an evaluation method for monitoring their success over time. Tranquillity indicators can be embedded in policy, management and planning frameworks.
- Further Study: Expand mapping beyond LDNP would enable the tranquillity of wider Cumbria to be better understood and protected. Further depth can be added with help

from emerging data sources (e.g., social media, mobile sensors) and realise opportunities for developing mobile apps for real-time reporting. Exploring the time factor in terms of impact of seasonality and particular calendar events might also prove a profitable avenue for further study. Citizen science enabled using appropriate mobile apps could enable further layers of evidence and data collection to be added to future work.

Collaboration between the Lake District National Park Authority and Friends of the Lake District is essential to align policy, share data, and engage communities, visitors and other stakeholders in safeguarding tranquillity for future generations.

1. Introduction

Tranquillity is a multi-faceted idea or concept that refers to a state of peacefulness, calm, and freedom from disturbance - both in terms of the wider geographical setting or landscape, as well as in the mind of the observer. In landscape studies, tranquillity is often associated with natural settings that evoke feelings of relaxation, restoration, and emotional well-being.

From a spatial perspective, tranquillity is influenced by a combination of sensory inputs – both positive and negative - such as the presence of noise, presence of natural sounds, aesthetically pleasing scenery and visual impacts from human structures, alongside the presence of certain environmental qualities like remoteness, low levels of human activity and high biodiversity. This inevitably means spatial patterns in tranquillity - its contributors and detractors - can vary markedly from place to place. It can be complicated by more individual or personal factors such as mood, cultural background, and expectations. Tranquillity is not just the absence of noise, other people or visual intrusion, but the presence of other qualities that foster a sense of harmony and relief from the everyday.

Tranquillity is increasingly recognised as a cultural ecosystem service, since it contributes to human health and wellbeing through interactions with nature and landscape. It plays a key role in protected landscapes such as national parks, and across the wider countryside and rural settings, where it supports recreational enjoyment, nature-connectedness, restorative health and spiritual connection.

This report builds on previous research by CPRE[1] and others to formally establish the components of tranquillity and map how it varies across a landscape to better inform decisions about policy and planning that affect this important aspect of the countryside. It builds on previous mapping and public perception surveys to develop a robust and repeatable approach to mapping tranquillity based on publicly available data and Geographical Information System (GIS) tools. This is supported using Participatory GIS (PGIS)[2] to validate mapping results with knowledge of the local area. Acoustic data and local case studies add further detail.

Tranquillity is central to the Lake District National Park's character and its World Heritage status but is threatened by development, tourism, and land use changes. As one of the special qualities of the park - and because of its role in the character and experience of the park - the conservation and enhancement of tranquillity is crucial in ensuring that the statutory purposes of the park. This places a duty on public bodies to seek to further these purposes and ensure protection of tranquillity within the park is upheld. Without any baseline assessment of tranquillity or mechanism by which to monitor it, this is not possible. Tranquillity is recognised in the Lake District National Park Partnership's Management Plan, both current (2020–2025)[3] and draft new plan[4], as one of the area's defining Special Qualities, contributing to its designation as

[1] https://www.cpre.org.uk/resources/mapping-tranquility/

[2] Participatory GIS (PGIS) is a collaborative approach that combines Geographic Information Systems (GIS) with community participation to incorporate local knowledge into spatial planning and decision-making. It empowers communities by allowing them to share their perspectives on local issues using digital or paper maps, which can then be used to inform projects like land-use planning, environmental management, and social equity analysis.

[3] https://www.lakedistrict.gov.uk/caringfor/lake-district-national-park-partnership/management-plan

[4] https://www.lakedistrict.gov.uk/aboutus/committee-meetings-calendar/park_committee/park-strategy-and-vision-committee-22-october-2025

both a National Park and a World Heritage Site[5]. The Plan emphasises that tranquillity is vital for enhancing visitor experience, supporting biodiversity, and preserving the cultural and scenic value of the region. It also guides planning and development decisions, ensuring that new proposals do not undermine this essential quality, thereby helping to maintain the Lake District's unique sense of place for future generations.

This report describes work carried out under contract from The Friends of the Lake District (FLD) to assess, map and monitor tranquillity in the Lake District National Park (LDNP) with the aim of supporting and informing FLD's decision making in their wider work on protecting the essential character of the park as a place for quiet and contemplative recreation[6]. The work has been carried out through a collaboration between Wildland Research Ltd[7] and Lune Geographic Ltd[8]. working closely with staff from FLD.

1.1 Previous work on tranquillity mapping

Tranquillity mapping in national parks and countryside settings is a useful tool to aid understanding and preservation of sensory and emotional qualities of landscapes that contribute to human well-being.

Early work by Caffyn and Prosser (1998) highlights the need to protect 'quiet areas' in national parks, framing tranquillity as a valued but under-recognised aspect of landscape management[9]. This was later expanded by CPRE (2005) working with a team from Northumbria University, which developed a national tranquillity map for England, integrating visual and acoustic factors to define tranquil spaces, underscoring the importance of remoteness, natural sounds, and lack of human disturbance in shaping perceptions of tranquillity (see Figure 1.1)[10]. More recent studies have refined these concepts using advanced spatial and perceptual methodologies. Hewlett et al. (2017)[11] and Brehme et al. (2018)[12] employ GIS-based landscape value mapping to assess tranquillity in protected areas such as the North York Moors and Howardian Hills. These studies demonstrate how tranquillity is not only a physical attribute but also a subjective experience influenced by cultural and personal values.

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[5] https://www.lakedistrict.gov.uk/caringfor/whs

[6] https://www.friendsofthelakedistrict.org.uk/news/webinar-what-is-tranquillity

[7] https://www.wildlandresearch.co.uk/

[8] https://lunegeographic.co.uk/

[9] Caffyn, A. and Prosser, B., 1998. A review of policies for 'quiet areas' in the National Parks of England and Wales. *Leisure Studies*, *17*(4), pp.269-291. https://doi.org/10.1080/026143698375105

[10] https://www.cpre.org.uk/wp-content/uploads/2019/11/mapping_tranquillity.pdf

[11] Hewlett, D., Harding, L., Munro, T., Terradillos, A. and Wilkinson, K., 2017. Broadly engaging with tranquillity in protected landscapes: A matter of perspective identified in GIS. Landscape and Urban Planning, 158, pp.185-201. https://doi.org/10.1016/j.landurbplan.2016.11.002

[12] Brehme, C., Wentzell-Brehme, S. and Hewlett, D., 2018. Landscape values mapping for tranquillity in North York Moors National Park and Howardian Hills AONB. International Journal of Spa and Wellness, 1(2), pp.111-132. https://doi.org/10.1080/24721735.2018.1493776

The integration of soundscape analysis has been particularly influential. Pheasant et al. (2008)[13] and Watts and Pheasant (2015)[14] explore how acoustic and visual stimuli interact to create tranquil environments. Their findings revealed that natural sounds, such as birdsong and water, enhance tranquillity, while anthropogenic noise diminishes it. The Tranquillity Rating Prediction Tool (TRAPT), validated by Watts and Marafa (2017)[15], offers a practical framework for assessing tranquillity across diverse settings, including urban parks and remote landscapes.

Technological advancements have enabled novel approaches to mapping experienced tranquillity. Wartmann et al (2020)[16] use social media data, interviews, and natural language processing to capture public perceptions of tranquillity. These methods allow for the identification of tranquillity hotspots based on user-generated content, offering a bottom-up complement to top-down expert-driven mapping.

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[13] Pheasant, R., Horoshenkov, K., Watts, G. and Barrett, B., 2008. The acoustic and visual factors influencing the construction of tranquil space in urban and rural environments tranquil spaces-quiet places?. The Journal of the Acoustical Society of America, 123(3), pp.1446-1457. https://doi.org/10.1121/1.2831735

[14] Watts, G.R. and Pheasant, R.J., 2015. Tranquillity in the Scottish Highlands and Dartmoor National Park–The importance of soundscapes and emotional factors. Applied Acoustics, 89, pp.297-305. https://doi.org/10.1016/j.apacoust.2014.10.006

[15] Watts, G. and Marafa, L., 2017. Validation of the tranquillity rating prediction tool (TRAPT): Comparative studies in UK and Hong Kong. Noise Mapping, 4(1), pp.67-74. https://doi.org/10.1515/noise-2017-0005

[16] Wartmann, F.M. and Mackaness, W.A., 2020. Describing and mapping where people experience tranquillity. An exploration based on interviews and Flickr photographs. Landscape Research, 45(5), pp.662-681. https://doi.org/10.1080/01426397.2020.1749250

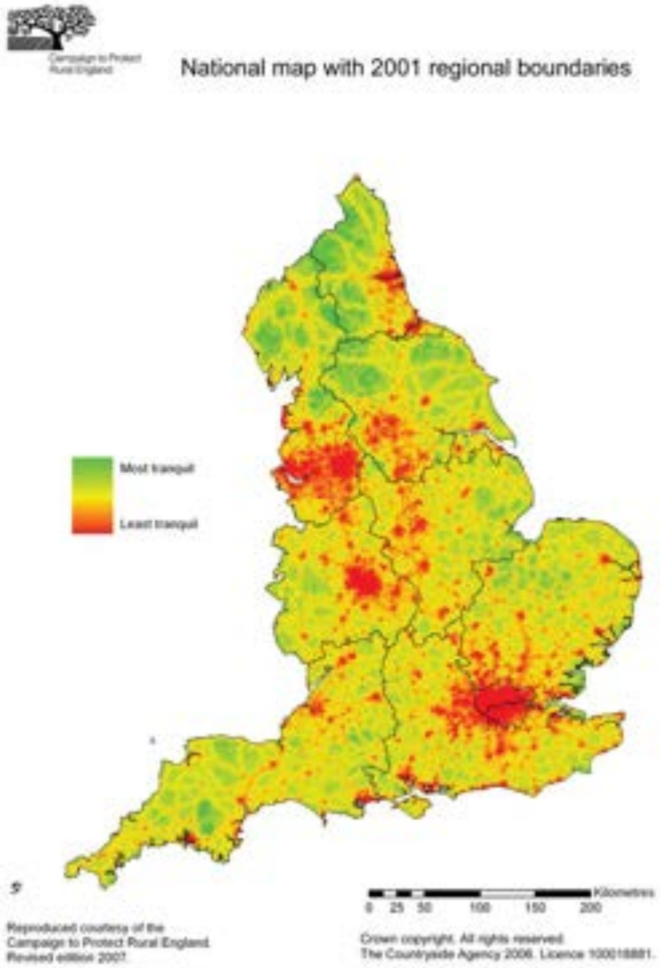

Figure 1.1 Tranquillity map for England (CPRE, 2007)

Chesnokova et al. (2019)[17] and Purves and Wartmann (2023)[18] address the links between spatial humanities and environmental science, examining how tranquillity and ideas of 'silence' are culturally constructed and spatially experienced. Their work emphasises the need for interdisciplinary approaches that account for both measurable environmental factors and more intangible or fuzzy cultural values.

In practical terms, tranquillity mapping supports landscape planning, tourism management, and conservation. For example, Hu et al. (2021)[19] develop a tranquillity perception scale from tourists' perspectives, highlighting its relevance for visitor experience design, while Langlands

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[17] Chesnokova, O., Taylor, J.E., Gregory, I.N. and Purves, R.S., 2019. Hearing the silence: finding the middle ground in the spatial humanities? Extracting and comparing perceived silence and tranquillity in the English Lake District. International Journal of Geographical Information Science, 33(12), pp.2430-2454. https://doi.org/10.1080/13658816.2018.1552789
[18] Purves, R.S. and Wartmann, F.M., 2023. Characterising and mapping potential and experienced tranquillity: From a state of mind to a cultural ecosystem service. Geography Compass, 17(11), p.e12726. https://doi.org/10.1111/gec3.12726
[19] Hu, M., Lu, Y., Zhuang, M., Zhang, X., Zhang, H., Zhang, Y., Zhang, J. and Liu, P., 2021. Development of tranquility perception scale: From tourists' perspective. Journal of Hospitality and Tourism Management, 49, pp.418-430. https://doi.org/10.1016/j.jhtm.2021.10.008

(2023)[20] applies multi-criteria mapping to propose new hiking routes in the Trossachs, demonstrating how tranquillity data can inform sustainable recreation planning.

Tranquillity mapping combines environmental data, acoustic science, GIS, and public perception to identify and protect spaces that offer opportunities for peace and restoration. As pressures on natural landscapes increase, tranquillity mapping offers a valuable tool for balancing access, enjoyment, and conservation in national parks and the wider countryside and where potential conflicts arise, conservation of tranquillity takes precedence under the Sandford Principles[21].

1.2 Limitations of existing methods

Existing methods for tranquillity mapping often rely on overly simplistic spatial modelling techniques, particularly in how they represent detractors; features that negatively impact perceived tranquillity. Two common approaches are the use of binary viewshed analyses and buffer zones, both of which present limitations in capturing the nuanced and subjective nature of tranquillity.

1.2.1 Binary Viewshed Analyses

Viewshed analysis typically determines whether a detractor (e.g., a road or industrial site) is visible from a given location based on intervening terrain. However, this method assumes a binary impact: if a detractor is visible, tranquillity is reduced; if not, it is unaffected. This greatly oversimplifies the perceived experience of being able to see a detractor since "can you see it, can you not?" visibility alone does not account for:

- Distance decay: the further away a visible detractor is from the observer the lower its impact will be.
- Contextual factors: a road seen from above may be more intrusive than one seen from below.
- Partial occlusion: intervening vegetation or terrain may obscure or hide parts of a detractor, reducing its visual impact.

Moreover, binary viewsheds ignore auditory and emotional dimensions, which are central to tranquillity. A detractor may be invisible but still audible, and thus still have an impact.

1.2.2 Buffer Zones

Buffers involve drawing zones of a fixed radius around detractors, within which tranquillity is assumed to be compromised. As an approach, buffering is often used to model noise disturbance, but like binary viewsheds, is similarly reductive:

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[20] Langlands, C., 2023. Multi-Criteria Tranquillity Mapping the Trossachs: Proposed New Hiking Routes from Aberfoyle to Callander. The Elphinstone Review, p.151.

[21] The Sandford Principle is a legal guideline for National Parks that states if there's a conflict between the purpose of conserving the park's natural beauty and the purpose of public enjoyment, conservation must take priority. This rule, established by the 1974 Sandford Committee, applies when the two purposes cannot be reconciled, ensuring that the natural environment is protected for future generations. It is now legally enshrined in Section 62 of the Environment Act 1995.

- It assumes uniform impact within the buffer, ignoring how effects vary with proximity, topography, and intervening landscape features.
- It fails to consider directionality - noise and visual intrusion are not isotropic since they vary based on wind, elevation, and line of sight.
- Buffers often disregard temporal variation, such as seasonal changes in vegetation or fluctuating noise levels.

1.2.3 Consequences of Oversimplification

These methods risk producing misleading or over-generalised tranquillity maps that do not reflect how we experience variations in tranquillity across a landscape. They may undervalue areas that feel tranquil despite their proximity to detractors or overvalue areas that are technically distant but still affected by noise or visual intrusion. This can potentially lead to poor planning decisions, misallocation of conservation resources, and reduced trust in mapping outputs.

1.2.4 Toward More Nuanced Mapping Approaches

Recent studies advocate for multi-criteria and perception-based models such as Wartmann and Mackaness (2020)[22] and Purves and Wartmann (2023)[23], which integrate acoustic data, landscape aesthetics, and user-generated content. These approaches better capture the complex combination of sensory, emotional, and cultural factors that shape overall measures of tranquillity.

This study combines advanced spatial analysis techniques with existing, publicly accessible data to assess both detractors and contributors to map tranquillity in the LDNP. Sensitivity models are used to assess the effect of data uncertainty and model weights to identify robust model outputs.

1.3 Mapping Individual Experience and Perceptions of Tranquillity

Perceptions of tranquillity are deeply personal and shaped by individual experiences, cultural background, education, emotional state, and overall expectations. What one person finds peaceful - such as the sound of a distant waterfall or the rustle of leaves - another may perceive as distracting or unsettling. Factors such as familiarity with nature, sensitivity to noise, and even past experiences in similar settings can significantly influence how tranquillity is felt and interpreted.

This subjectivity presents a challenge for traditional tranquillity mapping, which often relies on objective environmental data. To address this, many researchers have increasingly turned to social media platforms like Flickr, Twitter, Facebook, and Instagram as rich sources of user-generated content that reflect our real-world ‘lived’ experiences and emotional responses to landscapes.

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[22] Wartmann, F.M. and Mackaness, W.A., 2020. Describing and mapping where people experience tranquillity. An exploration based on interviews and Flickr photographs. Landscape Research, 45(5), pp.662-681. https://doi.org/10.1080/01426397.2020.1749250

[23] Purves, R.S. and Wartmann, F.M., 2023. Characterising and mapping potential and experienced tranquillity: From a state of mind to a cultural ecosystem service. Geography Compass, 17(11), p.e12726. https://doi.org/10.1111/gec3.12726

Studies such as Wartmann and Mackaness (2020)[24] and Wartmann et al (2019)[25] have demonstrated how geotagged photographs, captions, hashtags, and comments can be mined to identify locations where people report or visually represent tranquil experiences. These platforms can enable researchers to move beyond static models and incorporate dynamic, crowd-sourced data that reflect the diversity of human experience. They can also help identify temporal patterns, such as seasonal shifts in tranquillity, and spatial trends, like popular tranquil spots or emerging areas of concern due to noise or development.

1.3.1 Limitations of social media

While these platforms offer large volumes of real-time, user-generated data that can reveal where and when people experience tranquillity, and how they describe it, they do have several limitations that constrain their effectiveness:

- Demographic and platform bias: Social media users tend to be younger, urban, and tech-savvy, which may skew the representation of tranquil experiences. Older populations or those who prefer offline means of interaction or sharing of views may be underrepresented.
- Selective sharing: Users often post idealized or aesthetically pleasing content, which may not accurately reflect their full experience. Tranquillity might be over-emphasized in scenic locations and underreported in those that are perhaps less photogenic but are, nonetheless, genuinely peaceful places.
- Lack of contextual depth: While hashtags and captions can hint at emotional responses, they rarely provide detailed insights into why a location feels tranquil or how specific environmental factors contribute to that perception.
- Temporal and spatial inconsistency: Social media data is unevenly distributed across time and space, with popular tourist spots and peak seasons dominating the dataset, potentially masking quieter, less visited tranquil areas.

1.3.2 Participatory Mapping as an Alternative

Participatory mapping offers a more inclusive and context-rich approach to capturing spatial patterns in public perceptions of tranquillity. It involves engaging individuals or communities directly in the mapping process through workshops, surveys, mobile apps, or interactive GIS platforms.

Advantages of participatory mapping approaches include:

- Diverse representation: It allows input from a broader demographic, including those less active on social media, ensuring more equitable data collection.
- Contextual richness: Participants can explain *why* they perceive certain areas as tranquil, providing qualitative insights into sensory, emotional, and cultural dimensions.

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[24] Wartmann, F.M. and Mackaness, W.A., 2020. Describing and mapping where people experience tranquillity. An exploration based on interviews and Flickr photographs. Landscape Research, 45(5), pp.662-681. https://doi.org/10.1080/01426397.2020.1749250

[25] Wartmann, F.M., Tieskens, K.F., van Zanten, B.T. and Verburg, P.H., 2019. Exploring tranquillity experienced in landscapes based on social media. Applied Geography, 113, p.102112. https://doi.org/10.1016/j.apgeog.2019.102112

- Local knowledge integration: Residents and frequent visitors often have deep familiarity with landscapes, contributing nuanced understanding that may be missed by remote sensing or social media scraping.
- Customizable data collection: Participatory methods can be tailored to specific research goals, such as identifying seasonal tranquillity, evaluating the impact of development, or exploring accessibility.

Two innovative tools are used here to help capture public perceptions of tranquillity across the LDNP. These are Map-Me and Paper2GIS.

Map-Me[26] is a web-based participatory mapping platform designed to collect spatial data from the public. It allows users to:

- Identify landscapes they associate with tranquillity using a fuzzy spray can tool to 'paint' areas of the map they consider to be tranquil or not tranquil.
- Provide qualitative descriptions of their experiences that are then attached to the spray pattern.

This tool is particularly effective for gathering local knowledge and subjective perceptions across landscape units since, unlike other PGIS tools, it does not rely on using discrete xy points or polygons which can imply an accuracy or certainty that isn't appropriate for this kind of problem or application.

Paper2GIS[27] bridges the gap between analogue and digital mapping by allowing participants to draw on pre-printed base maps, which are then digitized and georeferenced using a simple digital photograph. The software then extracts the user-drawn information from the base map and converts this to GIS-readable format for subsequent analysis. This method is especially useful in:

- Workshops and outreach events, where digital access may be limited.
- Engaging non-digital natives, such as older adults or rural communities.
- Capturing spatial patterns in a tactile, intuitive way.

By enabling participants to mark tranquil areas, routes, or zones of disturbance, Paper2GIS facilitates a rich, spatially explicit dataset that reflects lived experiences and local values.

1.3.3 Mapping Recreational Popularity with Strava Heatmaps

One problem with existing maps based on detractors and contributors is the lack of detailed data on popularity of locations and routes and hence the number of people the observer is likely to encounter at any one time. This obviously affects the sense of tranquillity as too many people in a landscape at any one point in time can lead to a sense of overcrowding through general busy-ness, visibility of other people and general noise from conversation and movement, leading to negative impacts on tranquillity and sense of solitude.

Strava heatmaps[28] can provide a powerful visual representation of the popularity of routes and locations based on aggregated GPS data from millions of users engaging in activities such as

[26] https://map-me.org/
[27] https://link.springer.com/article/10.1007/s10109-022-00386-6
[28] https://www.strava.com/maps/global-heatmap

running, cycling, water sports and hiking. Strava heatmaps highlight popular paths with greater intensity of use, allowing researchers and planners to identify high-traffic areas and popular recreational corridors.

Here, Strava heatmap data can serve as a proxy for levels of human use/presence and associated activity levels, helping to assess potential impacts on perceived tranquillity. Areas with intense activity may experience reduced tranquillity due to crowding, noise, or visual disturbance, while less-used areas or routes may reasonably be assumed to retain a more peaceful character. However, as demonstrated by Venter et al (2023)[29] this data should be interpreted with caution, as it reflects a specific user demographic and activity type, and may not capture quieter forms of recreation or the full spectrum of visitor experiences.

Strava data reflects a narrow user base - primarily fitness enthusiasts - potentially excluding quieter recreational users. It tracks movement, not emotional or sensory experiences, and lacks context about why people visit or how they feel. Additionally, data is often temporally aggregated, masking seasonal or daily variations. Without integrating perceptual or qualitative data, Strava may misrepresent tranquillity, conflating popularity with disturbance. In the absence of alternative sources of data on recreational use, Strava heatmaps provide a useful indicator of intensity of use and associated impacts on opportunity to find solitude and tranquillity. Nevertheless, it should be used cautiously and in combination with more inclusive, experience-based methods.

[29] Venter, Z.S., Gundersen, V., Scott, S.L. and Barton, D.N., 2023. Bias and precision of crowdsourced recreational activity data from Strava. Landscape and Urban Planning, 232, p.104686. https://doi.org/10.1016/j.landurbplan.2023.104686

2. Project Goals

This project aims to enhance understanding of tranquillity within the LDNP through the creation of a detailed tranquillity map and verifying/validating this with public input via participatory mapping methods to develop a robust and repeatable monitoring framework that uses both quantitative spatial data and captures community perspectives. The outcomes will support planning and policy development, while fostering meaningful public engagement to ensure that tranquillity remains a valued and protected aspect of the LDNP landscape. Additional information will be provided from acoustic monitoring and case study descriptions.

The report comprises four integrated components:

- PART A: Spatial modelling of tranquillity contributors and detractors;
- PART B: Participatory GIS aimed at capturing important public perceptions of tranquillity;
- PART C: Ground-truthing and eco-acoustic monitoring to validate mapping data; and
- PART D: Case studies and storytelling that create a rich picture of tranquillity across the LDNP.

2.1 PART A. Create a Detailed Tranquillity Map of the LDNP

The aim of this project is to produce a high-resolution, spatially explicit tranquillity map of the Lake District National Park (LDNP), integrating visual, acoustic, and experiential data. Using advanced GIS tools and data such as Viewshed Explorer[30] and OS Terrain 50[31], PART A models the visibility of both tranquillity contributors (e.g. open views, water bodies, woodland) and detractors (e.g. roads, settlements, masts). Acoustic data for noise sources like roads and railways are also incorporated in the mapping work using the latest DEFRA noise models[32]. Additional layers such as remoteness (using Naismith's Rule)[33] and dark skies (via NASA and CPRE data)[34] are used to provide extra nuance in the discussion. Edge effects from outside the park are considered by ensuring data overlap with the park boundary. Detractors are combined using a weighted multi-criteria evaluation (MCE)[35] to generate a comprehensive negative tranquillity surface across the LDNP. A local minimum value model is used to combine

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30 Carver, S. and Washtell, J., 2012, April. Real-time visibility analysis and rapid viewshed calculation using a voxel-based modelling approach. In GISRUK 2012 Conference, Lancaster, UK, Apr (pp. 11-13). https://www.geos.ed.ac.uk/~gisteac/proceedingsonline/GISRUK2012/Papers/presentation-48.pdf

31 https://www.ordnancesurvey.co.uk/products/os-terrain-50

32 https://www.gov.uk/government/publications/strategic-noise-mapping-2022/explaining-the-2022-noise-maps#noise-mapping-geographic-information-systems-gis-datasets

33 Carver, S. and Fritz, S., 2000. Munro-bagging with a computer...? Naismith's rule and the long walk in. The Scottish Mountaineering Club Journal, 191, pp.317-322.

34 https://www.cpre.org.uk/light-pollution-dark-skies-map/

35 Multi-criteria evaluation (MCE) in GIS is a process that combines multiple criteria and their assigned weights to analyze and make decisions about spatial problems. It is used to overlay different geographic layers and identify the most suitable locations for a specific objective, such as land suitability analysis, site selection, or urban planning. See Carver, S.J., 1991. Integrating multi-criteria evaluation with geographical information systems. International Journal of Geographical Information System, 5(3), pp.321-339. https://doi.org/10.1080/02693799108927858

contributors to create a surface showing spatial variation in positive tranquillity[36]. These are combined to produce an overall tranquillity map as a continuous surface.

A key goal is to establish a robust and repeatable framework for long-term tranquillity monitoring. The methodology is designed to be replicable using publicly available datasets and open-source tools, with outputs provided in accessible formats (e.g. GeoTIFFs). The report includes detailed documentation to enable future updates and citizen science integration. Ground-truthing through site visits and eco-acoustic monitoring is used to validate the model, ensuring accuracy and reliability. This framework allows stakeholders to track changes over time, assess the impact of development or tourism, whether specific interventions or at a general level, and support adaptive management strategies.

2.2 PART B. Combine Scientific Modelling with Public Input

Recognizing the subjective nature of tranquillity, the project uses participatory GIS (PGIS) to capture public perceptions of tranquillity across the park. Tools like Map-Me and Paper2GIS allow residents and visitors to map tranquil and disturbed areas, annotate their experiences, and express confidence levels. These inputs are analysed using a novel Dempster-Shafer-based method developed by Huck et al (2025)[37] to create probabilistic tranquillity surfaces, which can be compared with scientific models. Surveys are also used to assess the relative importance of different tranquillity factors, informing model weighting and highlighting areas of consensus or disagreement. This participatory approach ensures that the final outputs reflect both expert analysis and lived experience.

2.3 PART C. Acoustic monitoring

The project uses five key locations across the park defined by FLD staff to assess visual and acoustic conditions through field visits and monitoring. These sites are chosen to represent typical areas and those experiencing threats to tranquillity, and are documented with photographs, sound recordings, and field notes. At one case study site, where green lane use by off-road vehicles has been identified as a specific threat to tranquillity, four Song Meter SM4 Acoustic Recorders[38] have been deployed to collect continuous sound data. This is used to validate the acoustic models and help identify elements that enhance or detract from the soundscape, offering insights into environmental impacts and informing future management strategies.

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[36] A local MINIMUM model is used here as contributors are scaled 0-255 where high tranquillity is recorded by lower values and low tranquillity with higher values. This keeps the scaling of the contributors in the same range as those of the detractors.
[37] Dempster-Shafer theory (DST) is a framework for reasoning with uncertainty by combining evidence from multiple sources. Unlike traditional probability, DST assigns belief to sets of propositions, not just single events, which allows it to represent a state of "don't know". It calculates belief and plausibility values and uses a combination rule to merge independent pieces of evidence, making it useful in fields like artificial intelligence and risk assessment where information can be incomplete or conflicting. See: Huck, Jonathan J., Timna Denwood, and Joanna E. Taylor. "Decision making under uncertainty: increasing the impact of public Participatory GIS." International Journal of Geographical Information Science (2025): 1-21. https://doi.org/10.1080/13658816.2025.2518556
[38] https://www.wildlifeacoustics.com/products/song-meter-sm4

2.4 PART D. Case Studies to Support Planning, Policy, and Public Engagement

The tranquillity map and monitoring framework serve as practical tools for planning, policy-making, and public engagement. By identifying areas of high and low tranquillity, the project can help guide development decisions, conservation priorities, and visitor management strategies. Case studies and storytelling are used to communicate findings in an accessible and compelling way, combining spatial data with photographs, sound recordings, and personal narratives. Outputs can be tailored for use by Friends of the Lake District (FLD) and other stakeholders, including visual materials for campaigns and policy advocacy. Ultimately, the project aims to raise awareness of tranquillity as a vital landscape quality and empower communities to protect and enhance it.

Further detail on methods used are provided in the next section.

3. Methods and results

The project is divided into four main parts as shown in the flow chart below (Figure 3.1):

Figure 3.1 Flow chart of methods used

3.1 Part A: Spatial Modelling

Mapping of tranquillity for the LDNP is based on a structured spatial modelling approach that integrates both negative and positive environmental factors. Two primary models are developed: detractors and contributors. The detractors model identifies elements that diminish tranquillity, such as visual intrusions and anthropogenic noise. This is achieved through (a) viewshed analysis, which maps the visibility of natural versus human-made features in the landscape, and (b) noise models that estimate soundscapes influenced by road and rail traffic, as well as aircraft activity. These components are weighted within a multi-criteria evaluation (MCE) model to reflect their relative impact on perceived tranquillity. The contributors model highlights features that enhance the tranquillity of the landscape. This includes mapping contributors using a maximum value approach, which identifies areas with the highest potential for positive sensory experiences. These two models - detractors and contributors - are combined using a simple, equally weighted multi-criteria method to produce a comprehensive tranquillity map for the park. Weights from the previous CPRE work based on public input are used here (Table 3.1). This final output provides a spatial representation of tranquillity across the park, supporting planning, conservation, and visitor management strategies.

In addition to visual and acoustic factors, the spatial modelling work incorporates other key dimensions of tranquillity which are then used in the Part D case study and storytelling component to better understand the spatial context of tranquillity measures. These include remoteness, topographic openness and dark skies. Remoteness is assessed using walking time and access data, offering insight into the perceived isolation of different areas. This helps identify locations that provide a sense of escape and solitude. Topographic openness considers the degree of enclosure and scale within a landscape using relative amount of sky and terrain visible from any location across the park. Dark skies are also considered, with light pollution mapping used to evaluate the potential for stargazing and night-time serenity. These supplementary factors enrich the overall tranquillity model, ensuring a holistic understanding of the sensory and experiential qualities of the landscape.

Together, these integrated datasets form a robust evidence base for evaluating and enhancing tranquillity within the LDNP, aligning with broader goals of sustainable landscape management and visitor experience improvement.

Results from the mapping of individual detractors and contributors and their combined mapping are given below, together with a brief non-technical description of how they we generated.

3.1.1 Detractors

Mapping of detractors is divided into two basic categories: visual and auditory. Visibility of a range of landscape detractors including linear features (roads and railway lines), built environment (masts, wind turbines, power transmission pylons and poles, buildings and structures), and human land use (urban or built-up areas, plantation forestry). Auditory impacts from human noises sources are limited to consideration of road noise and numbers of people/visitors.

Visibility is modelled here using the Viewshed Explorer software with Open Street Map (OSM), NE Living England[39] land cover or publicly available OS Mastermap data[40], together with the Ordnance Survey (OS) Terrain 50 digital elevation model (DEM). The Viewshed Explorer model is an advanced viewshed model that models the visual impact of a feature based on area and proportion of the feature that is visible taken intervening terrain and distance decay effects into account. The further away a feature is from the observer, the less impact it will have.

[39] https://www.gov.uk/algorithmic-transparency-records/natural-england-living-england
[40] https://www.openstreetmap.org/

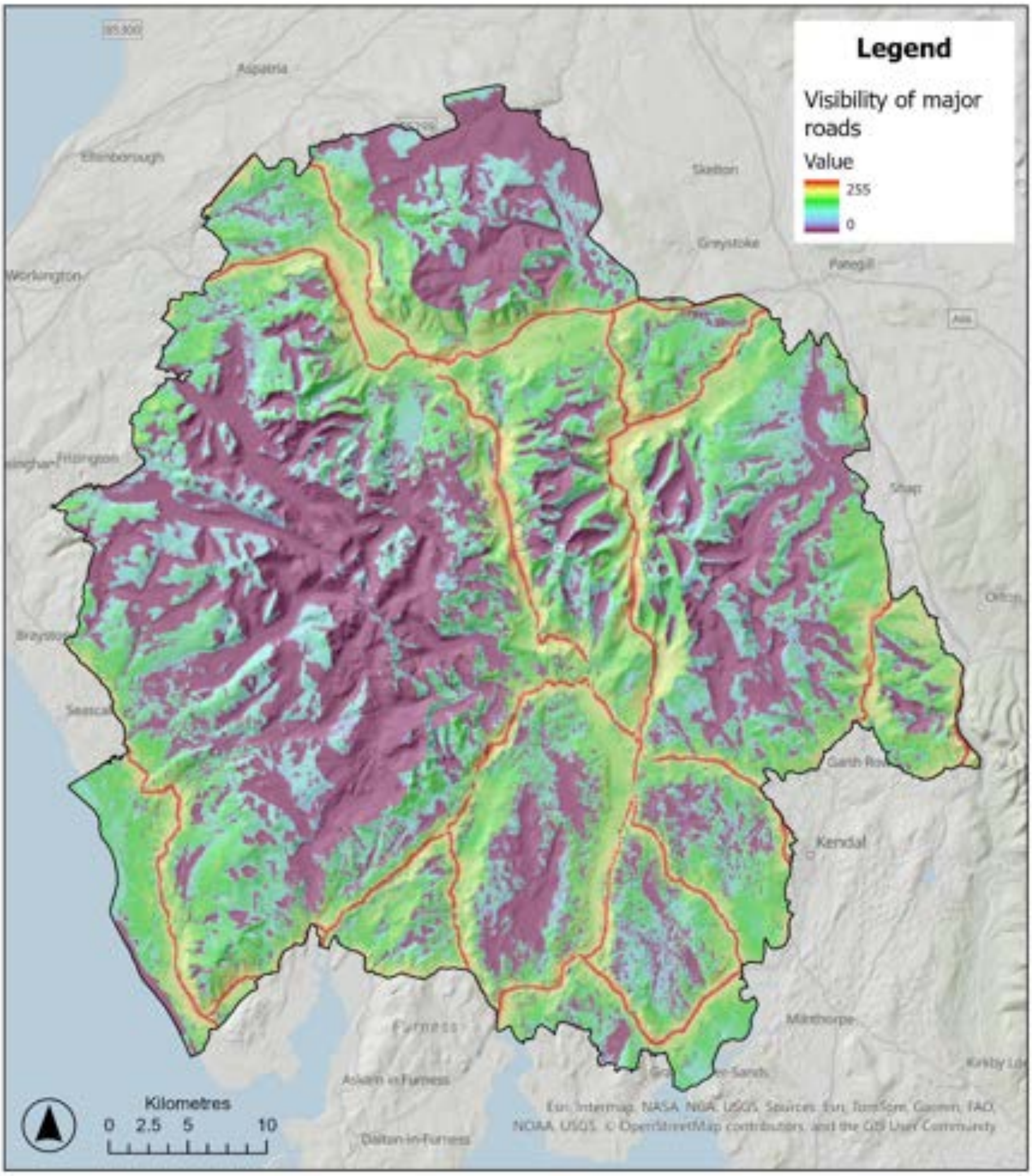

Figure 3.2 Visibility of major roads

Visibility of major roads: Visibility of major roads together with the traffic they carry is a significant detractor for measures of tranquillity. Figure 3.2 above shows the visibility of major roads based on OSM data. Visibility is standardised on 0-255 scale where 0 (purple) is zero visibility and 255 (red) is maximum visibility. This map illustrates how several large core mountain areas of the central northern and eastern fells are largely shielded from views of major roads by the intervening topography.

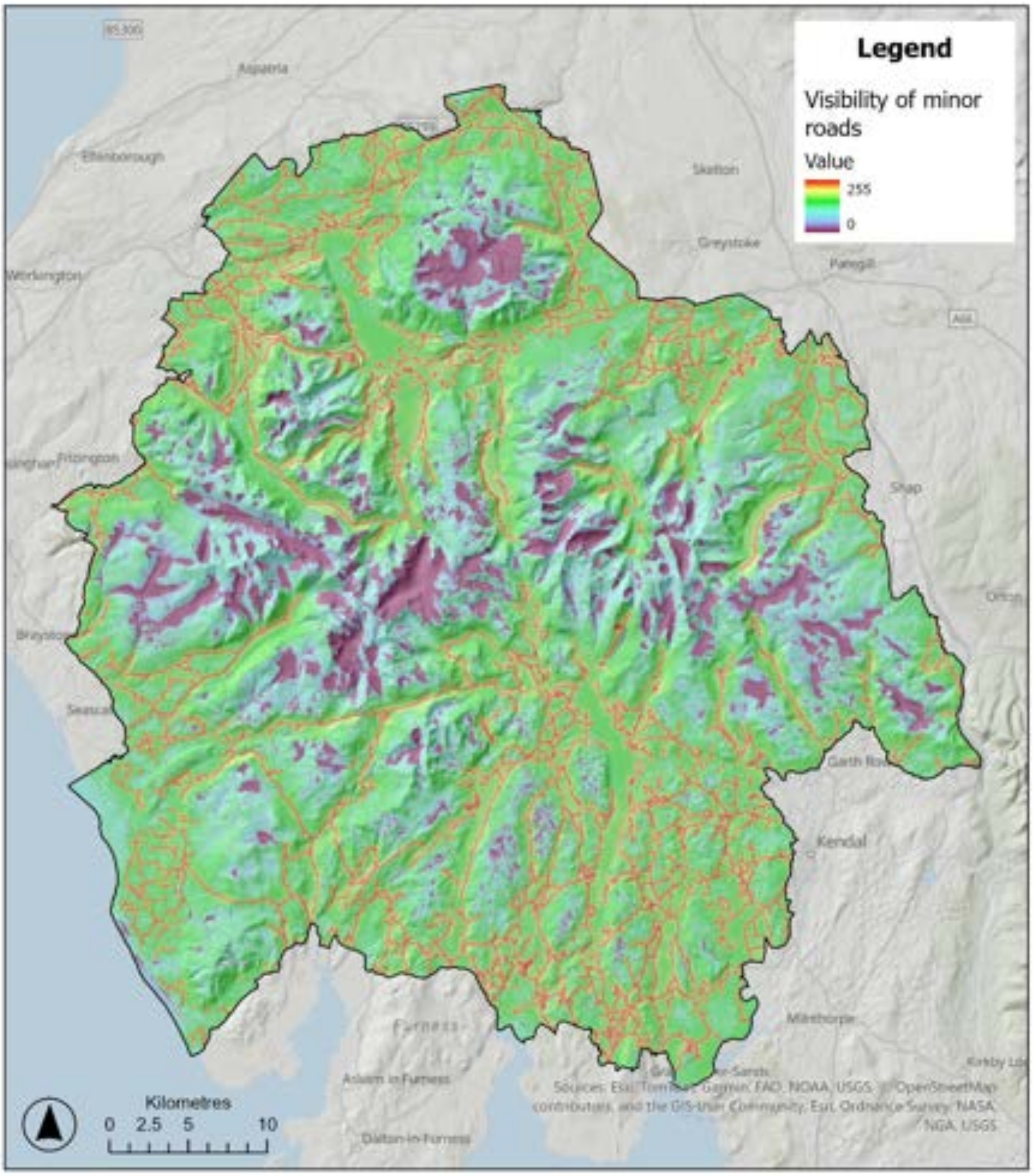

Figure 3.3 Visibility of minor roads

Visibility of minor roads: Visibility of minor roads is modelled in the same way as for major roads but restricted to B and unclassified roads as depicted in the OSM data. These are shown in Figure 3.3. Being greater in number, the visibility of minor roads is more prevalent across the LDNP, though significant areas of the central, northern and eastern fells remain free of views of minor roads.

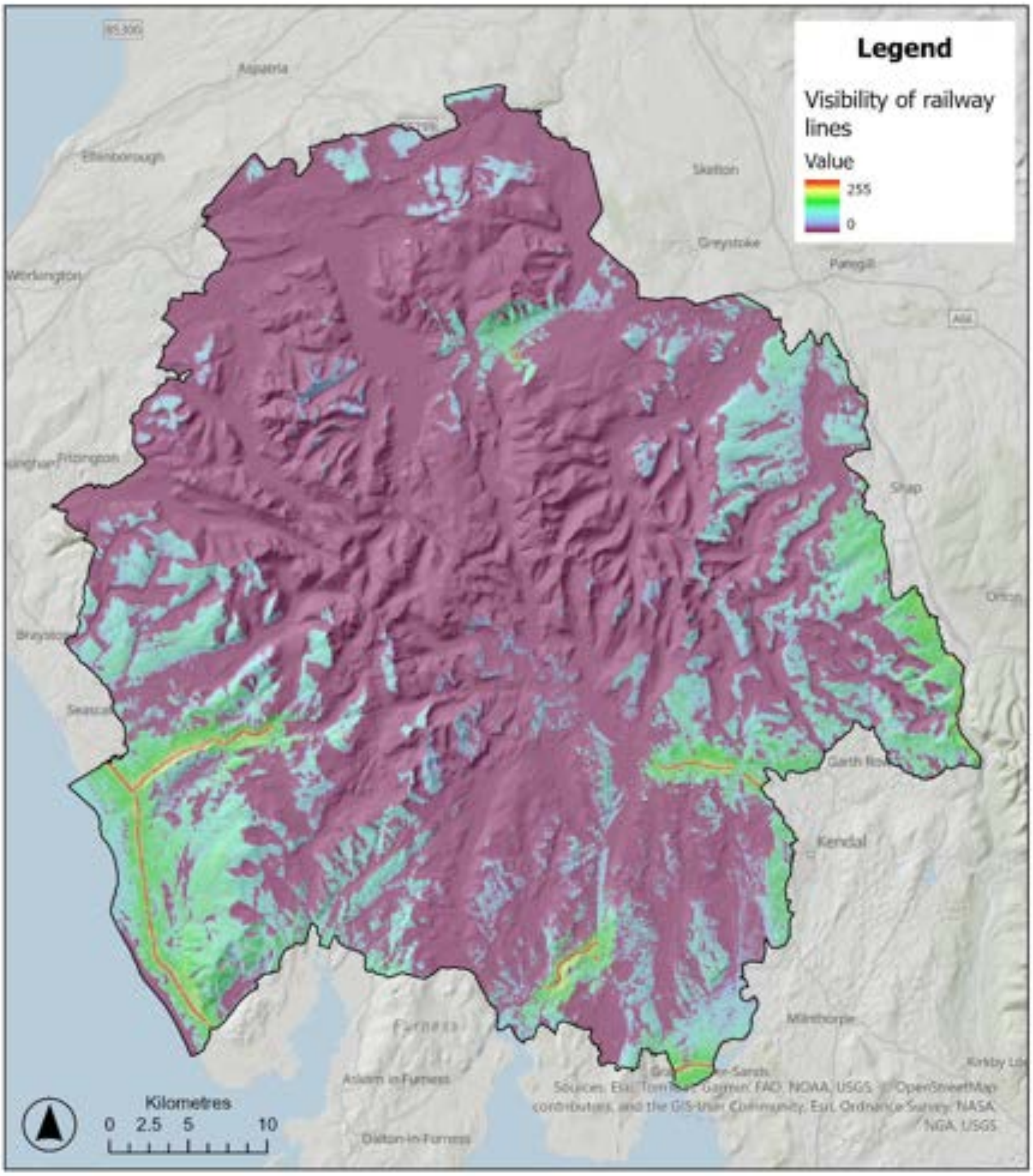

Figure 3.4 Visibility of Railways

Visibility of railway lines: Visibility of railway lines is modelled in the same way as for major and minor roads. These are shown in Figure 3.4. There are relatively few active railways lines in the LDNP. As a result, large areas of the park remain free of views of a railway line; the major area of impact being the coastal line along the southwestern edge of the park with additional impact from the Windermere line.

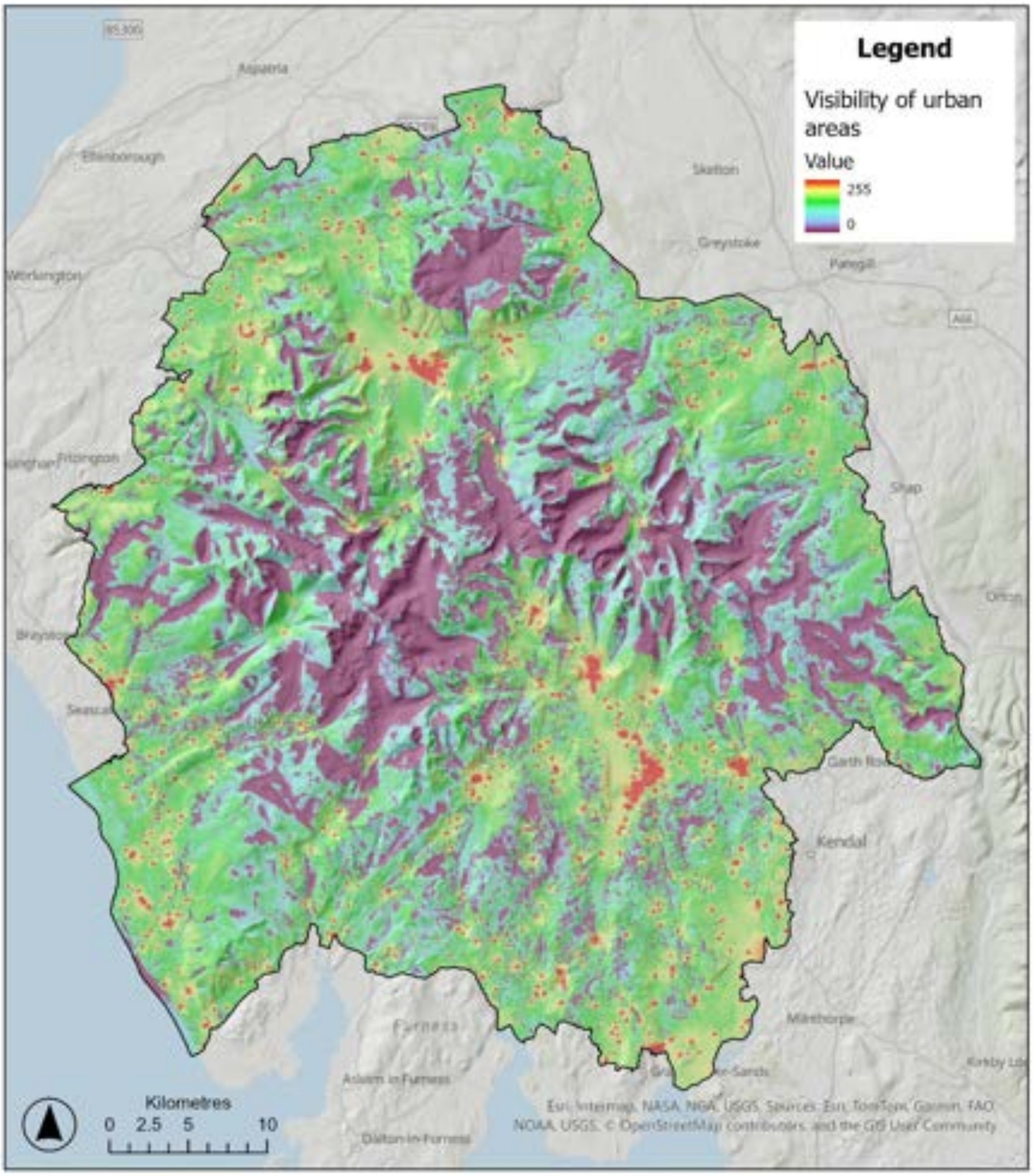

Figure 3.5 Visibility of Urban Areas

Visibility of urban areas: Urban areas are scattered across the park with major urban areas focused on Keswick, Ambleside/Windermere and Staveley with visible towns just outside the park including Kendal and Lindale. Here, urban land cover is extracted from the Natural England (NE) Living England land cover dataset. This is used to show the visual impact of urban areas across the park.

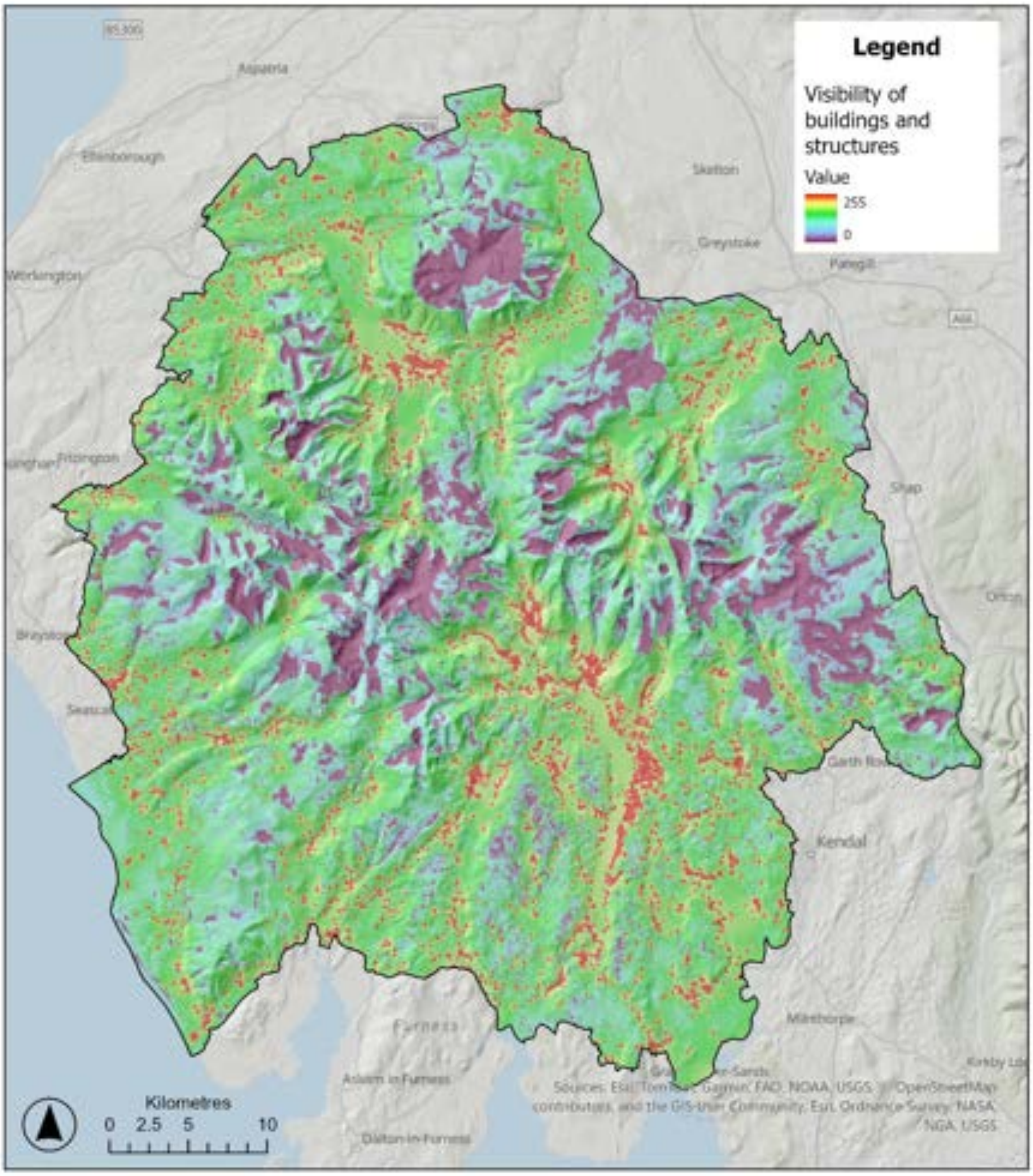

Figure 3.6 Visibility of buildings and structures

Visibility of buildings and other structures: There are a wide range of buildings and structures across the park. These extend beyond urban areas and include farm buildings, quarry structures, service stations, etc. The OS Mastermap building outlines[41] data are used to model visual impact of these on tranquillity across the park. This is shown in Figure 3.6 and while the patterns are like those in Figure 3.5, this shows a much wider distribution of impact than the urban areas alone due to the scattered nature of other non-urban buildings and structures.

[41] https://automaticknowledge.co.uk/resources/#GBBuildings

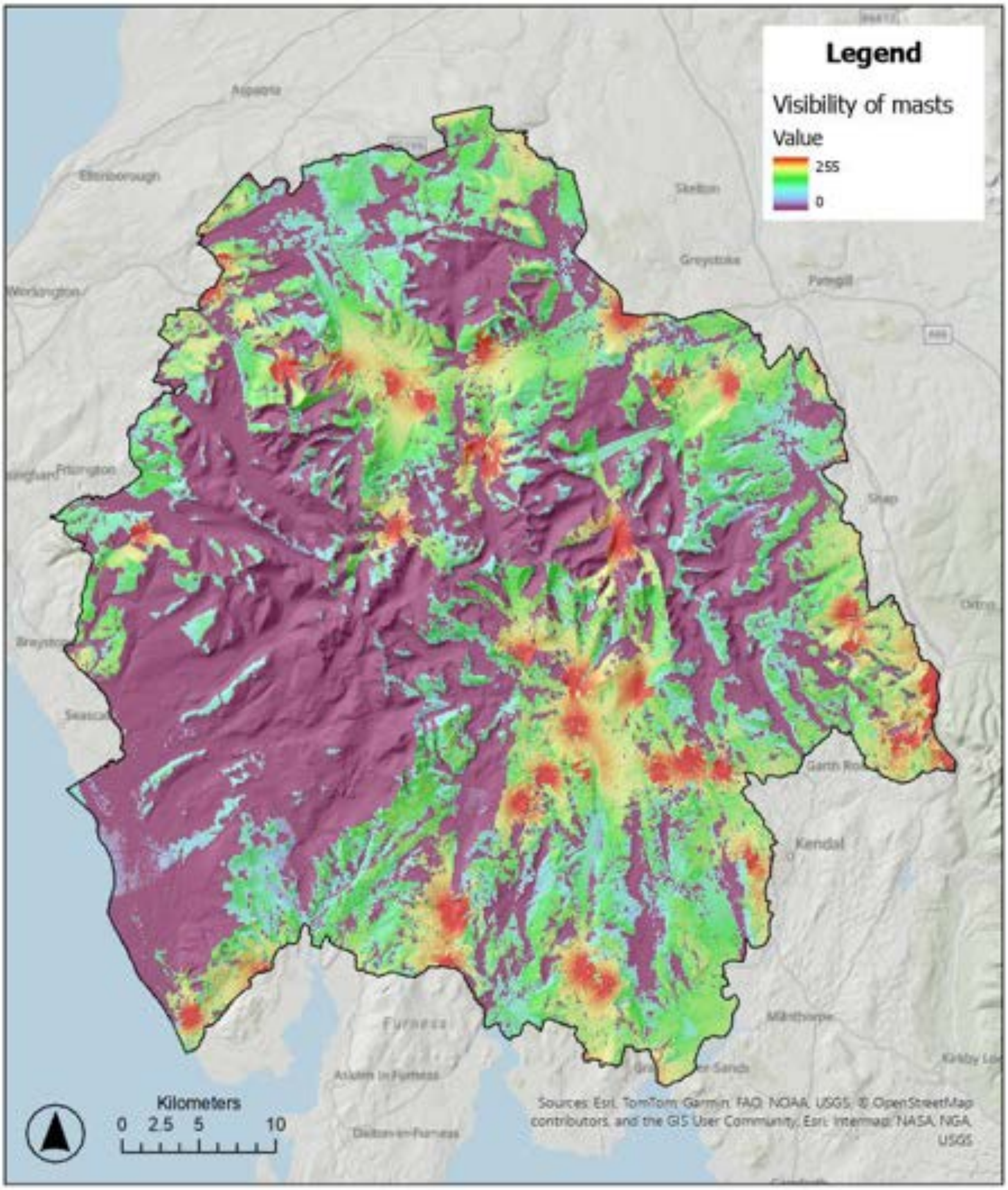

Figure 3.7 Visibility of Masts

Visibility of communication masts: There are several communications (cell or mobile phone) masts across the park. Visibility of these is calculated using the same methods as above from OSM data[42]. This is shown in Figure 3.7.

[42] Accessed via https://overpass-turbo.eu/

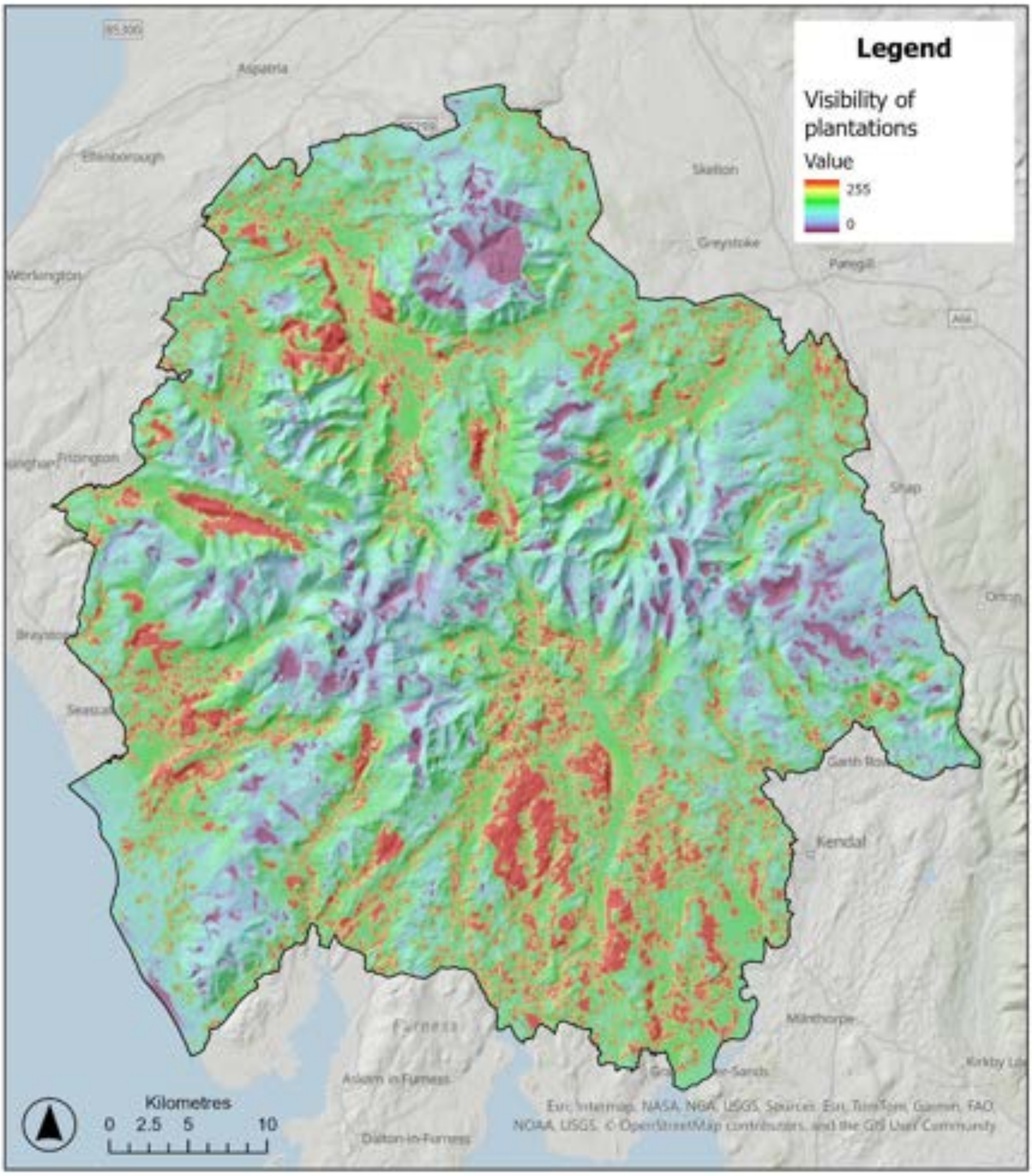

Figure 3.8 Visibility of plantation forestry

Visibility of plantation forestry: Plantations of non-native conifer appear throughout the park but dominate certain areas such as Eskdale/Miterdale Forest, Duddon valley, Winlatter Pass, Matterdale and Thirlmere, but by far the largest complex of plantation forest is Grizedale in the Furness Fells. Ennerdale also has substantial amounts of plantation forest but much of this is being replaced by more native woodland as part of Wild Ennerdale 'rewilding' project[43]. Plantation forestry is assumed to have a negative impact on sense of tranquillity due to its dark, straight-edged outline in the wider landscape appearing as an obviously non-natural land use.

[43] https://www.wildennerdale.co.uk/

Distribution of plantation forestry is taken from the NE Living England land cover data. The pattern of visual impact from plantation forestry is shown in Figure 3.8.

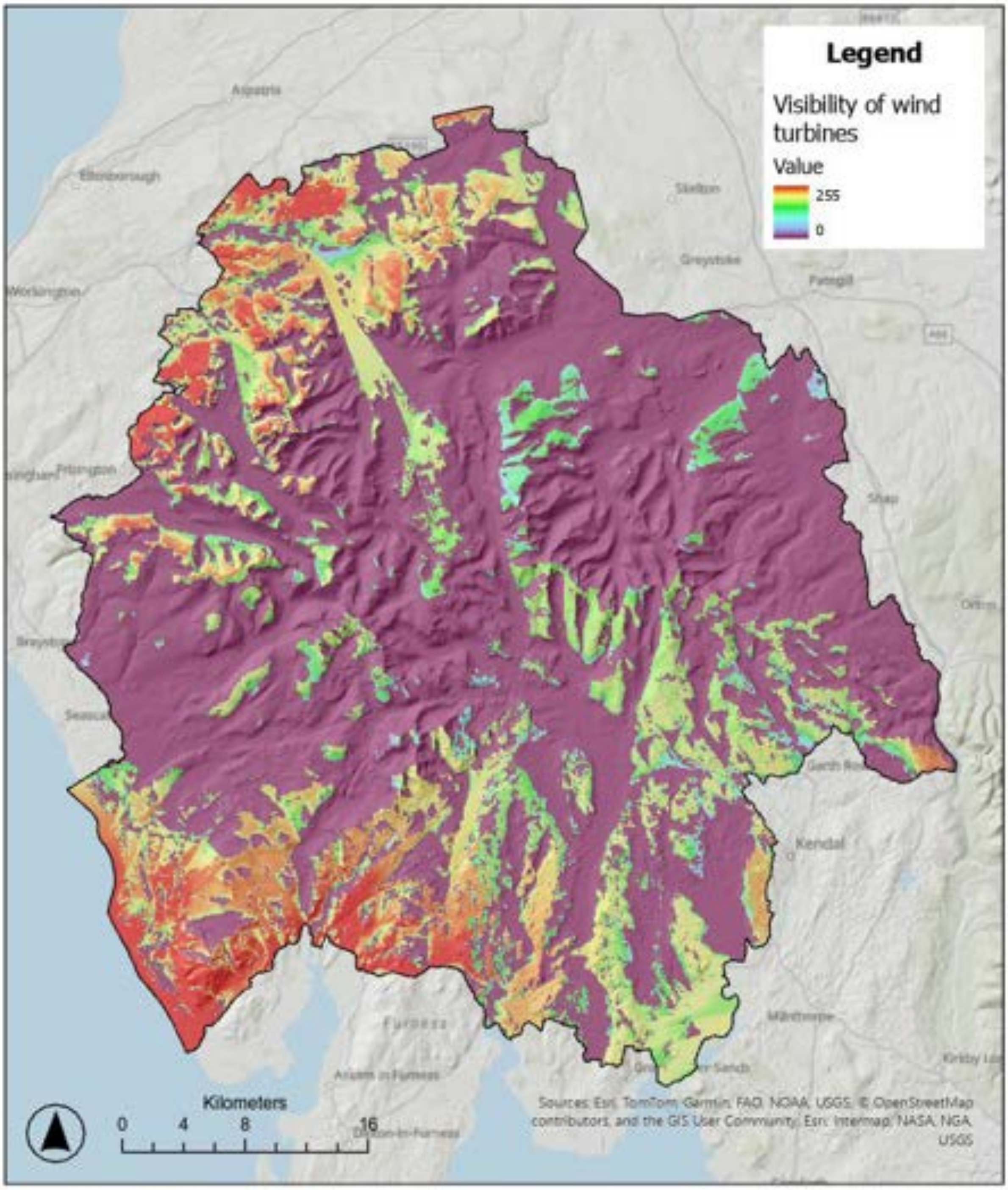

Figure 3.9 Visibility of wind turbines

Visibility of wind turbines: While there are very few wind turbines within the park, and those that do fall within the park boundary are small (20m to blade tip or less), the park is nonetheless surrounded by some significant wind farm developments including the very large arrays offshore at Walney Island and Robin Rigg. Viewshed search radius is increased to 30km for the purpose of these analyses given the size (and motion) of industrial wind turbines. Visibility of wind turbines across the park is shown in Figure 3.9. Small scale individual turbines such as commonly found at farms are not modelled and merge with building visibility in Figure 3.6.

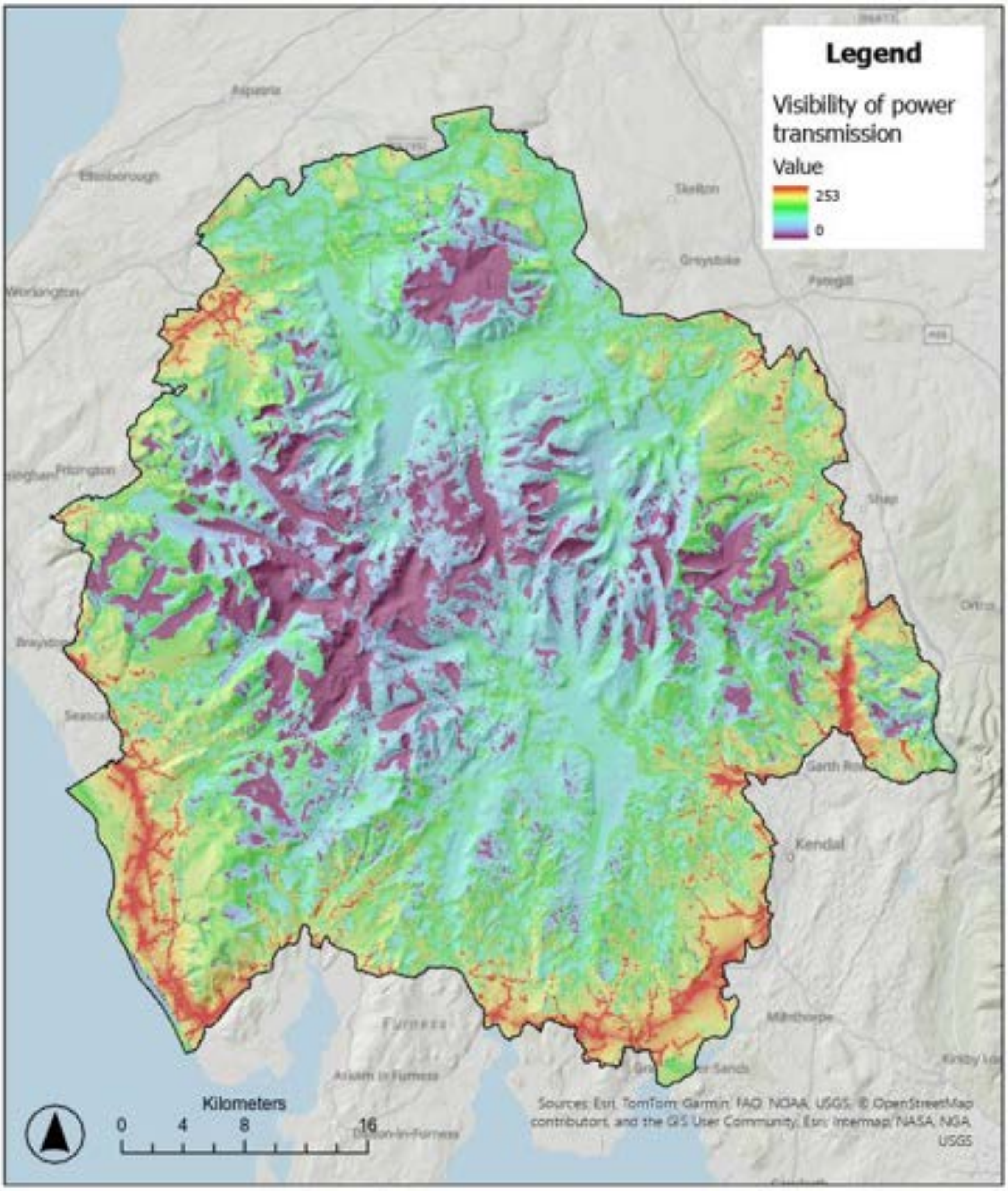

Figure 3.10 Visibility of power transmission infrastructure

Visibility of power transmission infrastructure: There are two types of power transmission infrastructure within the park; high voltage pylons between 20 and 50m in height, and power distribution poles up to 8m in height. Viewsheds are calculated for all power transmission pylons and poles across the park. These are shown in Figure 3.10.

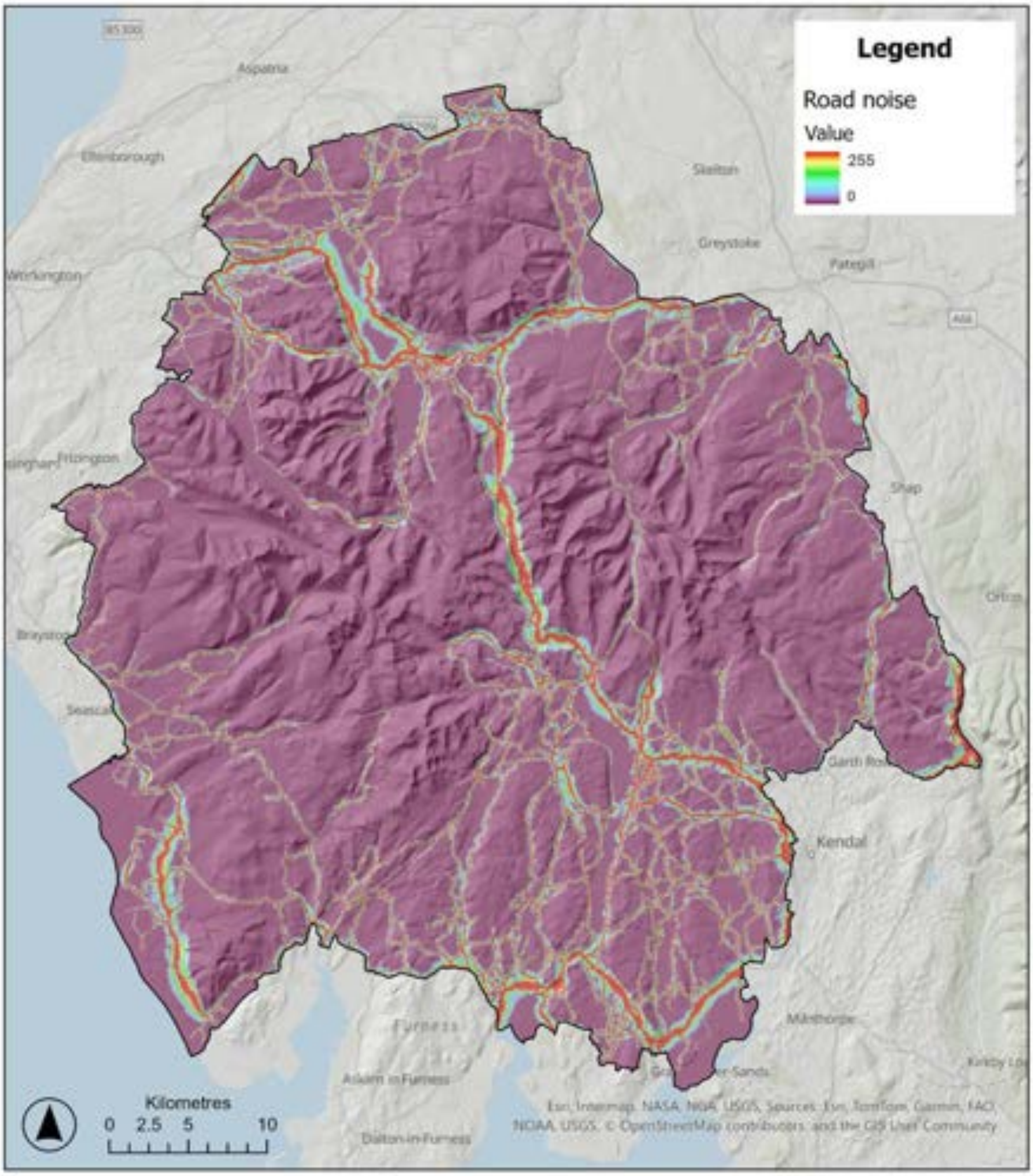

Figure 3.11 Road noise

Road noise: Noise from roads is assumed to have significant impact on tranquillity across the park. Noise from roads is based on DEFRA noise models[44] and shown in Figure 3.11.

[44] https://www.gov.uk/government/publications/strategic-noise-mapping-2022/explaining-the-2022-noise-maps#noise-mapping-geographic-information-systems-gis-datasets

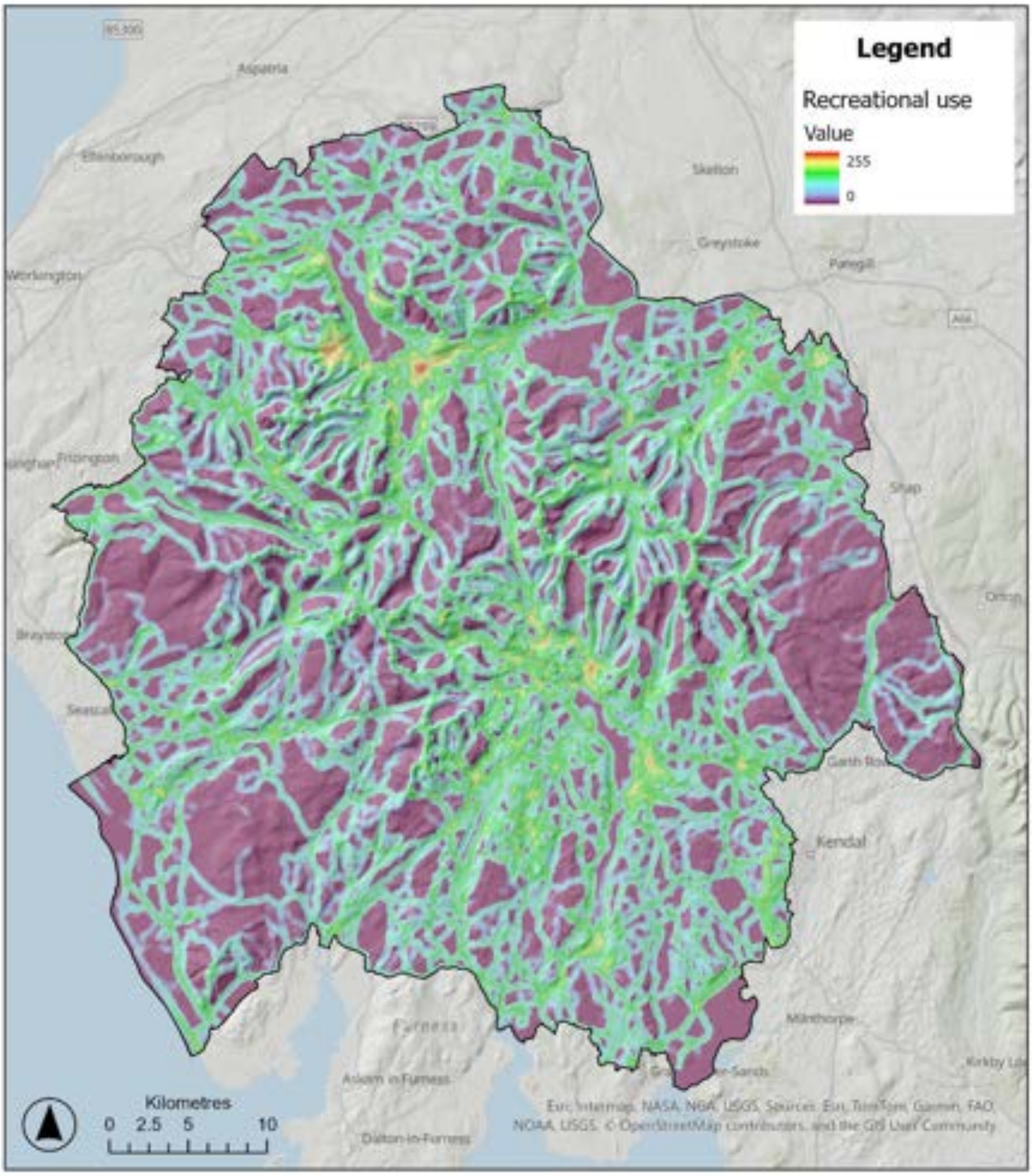

Figure 3.12 Recreational use

Recreational use: Large numbers of visitors/users in popular areas or routes within the park are assumed to have a negative impact on tranquillity through reducing opportunity for solitude and associated noise. Strava heatmap data[45] is used to provide a broad picture of the density of recreational use across the park revealing both hotspots of recreational use such as Whinlatter Pass and visitor concentrations in and around the attractions of the major towns such as Keswick, Ambleside, Windermere/Bowness, Newby Bridge and Pooley Bridge, along with a range of popular walking routes and peaks such as Blencathra, Helvellyn, The Langdale Pikes and Sca Fell. This is shown in Figure 3.12.

[45] https://www.strava.com/maps/global-heatmap

Table 3.1 Detractors and weights

Layer	***Description***	***Data source***	***Notes***	***Weight***
Urban	Built up areas including residential and industrial areas.	Living England Landcover (altered in house)	Sense check of dataset performed to correct errors. Viewshed analysis conducted using ViewshedExplorer software.	0.15
Conifer Plantation	Non-natural planted coniferous forest	Living England Landcover (altered in house)		0.04
Buildings	Individual buildings outside of urban areas.	Open Roads building footprint data combined with .gov lidar dataset.	Lidar surface data extracted based on building footprint, maximum building height added to height model used for viewshed.	0.1
Rail	Rail infrastructure.	OpenStreetMap rail data.	Rasterised at 50m resolution, viewshed performed.	0.05
Big Roads	Major roads.	OpenStreetMap roads data.		0.15
Small Roads	Minor roads and tracks.	OpenStreetMap data.		0.05
Communication Masts	Masts and towers.	OpenStreetMap point data.		0.04
Power Transmission	Power pylons and poles	OpenStreetMap point data.		0.06
Wind Power	Wind turbines	OpenStreetMap point data.		0.06
Road Noise	Area in which road noise can be heard above 35 decibels.	.gov Strategic noise mapping (2022).	Raster generalised to 50m.	0.15
Recreational use	Relative popularity of areas for recreational use inc. foot, cycle and water sports.	Strava heatmap data.	Screen grabbed and mean use calculated within 250m radius.	0.15

Visual and acoustic impact zones: All nine detractor maps are combined using a simple weighted linear summation MCE model to identify patterns in areas of high and low tranquillity across the park. The weights used are derived from the earlier public consultation exercises[46]. These are listed in table 3.1.

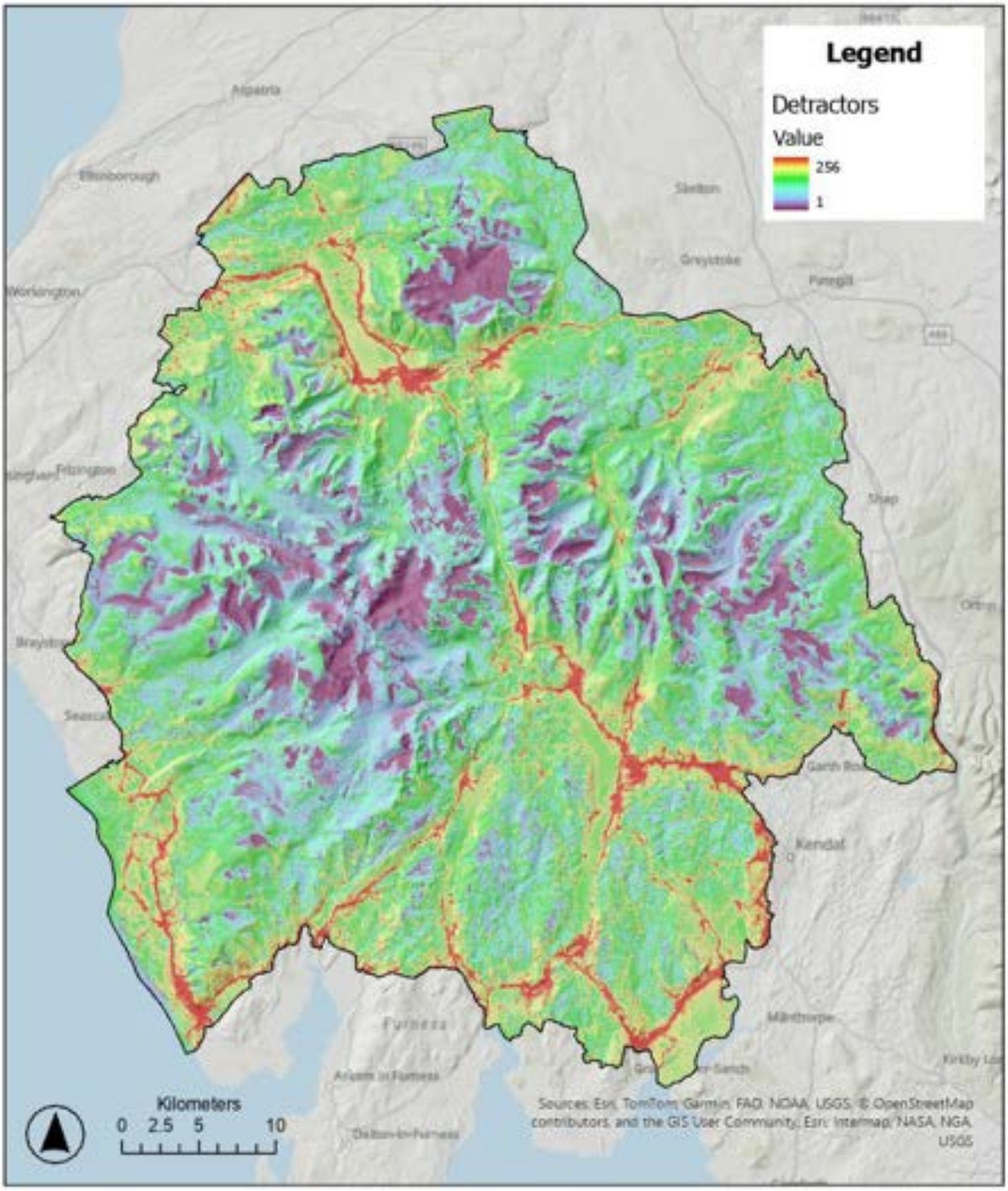

Figure 3.13 Detractors

[46] CPRE, Natural England, Blue Marble, 2024. Discover tranquillity: Understanding the public's perception of tranquillity. Overview: https://www.cpre.org.uk/explainer/why-tranquillity-matters-for-the-future-of-the-countryside/

Figure 3.13 shows the overall patterns of tranquillity in the park based on combination of the eleven detractors in Figures 3.2-3.12 using the weights listed in Table 3.1. Obvious patterns emerging from this analysis are the ribbons and nodes of low tranquillity within the principal transportation corridors and major settlements. These include the A590/5092/595 around the southern edge of the park, the A592/591 Newby Bridge-Windermere-Ambleside-Keswick corridor, and the A66 Penrith-Keswick-Cockermouth corridor. Areas of high tranquillity are the northern fells beyond Skiddaw and Blencathra, the central fells around Sca Fell, Great Gable, the Langdale Pikes, Upper Borrowdale, and the eastern fells centred around the Shap Fells and High Street. Several other tranquil areas stand out in the less popular and isolated valleys of Copeland Forest (e.g. Nether Beck and River Bleng), and Matterdale Common (e.g. Deepdale).

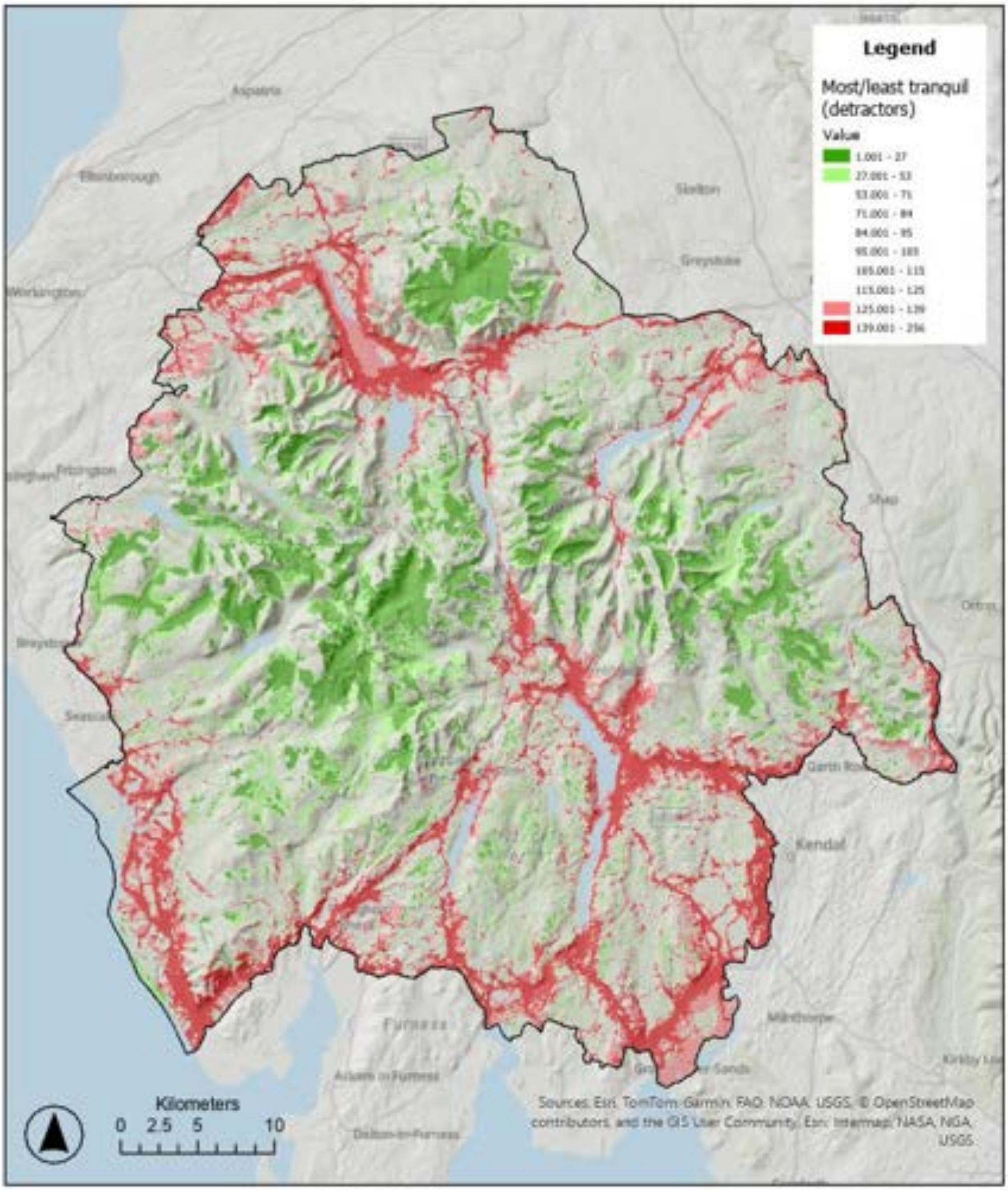

Figure 3.14 Most and least tranquil areas (detractors)

Figure 3.14 shows the top 10 and 20% most tranquil areas along with the bottom 20 and 10% least tranquil areas based on a reclassification of the map in Figure 3.13. Low numbers in dark green (top 10% most tranquil) and light green (top 20% most tranquil) indicate low impacts from detractors, while high numbers in red (bottom 10% or least tranquil) and pink (bottom 20%) indicate high impacts from mapped detractors.

3.1.2 Contributors

Contributors to tranquillity within the park are based around visibility of certain land cover types; namely, sea, open water, native woodland and open fell. These are deemed to have an overall positive impact on tranquillity based on their contribution to key aspects of landscape character associated with the park and its heritage. These were modelled using land cover data drawn from NE Living England land cover data together with the OS terrain 50 DEM data and the Viewshed Explorer software with a search radius of 5km. To maintain compatibility with the detractors mapping these data are scaled using 0 = high tranquillity and 255 = low tranquillity. These are described below.

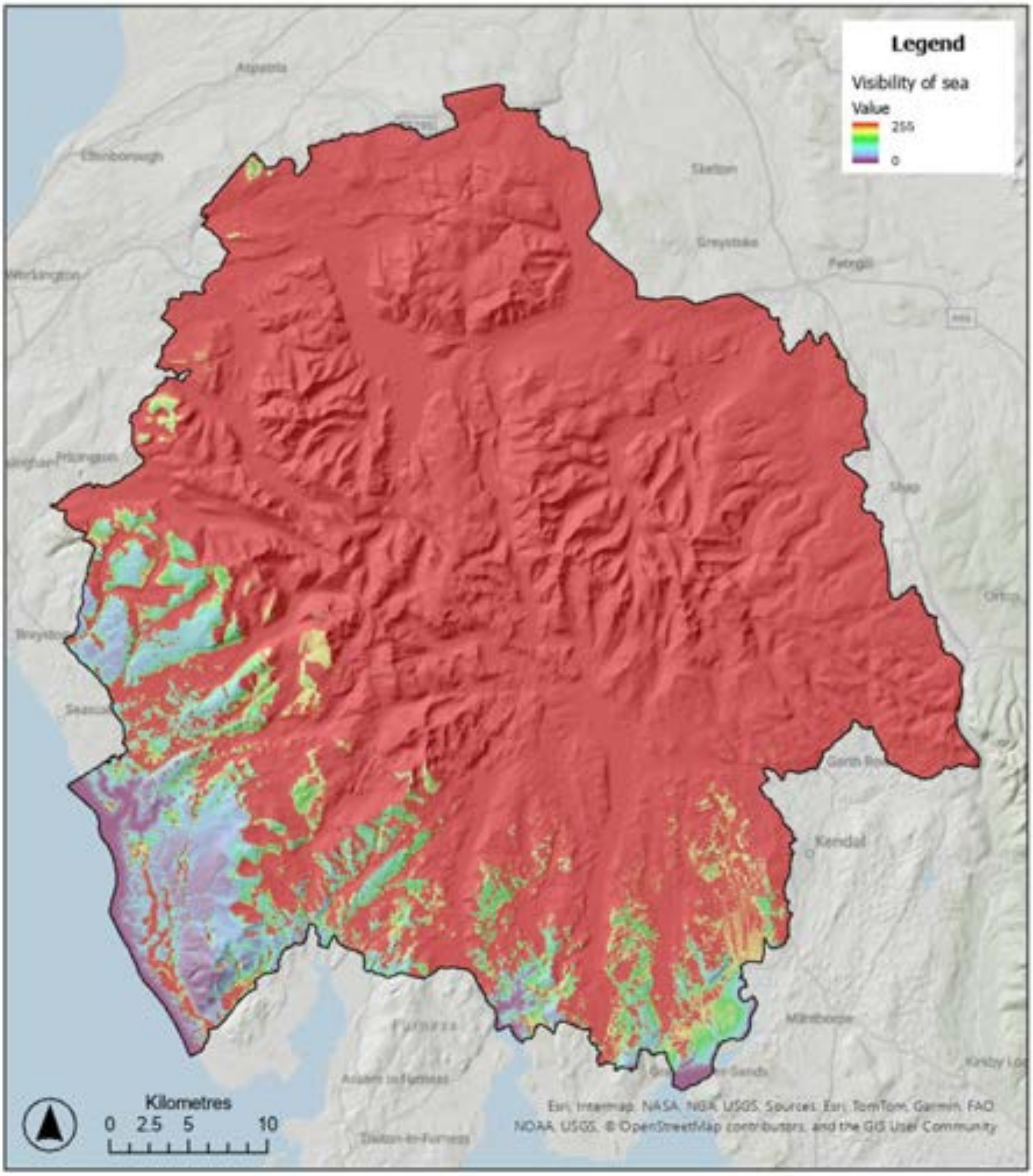

Figure 3.15 Visibility of sea

Visibility of sea: Views out to sea have long been associated with tranquillity and measures of landscape character, particularly in an island national like the UK. Sea views are predominantly experienced in the southern and southwestern edges of the park as shown in Figure 3.15.

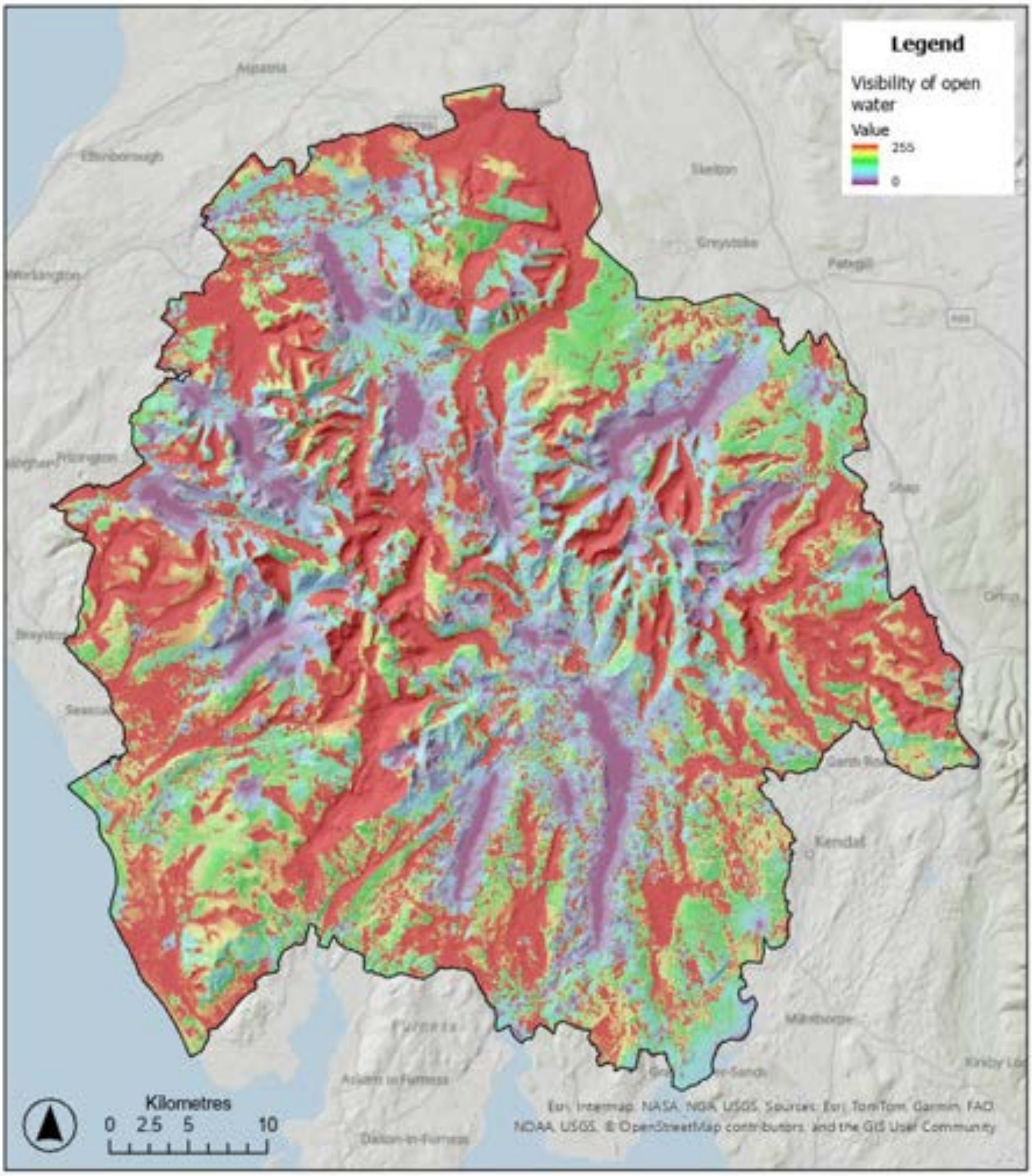

Figure 3.16 Visibility of open water

Visibility of open water: The Lake District is internationally renowned for its eponymous lakes, such that views of open water across the park's lakes, meres, tarns and waters is redolent of a tranquil landscape. Visibility of open water bodies across the park is modelled using open water bodies extracted NE Living England land cover data. High tranquillity is naturally found on and overlooking the park's many lakes as can be seen in Figure 3.16.

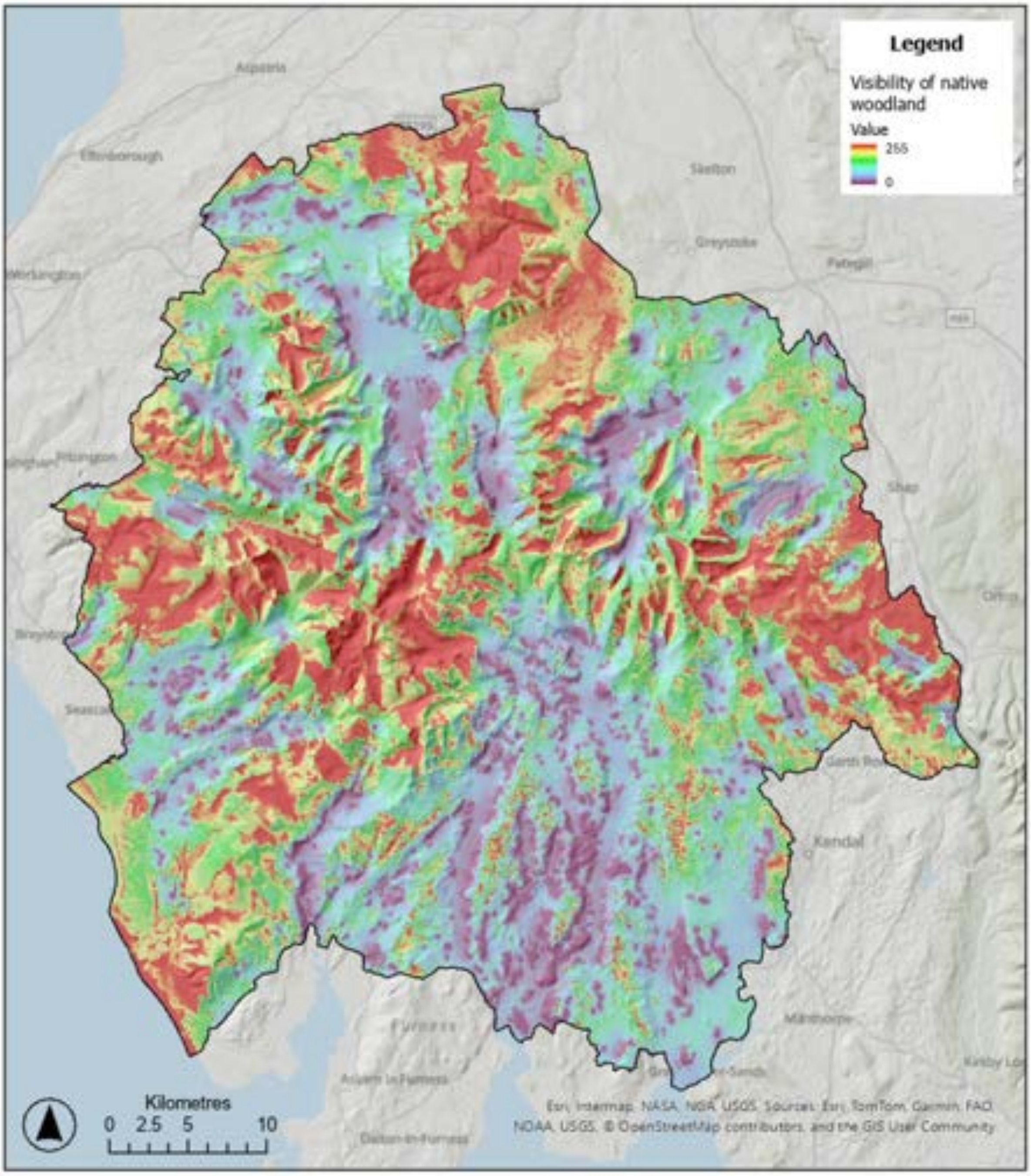

Figure 3.17 Visibility of native woodland

Visibility of native woodland: As opposed to views of non-native plantation forestry, views of native woodland are another contributing factor to landscape tranquillity in the park. Often found on the steeper slopes and on valley floors in some valleys, the pattern seen in visibility of native woodland is quite varied with some areas having very few areas of native woodland and others exhibiting much more. These pattern can be seen in Figure 3.17.

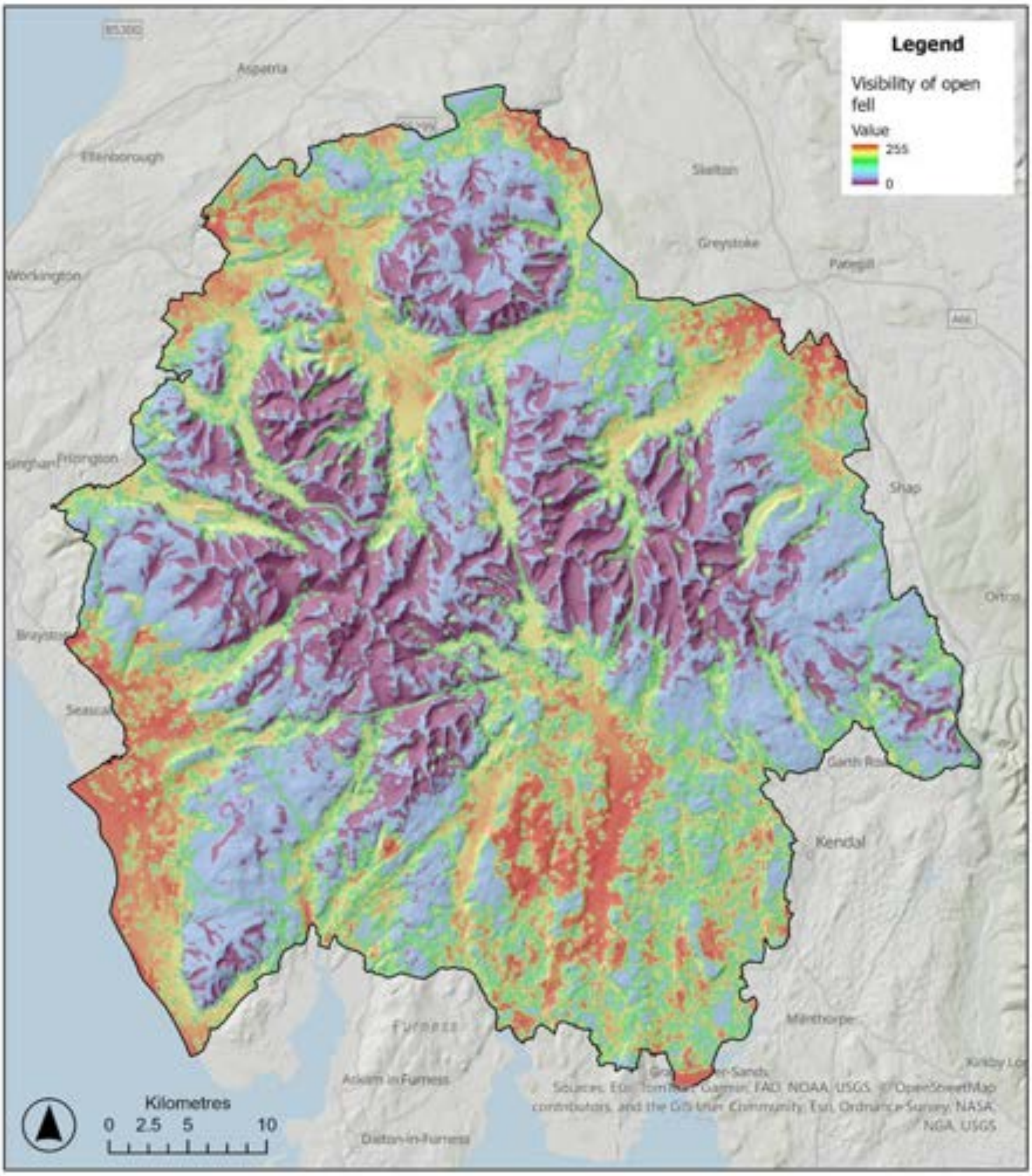

Figure 3.18 Visibility of open fell

Visibility of open fell: The fells, alongside the lakes, are the other primary landscape element associated with the park. Views of open fell are modelled using land cover data from NE Living England dataset and the results are shown in Figure 3.18.

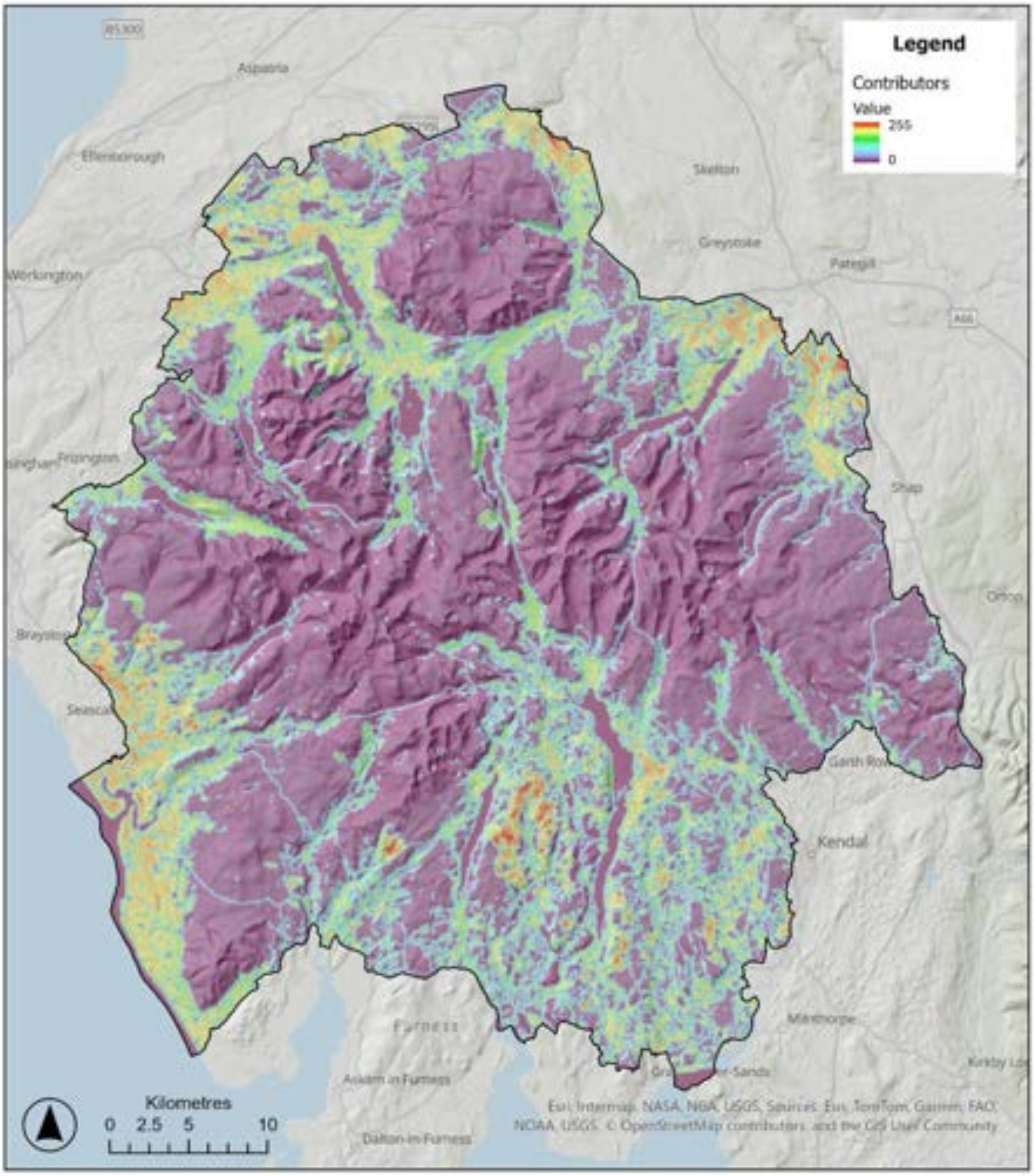

Figure 3.19 Contributors

Figure 3.19 shows the pattern of contributors to tranquillity across the park based on a MINIMUM value local cell statistic. This finds the highest tranquillity value on a point-by-point basis (bearing in mind that low values equal high tranquillity landscape score to match the values in the detractors mapping). High landscape tranquillity areas are seen in the central, northern, eastern and western fell areas and low tranquillity in the principal transport/settlement corridors and coastal plains.

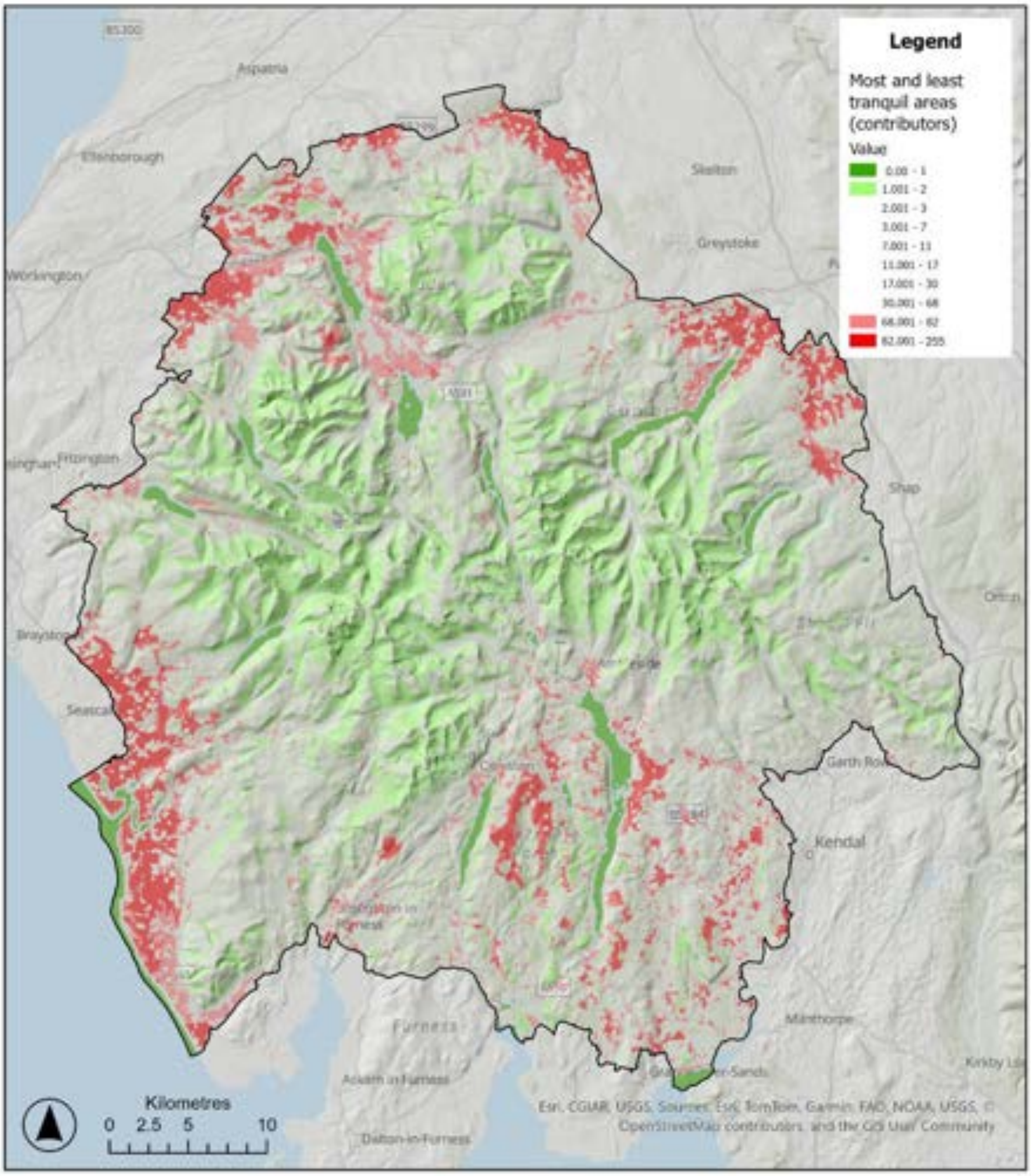

Figure 3.20 Most and least tranquil areas (contributors)

Figure 3.20 shows the top 10 and 20% most tranquil areas along with the bottom 20 and 10% least tranquil areas based on a reclassification of the map in Figure 3.19. Low numbers in dark green (top 10% most tranquil) and light green (top 20% most tranquil) indicate high contributor tranquillity, while high numbers in red (bottom 10% or least tranquil) and pink (bottom 20%) indicate low contributor tranquillity.

3.1.3 Overall tranquillity

An overall index of tranquillity is created by combining the detractors and contributors maps in an equally weighted overlay with lower values indicating higher tranquillity.

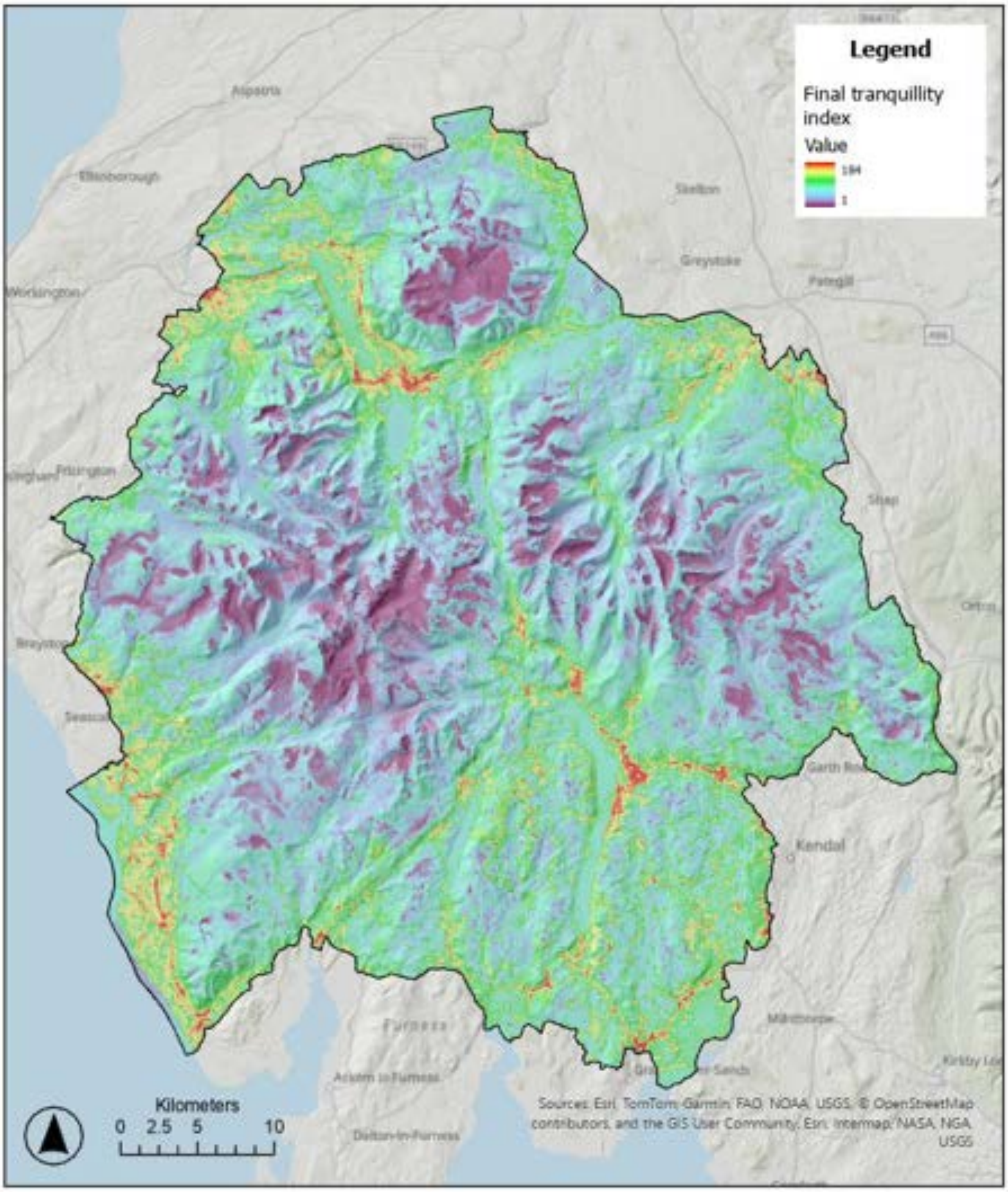

Figure 3.21 Final Tranquillity Index

The final tranquillity index is shown in Figure 3.21 above. This is based on the equal combination of the detractors and contributors maps in Figures 3.13 and 3.19 respectively. As per these two components the most tranquil areas in the park are found in the central, northern, eastern and western fells, particularly in the higher areas and heads of more remote and less visited valleys.

The least tranquil areas are the principal transport/settlement corridors and coastal plain of the southwestern edges of the park.

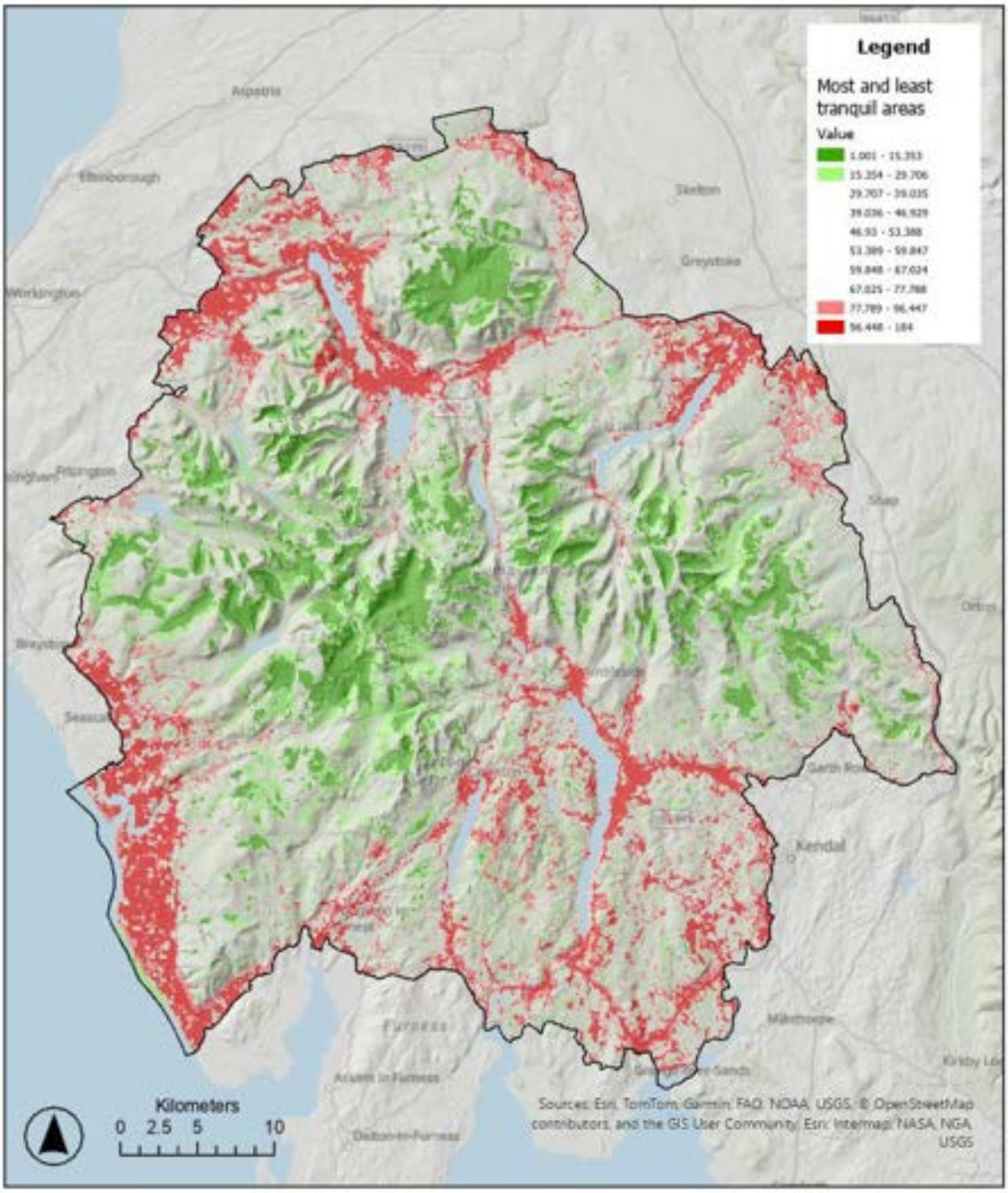

Figure 3.22 Most and least tranquil areas

An overall most and least tranquil areas map is shown above in Figure 3.22. This shows the top 10 and 20% most tranquil areas along with the bottom 20 and 10% least tranquil areas based on a reclassification of the map in Figure 3.22. Low numbers in dark green (top 10% most tranquil) and light green (top 20% most tranquil) indicate high overall tranquillity, while high numbers in red (bottom 10% or least tranquil) and pink (bottom 20%) indicate low overall tranquillity.

3.1.4 Sensitivity analyses

In any complex analysis involving multiple criteria based on data from various sources, modelled using different methods and with different user weights, it is good practice to perform a sensitivity analysis to determine the degree of variability in the outputs based on criteria choice and user specified weights. Here, two sensitivity analyses are carried out, one to test the potential effects of user-specified weights, and the other to test criteria choice. A bootstrapping approach using Monte Carlo Simulation[47] is used to test for the possible effect of uncertainty in user-specified model weights, while a jack-knifing approach or "leave one out" analysis is used to explore the impact of criterion choice in the tranquillity models[48].

While both the bootstrapping analysis (Figure 3.23) and jack-knifing analysis (Figure 3.24) indicate variability in the top 10% most tranquil areas, there is a high degree of consistency in the core tranquil areas across the park, particularly in the high fells and smaller, more remote and less-frequented valleys. There is some variation across the park around the edge of the core areas as might reasonably be expected with a sensitivity analysis of this nature. This is not of undue concern and simple demonstrates the fuzzy nature of model weights and layer selection.

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[47] Monte Carlo simulation is a computational technique that uses repeated random sampling to predict the probability of different outcomes in uncertain situations. By creating a model and running thousands of simulations with random inputs, it provides a range of possible results to help analyse risk and make informed decisions. See: Openshaw, S., Charlton, M. and Carver, S., 1991. Error propagation: a Monte Carlo simulation. Handling geographical information: methodology and potential applications, pp.78-101.

[48] A jack-knifing sensitivity analysis is a statistical technique that repeatedly recalculates a statistic while leaving out one data point or study at a time to assess its influence on the overall results. By comparing the results of each iteration, it helps identify the effect of individual data points or studies and ensures the findings are robust and not overly sensitive to a single outlier. This method is useful for assessing bias and standard error.

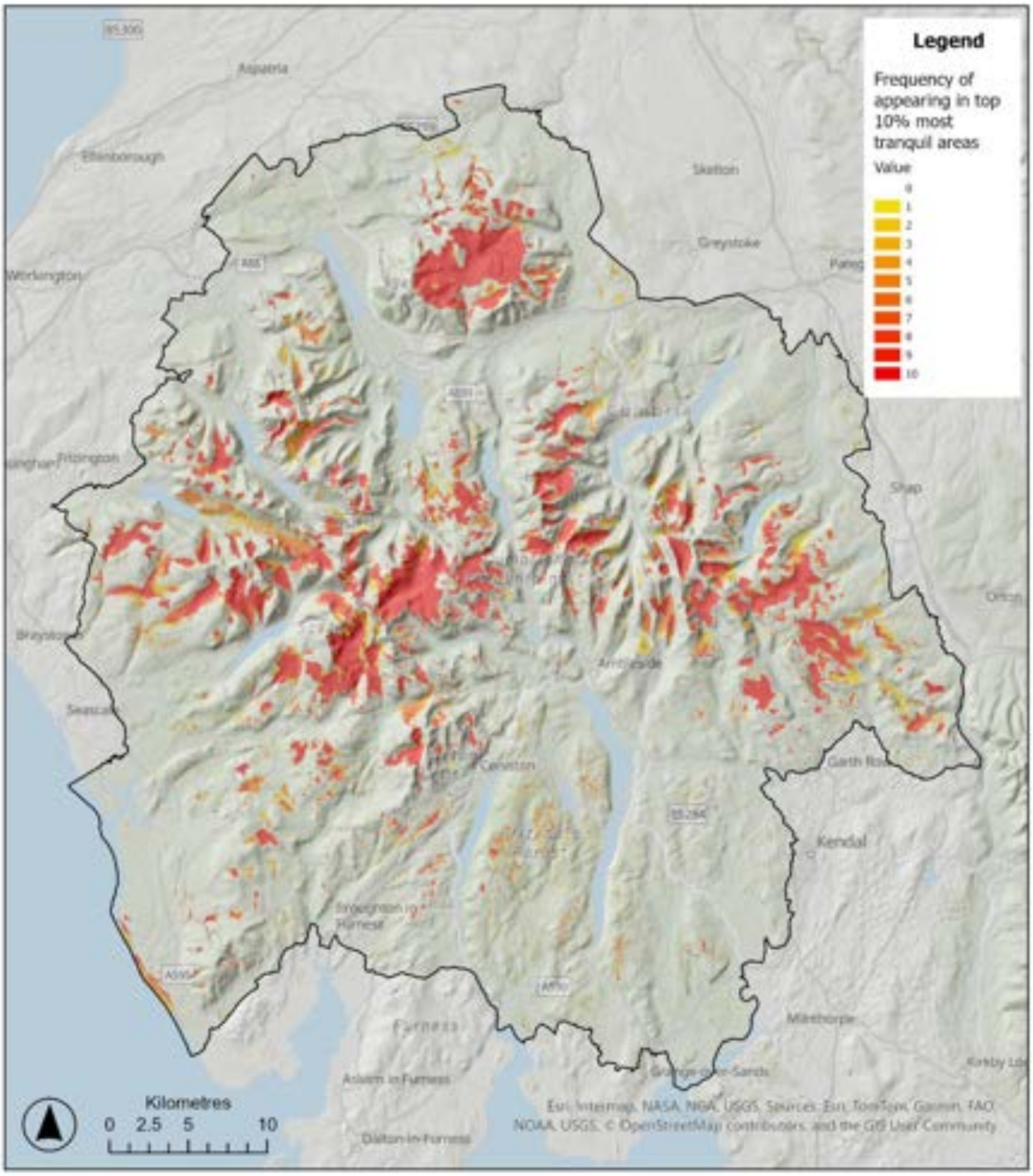

Figure 3.23 Bootstrapping (Monte Carlo) analysis showing robust tranquil areas

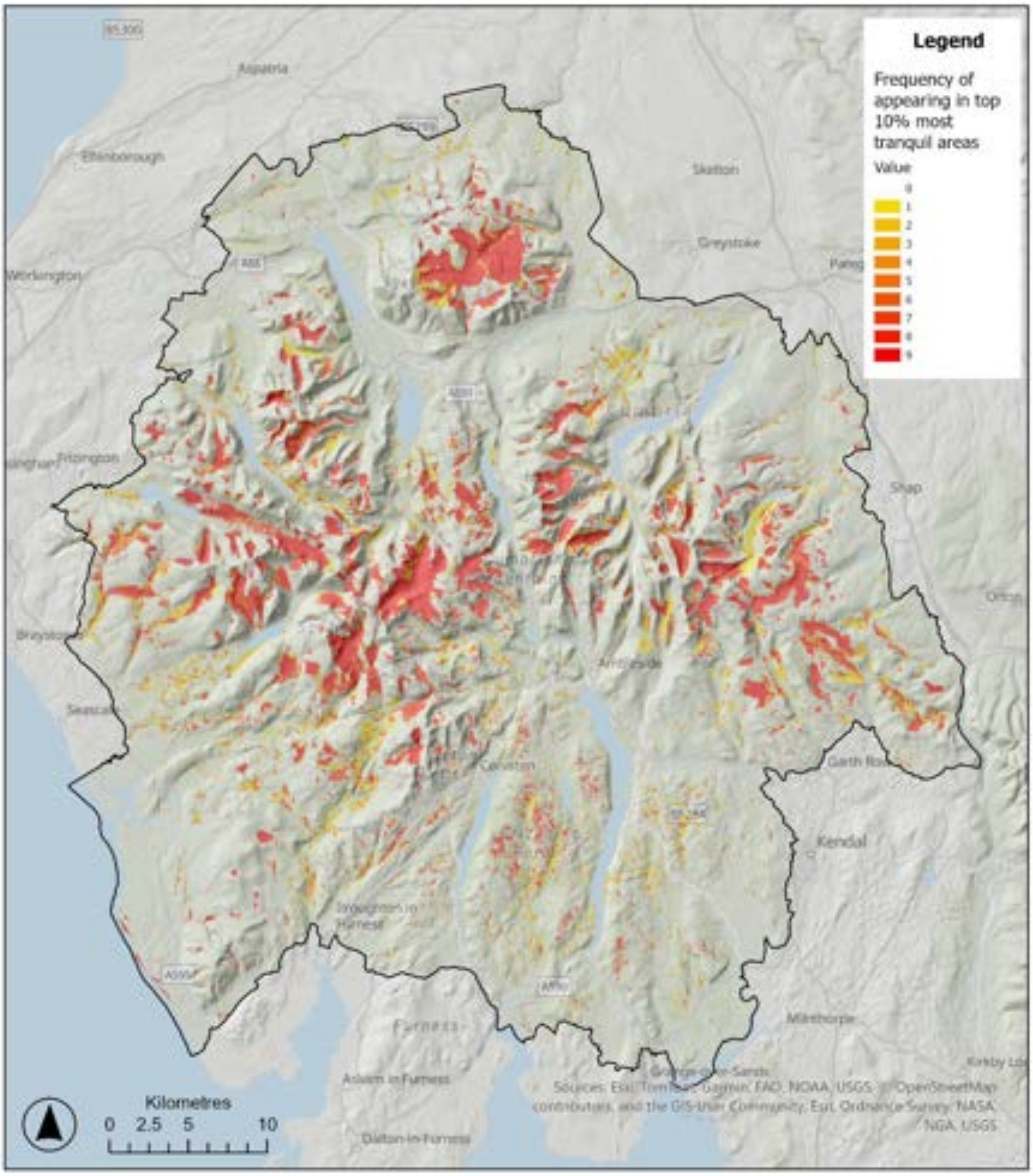

Figure 3.24 Jack-knifing (leave one out) analysis showing robust tranquil areas

3. 2 Part B: Participatory Mapping (PGIS)

3.2.1 Data Collection

As described above, Participatory GIS data were collected using two separate tools:

- **Map-Me:** a digital tool based on Google Maps with a 'spray can' (or 'airbrush') interface that allows people to identify locations by spraying 'paint' onto the map. The map is fully interactive, allowing users to add data at any scale. This was the primary data collection approach.
- **Paper2GIS:** a paper-based tool that allows participants to draw onto a paper map using a marker pen. The map is then photographed and the markup is automatically extracted from the map and loaded into a GIS dataset. Maps were provided at two scales, one with the LDNP on a single sheet (Appendix 2a), and a set of four one with a quarter of the LDNP on each sheet (e.g., Appendix 2b). This was a secondary data collection approach, primarily intended to provide an accessible option for those who do not have the equipment, skills, or inclination to engage meaningfully with a digital map interface.

Both surveys were preceded by the same demographic questionnaire (provided in Appendix 1), and then asked two questions:

Map-Me:

- *"Please use the spray can to spray the areas of the Lake District that you would describe as tranquil"*
- *"Please use the spray can to spray the areas of the Lake District that you would describe as not tranquil"*

In both cases, participants were asked to provide a short text statement explaining why they thought each location was tranquil, and to rate their level of confidence on a scale of 1-10.

Paper2GIS:

- *"Please outline areas of the Lake District that you would describe as tranquil"*
- *"Please outline areas of the Lake District that you would describe as NOT tranquil"*

In this case participants were not asked for any further information, in support of the desire for maximised accessibility.

3.2.2 Participant Data

Participant recruitment was the responsibility of Friends of the Lake District, with most participants recruited via The FLD mailing list, and at events attended by FLD (e.g., Westmorland County Show). Social media was used to share the survey to a wider audience. Following cleaning and checking, valid data were collected from 124 participants, of which 99 completed the survey using Map-Me, and 25 using Paper2GIS.

Women were slightly overrepresented against a conventional population (68%), which is common in studies like this. The distribution of ages was very good, but with a slight underrepresentation of younger age groups against a conventional population, which is expected given the recruitment strategy. Both are illustrated in Figure 3.25.

It is also perhaps expected that participants generally engaged in pursuits such as walking, swimming, cycling and climbing when in the LDNP; were either resident or regular visitors to the LDNP, and felt a strong or very strong connection to the Lake District landscapes.

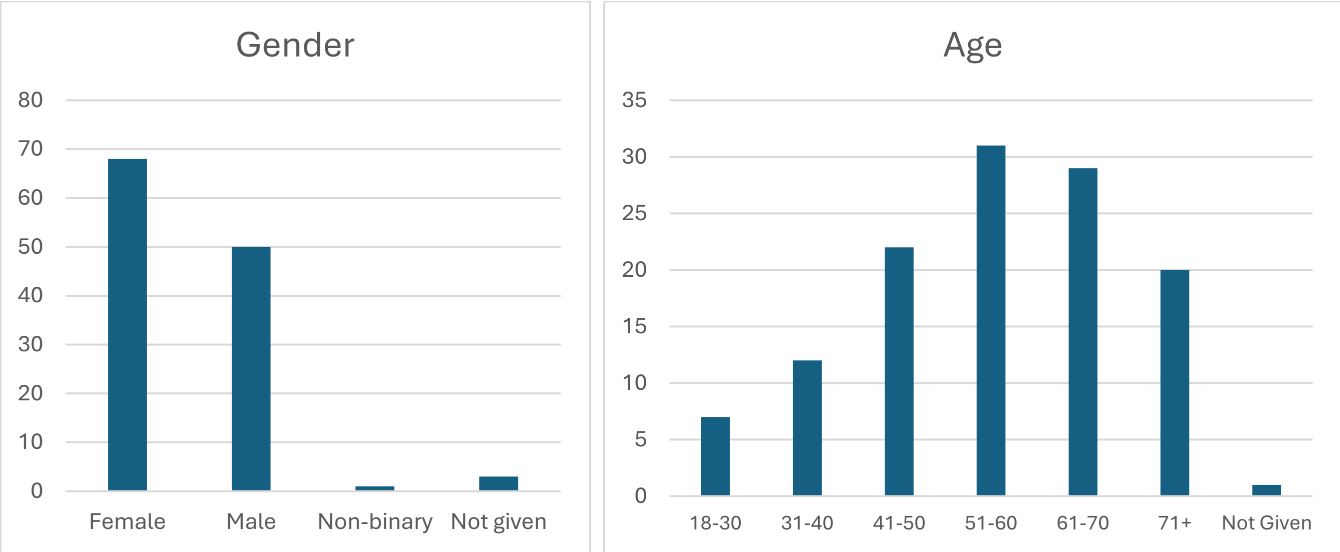

Figure 3.25 Charts showing the gender and age distributions of the PGIS participants

3.2.3 PGIS Results

Areas identified as tranquil and not tranquil by the 99 Map-Me participants are illustrated in Figure 3.25. This map uses a combination of transparency and colour composite operation (after Huck et al., 2019)[49] to allow both variations in spray density and locations of disagreement to be easily visualised. In the latter case, the 'multiply' colour composite operation is used, which is analogous to the way in which a desktop printer works: areas in which the tranquil (cyan) and not tranquil (magenta) coincide in similar amounts are easily identified as the colours 'mix' to form dark blue.

The patterns identified by the participants clearly focus perceptions of 'tranquillity' toward the high fells, and 'not tranquillity' towards the main roads (A66, A590 and A591 all clearly visible in magenta), settlements (Windermere, Bowness, Ambleside, Grasmere, Keswick) and tourist hotspots (Derwent Water, Ullswater, Coniston). Disagreement between participants is typically found at locations on the interface between the key 'tranquil' and 'not tranquil' zones, though there are some locations in which there is evidence of genuine disagreement between participants (e.g., in the vicinity of Borrowdale).

Very similar patterns are also reflected in the data collected from the 25 Paper2GIS participants, which is presented using the same approach in Figure 3.26. The only notable difference is that the smaller volume of data means that disagreements are not very prominent.

[49] Huck, J. J., Whyatt, J. D., Dixon, J., Sturgeon, B., Hocking, B., Davies, G., ... & Bryan, D. (2019). Exploring segregation and sharing in Belfast: A PGIS approach. *Annals of the American Association of Geographers*, *109*(1), 223-241. https://doi.org/10.1080/24694452.2018.1480930

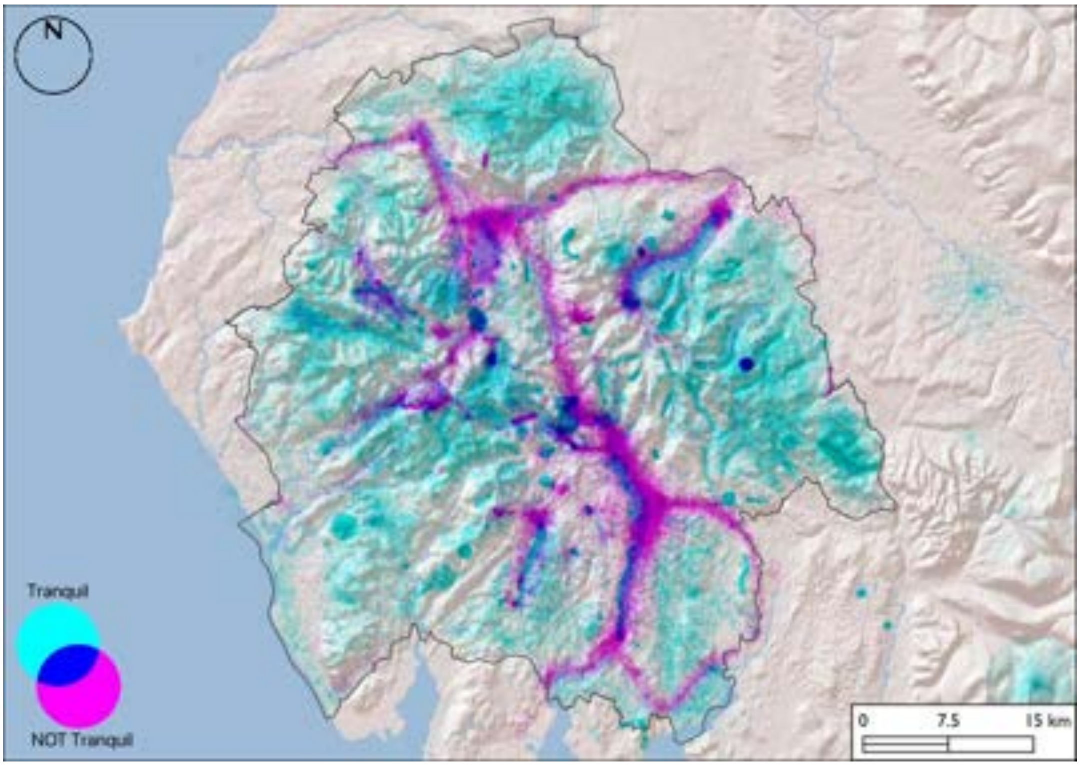

Figure 3.26 Map visualising the ‘raw’ Map-Me data collected from 99 participants illustrating areas of tranquillity (cyan), not tranquillity (magenta), and disagreement between participants (dark blue).

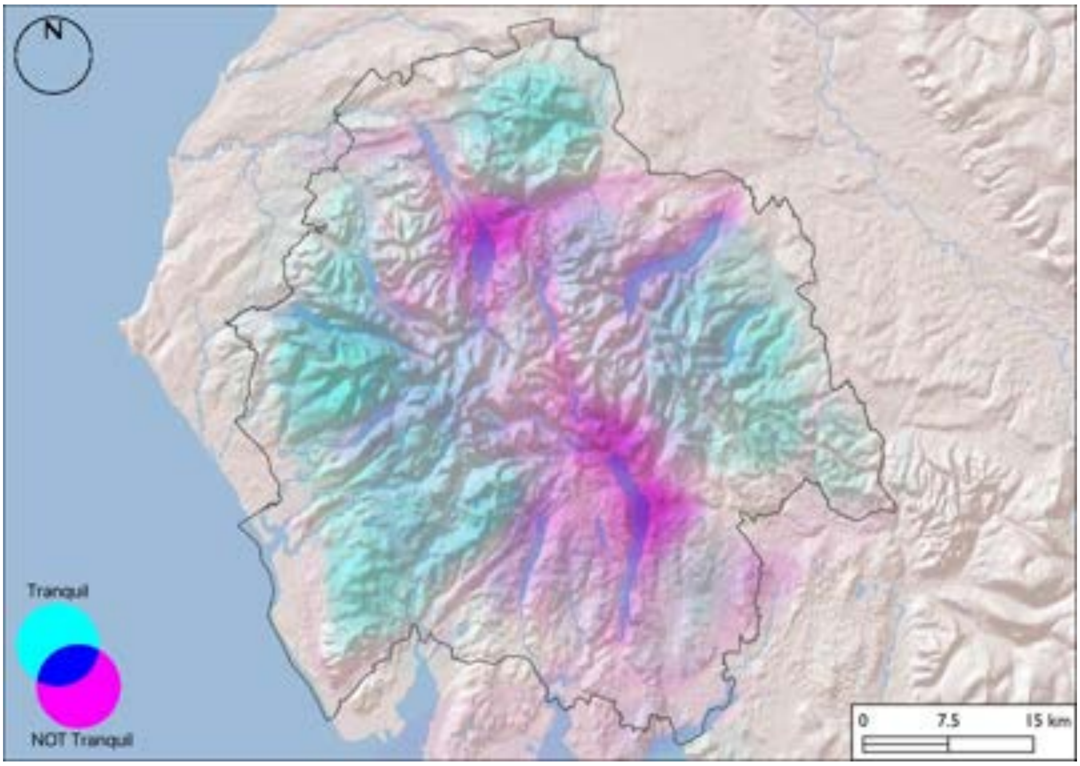

Figure 3.27 Map visualising the ‘raw’ Paper2GIS data collected from 25 participants illustrating areas of tranquillity (cyan), not tranquillity (magenta).

One of the greatest challenges to the meaningful uptake of PGIS in decision making has been a lack of suitable analytical methods, leading to an inability to quantify the findings (Huck et al., 2025)[50]. This is key, because without quantification there is no way to combine the outputs with other scientific data sources, nor is it possible to satisfy the requirements of decision makers who require a formal characterisation of the *weight of evidence* contained within the dataset. Though this challenge is well understood, it is difficult to resolve for several reasons. Perhaps the biggest problem is that most quantitative methods are based on the fundamental assumption that each data point is independent from the others.

In the case of PGIS, this means that each participant's opinions are independent from those of the other participants. It is well established, however, that this is not the case, because people's opinions are shaped by other people (e.g., one participant may have influenced the other, or two could have been influenced by the same non-participant) and other forces (e.g., participants are likely to have been affected by the same news, television, social media content etc.). Public opinion cannot, therefore, be reasonably considered as statistically independent, and methods that require this assumption cannot be rigorously applied.

To illustrate this issue, we can consider how much new information we gain when someone tells us something. Say that we are trying to form an opinion on whether Cat Bells summit is tranquil, and 100 participants tell us that it is *not* tranquil because there are too many people there. Before anyone has told us anything, we have a neutral position on the matter. After one participant has told us something, then our opinion is likely to shift substantially, as everything that they told us is new information. When the second participant tells us the same thing, then this adds weight to the view and shifts our opinion a little further, but not by the same amount because it has not doubled the amount of information that we have. Each additional participant will then add *some* additional information and affect our opinion, but the amount of new information (and so the impact on our opinion) reduces with each contribution.

Consider, for example, how much our opinion is likely to differ between when we hear it for the 99th and 100th time – this will have little impact on our opinion compared with the information from the first and second participant. Though this example is rudimentary, assuming statistical independence is to assume that the evidence from the 100th participant adds just as much new information as the first did, and as a result leads to substantial over-estimation of the level of confidence in the findings (and a commensurate under-estimation of the uncertainty).

Huck et al. (2025) were the first to provide a solution to the challenge of quantifying public opinion, with a method based on a mathematical framework for modelling evidence known as Dempster-Shafer theory. Huck et al. (2025) addressed the issue of statistical non-independence by separating the 'new' and 'overlapping' information from participant contributions before combining them to determine the resulting opinion. In addition to this, it also addresses a number of the other key challenges associated with the quantification of public opinion, including: it is commutative (the order of the participant submissions does not impact the results); it accounts for the level of confidence each participant had in their submission (e.g., the amount of information in the opinion of a day-tripper who had not actually been to the summit would be expected to be quite different from that of a local resident of walked the summit regularly); it incorporates spatial uncertainty into the analysis; it accounts for the

[50] Huck, J., Denwood, T. and Taylor, J., 2025. Embracing Uncertainty in Participatory GIS: Perceptions of tree planting in the English Lake District. https://research.manchester.ac.uk/files/682703750/HUCK-Uncertainty-2.pdf

number of participants that contributed data to a given location (e.g., so a small number of unanimous votes can't lead to the formation of an extreme opinion) and; it represents the results in an easily understandable value of 'probability of tranquillity'. This approach has therefore been used here to combine the Map-Me and Paper2GIS datasets into a 'probability of tranquillity' map, which is illustrated in Figure 3.28.

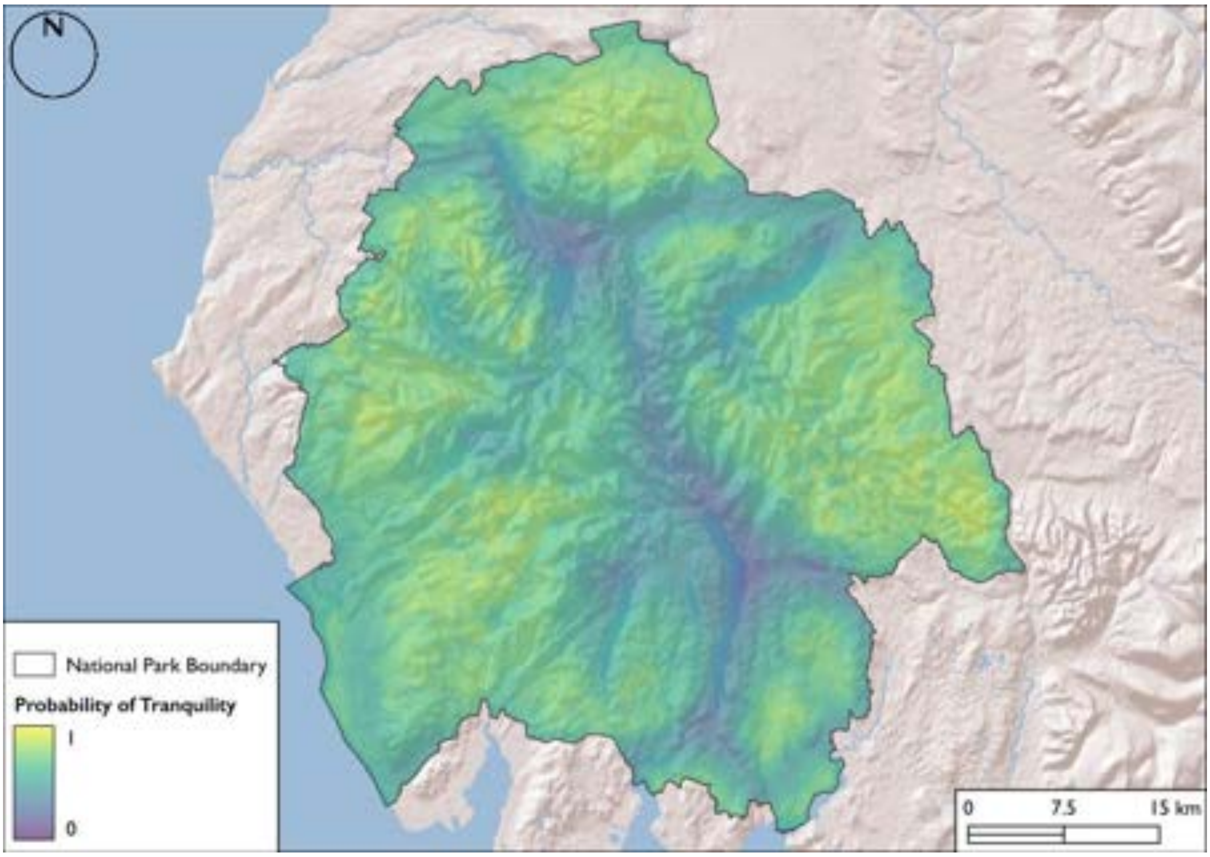

Figure 3.28 Map visualising probability that a location is tranquil, based on the views of the participants.

Given the similarity in the patterns of data between both datasets, it is no surprise to see the same patterns reflected here, but in this form the dataset has several additional features:

- It provides a continuous surface of *probability of tranquillity* values, by gathering evidence within a given radius and using a spatial weighting function (linear inverse distance weighting) to weight the impact of each evidence point such that the furthest away data had the least impact on the result. The radius was set to 2000m, which approximates the mean diameter of the 'spraycan' nozzle on the Map-Me user interface;
- It is participant-normalised, meaning that the weight of evidence for a given participant is not impacted by the amount of data (e.g., spray, multiple Paper2GIS submissions) that the individual submitted;
- It deals with the issue of public opinion not being independent (in the statistical sense), which can lead to overconfidence in findings when 'standard' analytical methods are

used. Here, contributions are disaggregated into 'overlapping' and 'new' information to permit the valid processing of evidence into belief functions, and then into probabilities;

- It accounts for the self-reported confidence values given by the Map-Me participants (with Paper2GIS participants set to a confidence of 0.5 in the absence of further information); and
- It accounts for the number of participants that provided information for a given location, with locations for which data was gathered from fewer than 20 participants down-weighted using a negative exponential function.

Based on this surface, it is then possible to extract the locations for which we are most and least confident that it is tranquil. Figure 3.29, for example illustrates the only the areas in which the probability is greater than 70% that a location is tranquil or not tranquil.

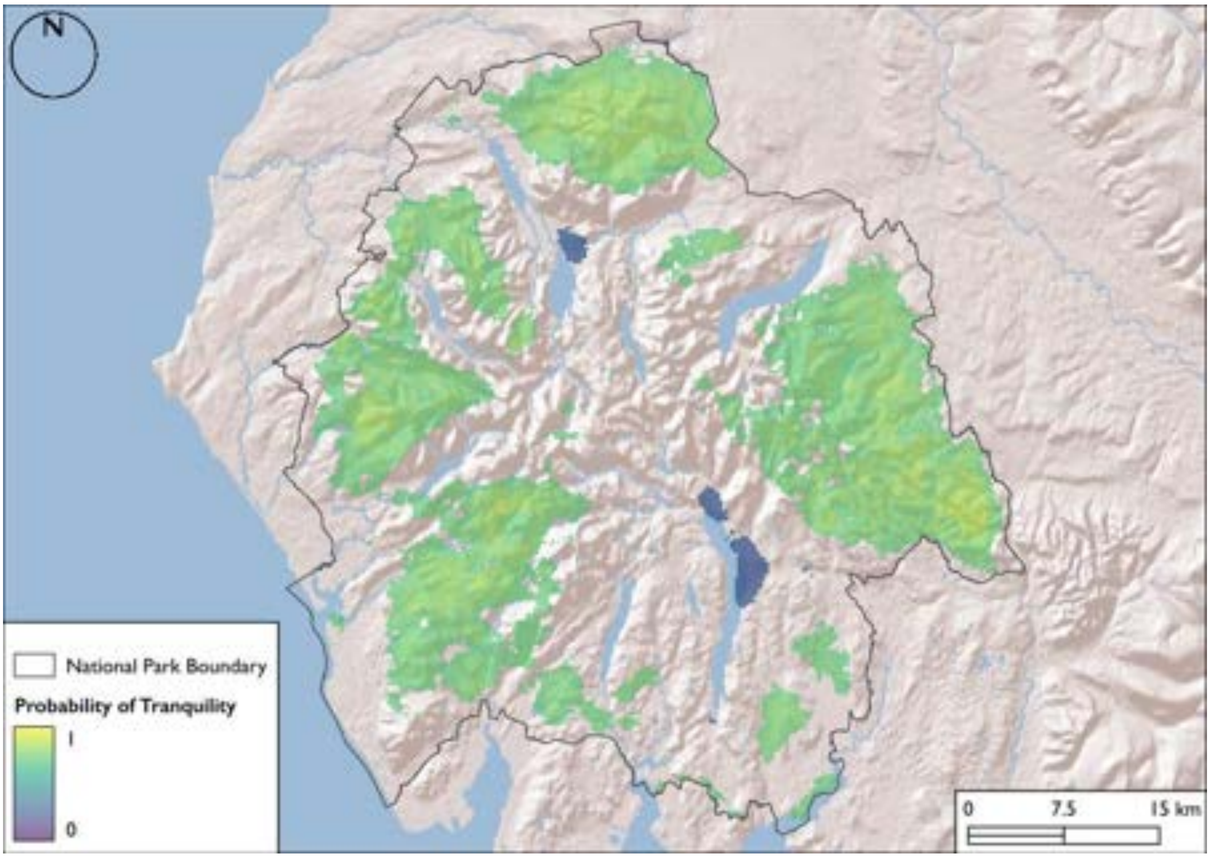

Figure 3.29 Map visualising the locations in which the probability that a location is tranquil (green-yellow) or not tranquil exceeds 70%.

As can clearly be seen, the most tranquil areas are located on the remote fells, notably excluding the more accessible and popular peaks (e.g., Cat Bells, Helvellyn, Scafell Pike etc.). The only locations with a probability of non-tranquillity of greater than 70% are the urban tourist hotspots of Bowness/Windermere, Ambleside and Keswick. The lower level of confidence in locations that are not tranquil is, in part, the result of disagreement about the 'boundary' beyond which a location may be considered tranquil. This is because tranquillity is an example of a *vague* concept (Huck et al., 2014)[51], with definitions likely to vary between individual based on their own perceptions and experiences. For example, relatively few people would be expected to argue that a remote peak is not tranquil, whereas other relatively busier parts of the park will appear very tranquil to some people (perhaps those visiting from a city, for example), but not so for others (e.g., someone who lives in a Cumbrian village with lower levels of tourism).

3.2.4 Comparison of PGIS vs modelled tranquillity

A visual comparison of the PGIS *probability of tranquillity* map from Part B and the overall tranquillity map from Part A illustrates a general agreement, with a broad match between public perceptions of tranquillity in the LDNP, and the modelled values particularly highlighting the Skiddaw/Blencathra massif in the north, and both western and eastern fells.

There are, naturally, differences in the detail between the two approaches since public knowledge is based on opinion and experience (e.g. many visitors will see the many areas of the park as tranquil compared to where they live or other places they frequent) while the patterns seen in the Part A spatial modelling are based on interpretation of tranquillity in mapped detractors and contributors and their assigned model weights just within the park itself. This is shown in Figure 3.30.

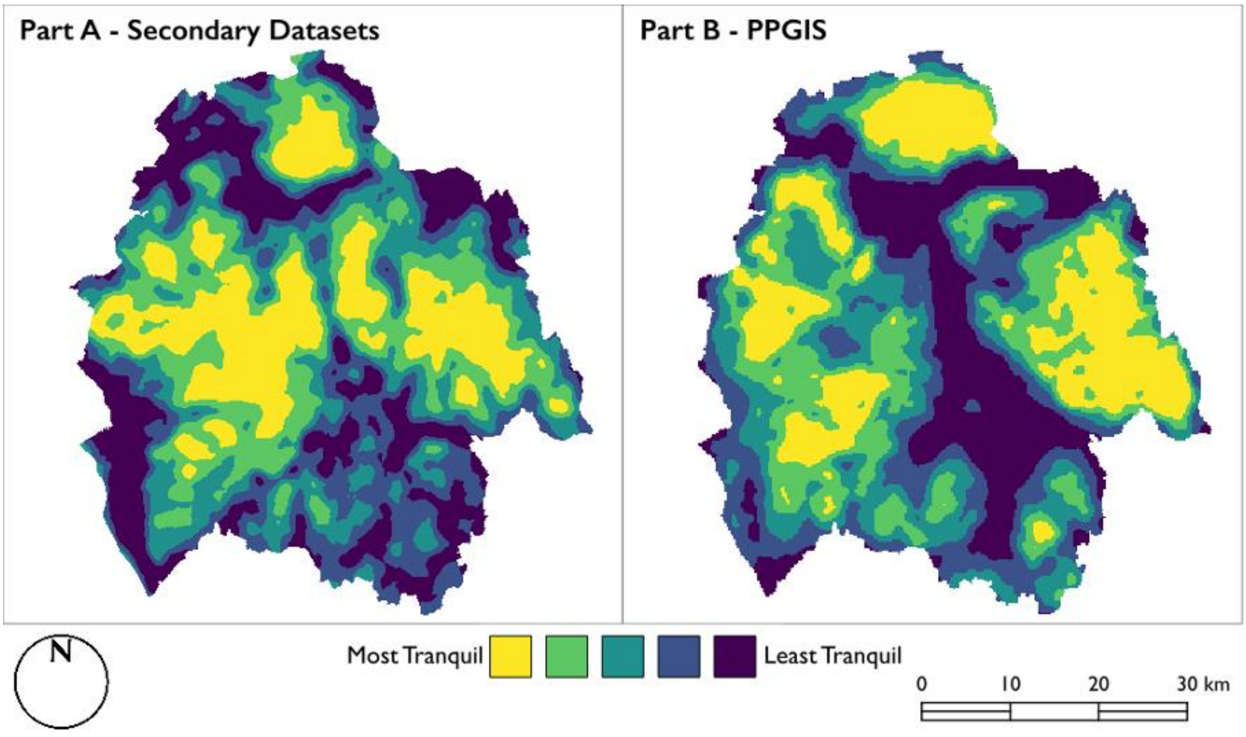

Figure 3.30 Comparison of GIS and PGIS tranquillity maps

[51] Huck, J. J., Whyatt, J. D., & Coulton, P. (2014). Spraycan: A PPGIS for capturing imprecise notions of place. Applied Geography, 55, 229-237. https://doi.org/10.1016/j.apgeog.2014.09.007

The most notable difference between the two maps in Figure 3.30 relate to the impact of the main roads and settlements, which appear to have a greater impact on perceived tranquillity in the PGIS dataset (Part B) than in the secondary data analysis (Part A). This is clear through the greatly enlarged "Least Tranquil" zones in the Part B map surrounding the vicinity of Keswick, Windermere/Bowness, Coniston and Grasmere; as well as the major roads that link those centres together. Conversely, the PGIS analysis found several areas to be substantially more tranquil than the secondary data analysis, including the northern part of the Skiddaw massif, the eastern flank of the Eastern Fells (towards the M6 motorway and West Coast Mainline railway), the south-eastern lakes (near Whitbarrow, extending towards Kendal), and the plain along the west coast (e.g., the vicinity of Ravenglass and Bootle). It is notable that all of these are characterised by having multiple detractors to tranquillity (e.g. proximity to and visibility of the motorway and mainline railway) but having relatively low levels of visitor numbers. This is elaborated further in section 3.2.5, which identifies the presence of people in the landscape as the dominant theme affecting participants' perceptions of tranquillity.

The example of the west coastal plain is of particular interest because it features so highly amongst the various detractors (see Figure 3.14) and poorly amongst contributors (see Figure 3.20) in Part A, resulting in it being classified amongst the least tranquil areas on the park (see Figure 3.22). Amongst the Part B PGIS participants, however, it was seen as strongly tranquil, albeit only a relatively small number of participants contributed data at this location. The low number of participants has resulted in lower tranquillity score for this area, due to a down-weighting effect in the algorithm intended to reduce bias. Were this not applied, the probability of tranquillity along the plain would have been much higher (in the region of ~0.8 rather than ~0.3, making it amongst the most tranquil locations in the park). As a result of the low number of participant contributions and the subsequent down-weighting of the tranquillity score, the coastal plain exhibited some of the highest levels of uncertainty in the study which suggests the areas of greatest uncertainty for the PGIS analysis are around the edge of the park which receive fewer visitors. Most of these areas are characterised by either being peripheral to the park (thus attracting uncertainty due to lack of participant contributions) or in areas of high disagreement (e.g., the transition zone between the A66 and Skiddaw massif).

The west coastal plain represents the largest contiguous area of high uncertainty in the analysis, which would mark it out as a strong candidate for further data collection and analysis. More broadly, this example highlights a possible mismatch between the weighted contributors and detractors included in the Part A secondary analysis (Table 3.1). The weights for contributors and detractors were extracted from the previous CPRE work based on public input (six focus groups and a national survey of 2,000 respondents). It is possible, however, that they might not adequately reflect the unique characteristics of the LDNP. This could be due to a range of reasons, perhaps including the effect of the acute tourist pressures felt in the park, which might not be adequately captured in a survey across the national a whole. Further work into the nature of perceptions of tranquillity within the LDNP could also, therefore, be productive, as it may allow a more nuanced understanding of the perceptions of the people who live, work and enjoy this unique landscape.

3.2.5 Analysis of Text Data

Participants who took part in the study via both Map-Me and Paper2GIS were asked: ***"What does tranquillity mean to you? What do you think of when you hear the term?"***, with responses given in a free-text box. Analysis of the resulting text, supported by the Lumo AI platform[52], identified nine key themes in participant's characterisation of 'tranquillity' in the LDNP, each of which are presented below with an exemplar quote and some explanatory bullet points:

1. **Low Visitor Numbers & Remoteness** e.g., *"Wild Ennerdale – very few visitors... The whole block of far-eastern fells is lonely country only frequented by fell-baggers and a few ponies."*
    - Areas that receive few visitors, whether because they're far from main roads, require a longer walk, or are simply "off-the-beaten-track", are often described as the most peaceful.
    - Remote valleys (e.g., Wild Ennerdale, Duddon, Back of Skiddaw, Measand, Hard Tarn) and high-altitude ridges often feel quieter, even in summer.

2. **Limited Vehicular Access** e.g., "*The southern side of Ennerdale lake, where there is no road...*"**:**
    - The absence of nearby roads, car parks, or traffic noise is a core factor of tranquillity.

3. **Natural Soundscape** e.g., *"Langstrath has silence – streams, pools and waterfalls and high mountain surrounds."; "The lack of man-made noise is palpable."*
    - The dominance of natural sounds (e.g., running water, waterfalls, streams, wind, bird calls etc.) creates a sense of calm.
    - When human-made noises (cars, motorboats, loud tourists) are missing, respondents highlight a "silence" or "only the sound of nature."

4. **Water Features & Views** e.g., "*Hard Tarn is one of the most tranquil places imaginable – Tarn with rocky shoreline, surrounding cliffs, very few people or paths.*"
    - Lakes, tarns, rivers, and waterfalls are frequently linked to tranquillity, especially when they are secluded (e.g., Hard Tarn, Kentmere Reservoir, Crummock Water).
    - Expansive, unobstructed vistas (e.g., 'wide skies', panoramic mountain views) enhance the feeling of openness and peace.

5. **Minimal Built Infrastructure** e.g., *"No houses, no shops, or roads - just a few farms. The landscape is essentially free of built structures, which makes the area feel profoundly quiet."*
    - Areas with few or no buildings or tourist facilities are perceived as more serene.
    - Even modest structures (a lone barn, an old farmstead) are acceptable if they blend into the landscape and do not attract crowds.

6. **Seasonal & Temporal Factors** e.g., "*I tend to walk the high hills more in winter... In summer months, almost nowhere in the Lakes is tranquil.*"

[52] Lumo: Privacy-first AI assistant where chats stay confidential

- Many sites are tranquil only outside peak holiday periods; early mornings, weekdays, or winter months are repeatedly mentioned as optimal times.
- Some respondents deliberately avoid “summer rushes” and instead visit during shoulder seasons or off-peak hours.

7. **Intimate Landscape Elements** e.g., “*The landscape is intimate – small woods and fields, quiet lanes and lovely buildings.*”
   - Small woods, blue-bell glades, quiet lanes, and intimate valleys are valued for their “cosy” feel.
   - The combination of gentle terrain, low footfall, and a sense of enclosure contributes to personal reflection and relaxation.

8. **Contrast with Over-Touristed Spots** e.g. “*Bowness is overcrowded, noisy and unpleasant… The main roads into and through the Lakes are too busy – queues, illegal parking, pollution.*”
   - Popular fells (Scafell Pike, Helvellyn), lakeside towns (Windermere, Bowness, Ambleside, Keswick) and heavily trafficked routes (A590, A66, A595) are described as crowded, noisy, littered, and stressful.
   - The negative impact of parking scarcity, illegal parking, litter, and bright night-time lighting are also highlighted.

9. **Personal Strategies for Finding Calm** e.g., “*I avoid Lake District at peak times… I visit certain places outside of ‘peak times’ or travel to the coast – not as busy.*”
   - Many respondents deliberately plan visits to avoid crowds (e.g., *“walk in winter,” “choose lesser-known fells”, “use quiet bridleways”*).
   - Some rely on local knowledge, private land access, or specific “hidden gems” known only to residents.

Overall, responses to both the Map-Me and the paper2GIS surveys suggest that tranquillity in the Lake District is strongly associated with a sense of escape from human intrusion, and the responses reveal several recurring themes. The most dominant factor is that fewer people in the landscape creates greater opportunity to experience solitude. This is cited by over half of participants in the surveys. People consistently link tranquillity to the absence of crowds and the ability to experience landscapes without social pressure or congestion. As one respondent put it, *“Quiet valley with beautiful pools and waterfalls. Difficult to access so very few people about.”* Another noted, *“Where one is not jostled by lots of people… you can sit and think or walk and think.”* This desire for solitude underscores the importance of managing visitor numbers and dispersing activity away from sensitive areas in an era where over-tourism is becoming a problem for the park.

Closely tied to solitude is the theme of peace, quiet, and natural calm, which dominates Paper2GIS responses (72%) and appears in nearly a third of Map-Me survey entries. Respondents describe tranquillity as an immersive sensory experience, where natural sounds replace anthropogenic noise. *“Langstrath has silence – streams, pools and waterfalls and high mountain surrounds,”* wrote one participant, while another summed it up simply: *“Peace and* *quiet. no motorbikes. no litter."* The absence of traffic and mechanical noise is critical, with over a quarter of Map-Me responses and 40% of Paper2GIS entries highlighting low traffic and low noise as essential. Comments such as *"Limited vehicular access and none above Stonethwaite camp site"* and *"No traffic or aeroplane noise… peaceful, able to think your own thoughts"* illustrate how infrastructure and transport strongly influence perceptions of tranquillity.

Beyond these core drivers, respondents frequently mention nature and natural soundscapes, views and sense of scale, and water features as integral to tranquil experiences. Around one-fifth of responses reference wildlife and trees, often alongside the soothing presence of water: *"The only noises you can hear are those of nature; water, wildlife, wind… mind completely calm."* Expansive vistas and dramatic scenery also play a major role, with comments like *"Ridges of Grey Crag are airy with wide views, big skies – completely deserted"* and *"Space, peace and wide views."* Water bodies—lakes, tarns, and rivers—are repeatedly linked to calmness, as in *"Crummock Water… where I can swim without crowds and gaze at the water afterwards."* High places and remoteness add more detail, offering opportunities for reflection: *"Sitting on top of any fell… often quiet, with superb views down the valley."* Finally, wellbeing emerges as a cross-cutting theme, with respondents framing tranquillity as restorative and therapeutic: *"Time to think. beautiful landscapes. peace…."* Collectively, these insights highlight that tranquillity is multi-dimensional, blending physical isolation, sensory qualities, and emotional benefits—an experience shaped as much by what is absent (noise, crowds, infrastructure) as by what is present (nature, views, and space).

3.2.6 Participant feedback

Participants who completed the Map-Me Survey had the opportunity to provide text-based feedback at the end of the survey. Though some provided feedback on the tool itself (as is the intention of the question), there was also quite a lot of further reflections on tranquillity.

Few participants commented on the Map-Me platform itself, though one respondent stated that *"the spray can thing is ace"* and another who had never taken part in a PGIS survey before, said that they were initially apprehensive, but found the system to be *"really easy to use and interesting"*. Two participants noted that they struggled with the interface, one of which noted that it *"exceeded their current digital abilities"* and perhaps would have been better suited to the Paper2GIS option. One respondent also questioned why the mapping exercise was confined to the National Park and suggested expanding it to cover the whole of Cumbria, arguing that many tranquil experiences lie just outside the park's boundary. Some warned that the promotion of tranquil spots can turn them into new tourist magnets, undermining the very serenity they once offered (e.g., *"I'm not inclined to tell anyone where the few tranquil places are."*). A third suggested that horse riding should have been included in the list of activities, as they did not feel that women were well represented with the current list.

Many of the comments elaborated further on the information already given. One participant described how *"Tranquillity is THE most important landscape asset … and yet the one most neglected by policy"*. Many of the issues that were raised here are also reflected above, such as traffic, parking and over-tourism, particularly in the context of Windermere, Bowness, Keswick and the surrounding lakes, in which one participant reported feeling *"being crushed by crowds"*. Other concerns included insufficient public toilets, poor waste-water management, and the proliferation of overnight camping that leaves behind rubbish and visual intrusion. Some also reflected on the subjectivity of tranquillity, that it is personal and can shift with time of day, weather conditions, and activity. For example, one participant noted that many places they marked as tranquil could feel noisy on a stormy day, while other locations deemed “not tranquil” might be perfectly peaceful early in the morning or in the off-season.

One participant proposed ways to improve matters in the offered a range of suggestions, including improving transport through free shuttle buses, expanded train services, and better cycling infrastructure; all of which could reduce car dependency. Another suggested that education about responsible recreation, especially concerning fly-camping, litter, and respect for the environment, could help to preserve quiet spaces.

3.3 Part C: Ground-Truthing and Acoustic Monitoring

3.3.1 Sound recordings

Four acoustic monitoring locations were chosen to represent characteristic landscapes within the LDNP which also highlight key challenges for landscape management. The choice of areas was limited by the constraints of land ownership and the need to place recorders in locations where we had permission from the landowner. In the end this led to the focus on one of the case study sites, where green lane use by off-road vehicles has been identified as a specific problem for tranquillity. At this site four Song Meter SM4 Acoustic Recorders were deployed during the second two weeks in September to collect continuous sound data throughout the day.

Given the limited spatial focus of the sound recorder deployment the approach was designed to: 1) Explore how we could validate the acoustic models developed for the whole park by assessing noise levels outside of areas not currently covered by existing noise mapping and 2) Go beyond only considering noise to identify specific acoustic events that enhance or detract from the soundscape. The final goal was to use this 'soundscape' approach to offer insights into environmental impacts within the park that are difficult to capture using the standard spatial approach based on remote-sensing data.

3.3.2 Data and analysis

Sound recordings were made during the period 11th September 2025 to 24th September 2025. Recorders were programmed to record during from sunrise to sunset. Sound recorders were synchronised for time and GPS location using a Garmin GPS module. The sensitivity of the recorders was checked using a Temna dB sound calibrator. In addition, a series of spot recordings were made using a Zoom H1n recorder at several locations across the park to supplement the continuous recordings made by the SM4 recorders. See Figure 3.31[53] and Table 3.2.

Table 3.2 Sound recordings

Type	*Number*	*Location*	*Coordinates*
Spot	1	Devoke Water	54.362217, -3.289883
"	2	Devoke Water (track)	54.363100, -3.288917
"	3	Birker Fell road	54.364900, -3.275067
"	4	High Ground Farm	54.370667, -3.273450
"	5	Burnthwaite, Wasdale Head	54.471417, -3.244317
"	6	Wasdale Head car park	54.465683, -3.255783
"	7	Wast Water, northern shore road	54.443250, -3.300817
"	8	Colwith, Elterwater	54.418783, -3.033950
"	9	Elterwater Hall, track to Dale End	54.429100, -3.043683
"	10	Park Foot camp site	54.436025, -3.035637
"	11	Park Foot, Ullswater Wake and Surf	54.603500, -2.829683
"	12	Pooley Bridge	54.607433, -2.825483

[53] SM4s were deployed in pairs adjacent to and further away from the green lanes. These appear coincident at the map scale in Figure 3.29.

“	13	Pooley Bridge	54.612350, -2.821017
“	14	Glencoyne, lake shore	54.595067, -3.158867
“	15	Derwent Bank	54.576050, -3.163567
“	16	Cat Bells, Old Brandelhow	54.581000, -3.166083
“	17	Cat bells car park	54.596417, -3.138383
“	18	Keswick, Lake Side car park	54.362217, -3.289883
“	19	Elterwater Common	54.429100, -3.043683
SM4	1	Elterwater Hall, adjacent to track	54.430030, -3.042430
“	2	Elterwater Hall, 15m from track	54.429760, -3.042920
“	3	Holmeshead Farm, adjacent to track	54.410070, -3.000320
“	4	Holmeshead Farm, 15m from track	54.409340, -2.998300

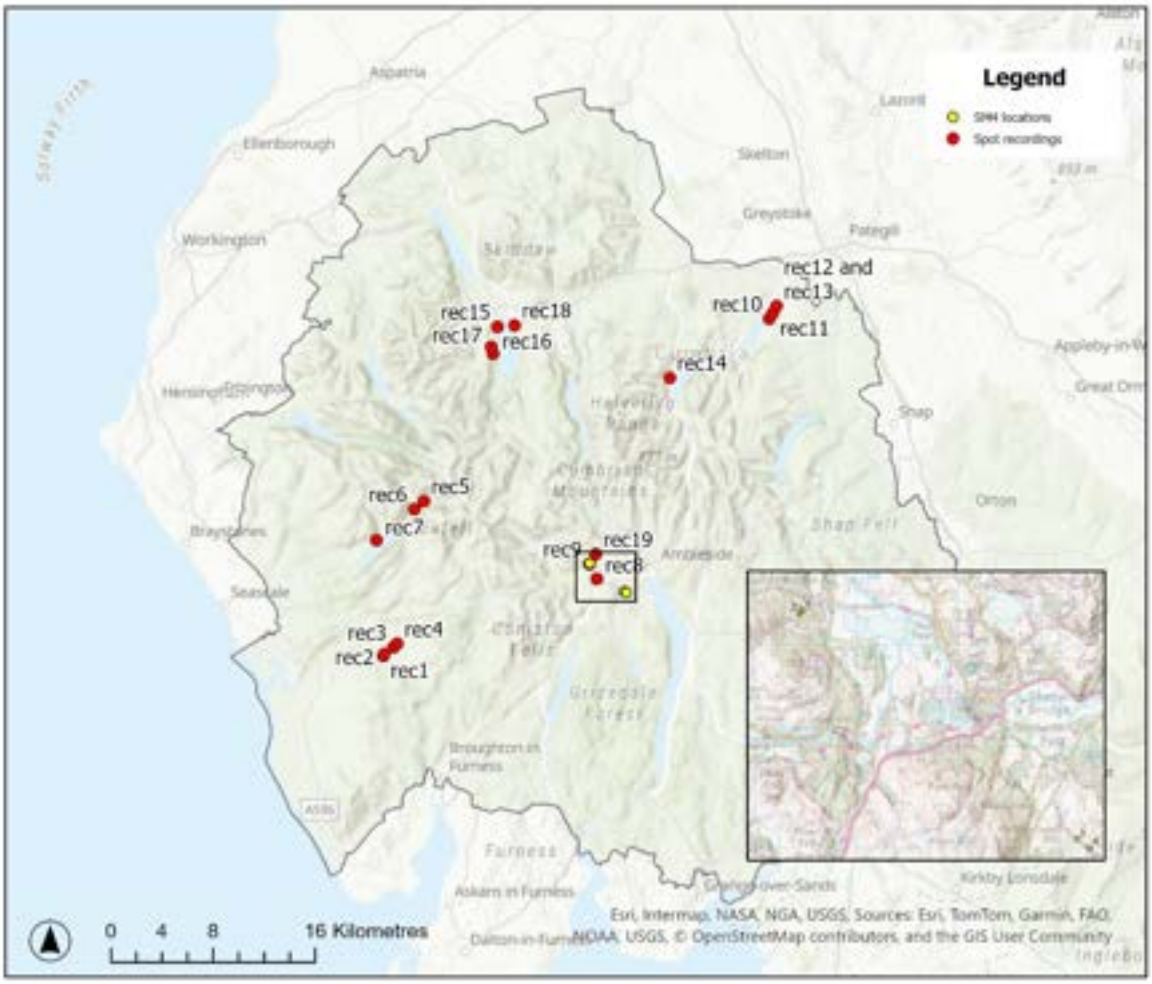

Figure 3.31 Sound recorder locations

Whilst recordings at the SM4 locations were made continuously over this period, the sound recordings were then segmented into 1-minute sound files for analysis. A series of acoustic index metrics were then calculated using the scikit-maad package[54] which is an open-source

[54] https://scikit-maad.github.io/

Python package built by the research team at the Natural History Museum in Paris and which is dedicated to the quantitative analysis of environmental audio recordings. It is designed to work with large audio datasets and uses powerful machine learning techniques, which allow us to measure acoustic properties and identify key patterns in all kinds of soundscapes. This approach relies on converting sound recordings into spectrograms which visually represent how sounds vary across the audible frequency range over time and then assessing the patterns in these recordings. These spectrograms also allow us to visually 'audition' our recordings to look for specific acoustic events and then validate the large machine learning approach. See Figure 3.32.

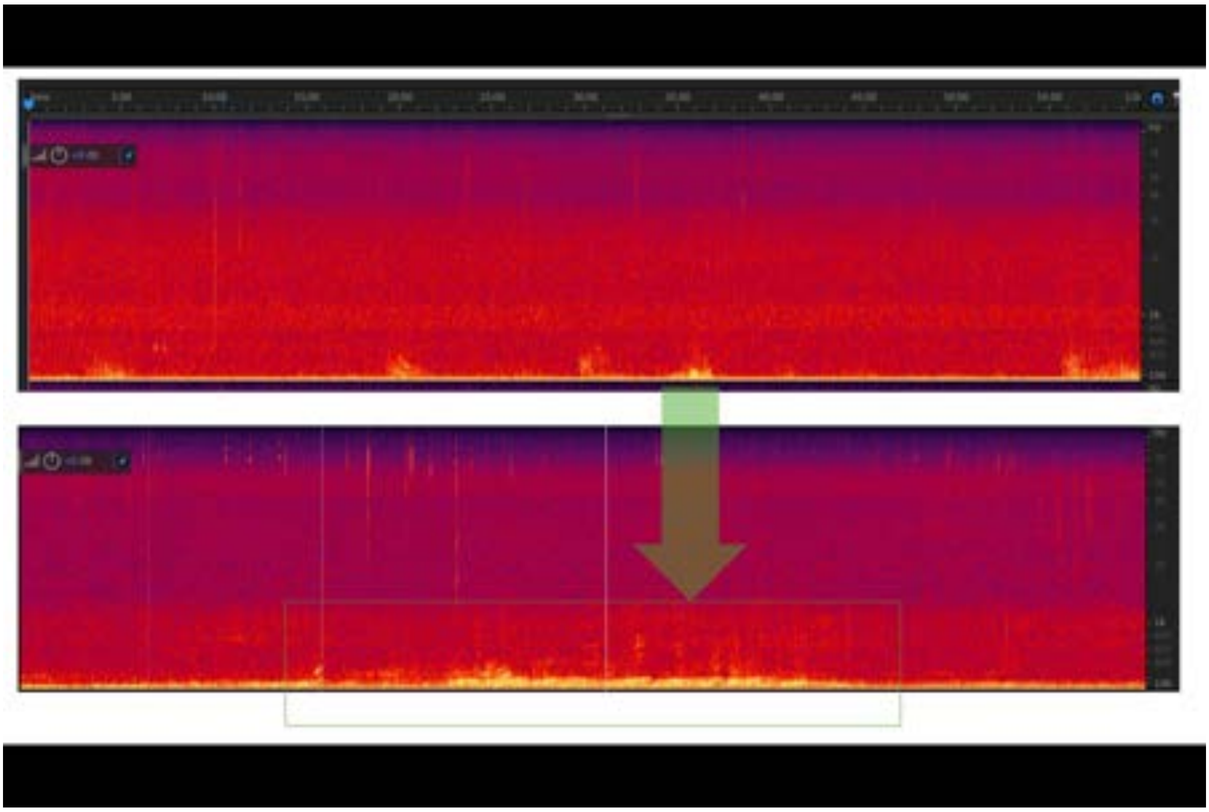

Figure 3.32 Spectrogram showing how sound frequency varies from low (bottom) to high (top) over time at one of the recorder locations. Top spectrogram shows the *one-hour* period from Recorder 4 – 10.40am 13.9.25 and noted sound sources include: birds, people and cars. The lower spectrogram lasts a few minutes and shows a zoom into the sound of a car.

We selected a range of acoustic indices to test during for analysis which are relevant to the focus in the current study of quantifying noise and its potential impact on tranquillity:

LEQt - Temporal domain equivalent sound level (suited for noise analysis)
BGNt - Background noise (temporal)
SNRt - Signal-to-noise ratio (temporal)
LEQf - Frequency domain equivalent sound level
BGNf - Background noise (frequency)
SNRf - Signal-to-noise ratio (frequency)

The acoustic indices derived from scikit-maad, provide essential metrics for characterizing noise pollution and assessing tranquillity. LEQt (Temporal) domain equivalent sound level has been widely adopted in protected natural area studies as it correlates with human perceptual responses to environmental noise, with values as low as 31 decibels (dB) observed in very quiet natural settings (Oberman et al. 2025)[55]. Given that for this study the recorders dB sensitivity was set individually at the start of deployment, we were able to use this metric to measure the average sound energy over the 1-minute period of each final recording segment. As this is the standard metric for noise assessment and provides a single dB value for each recording it allows us to compare noise levels between different recorders and track how this varies using daily and hourly patterns.

In addition, it allows us to assess whether the sound levels measured at the four recorder sites exceed the tranquillity thresholds that have been identified in the scientific literature at other analogous sites in the UK. In the study by Oberman it is established that ~38-42 dB is the threshold for sounds being considered noise in natural areas. In descriptive terms we can see from the analysis that the dB levels are higher overall at SM4 recorder locations 3 and 4 (see Figure 3.33). At these two adjacent recording locations sites dB levels seem highest on the 14th and 15th September, with recorder 3 having highest levels overall with a peak on 13th September between 11.30-12.30. All recorder sites present peak activity on September 15th. In addition to the patterns over the duration of the recording period there are also clear daily patterns which again show that recorder 3 has the highest dB levels of all the recorders. Average dB levels are highest at all sites during the period 12.00 – 16.00. See Figure 3.34.

As noted we have focused our detailed analysis on considering how noise levels can be measured using passive acoustic monitoring over time at four key locations in the park and how the results from this specific local case study can enrich our understanding of the wider spatial mapping products we have developed for the LDNP. A key factor in this approach is comparing our acoustic analysis to existing mapping from DEFRA for the LDNP which considers noise (see Figure 3.9). The four SM4 recorders were placed in ‘green lane’ areas which are outside the existing areas considered by the DEFRA mapping which is a spatial model that uses distance decay to consider the impact of road noise on surrounding areas. This predictive model defines a threshold of 35dB with areas predicted to have noise levels below that classified as not experiencing noise. SM4 recorders 1-4 locations are shown in Figure 3.35 in relation to the spatial data on road noise and jet noise.

[55] Oberman, T., Latini, A., Aletta, F., Gozzi, G., Torresin, S., & Kang, J. (2025). Human sounds and associated tonality disrupting perceived soundscapes in protected natural areas. Scientific Reports, 15, 28759. https://doi.org/10.1038/s41598-025-08524-y

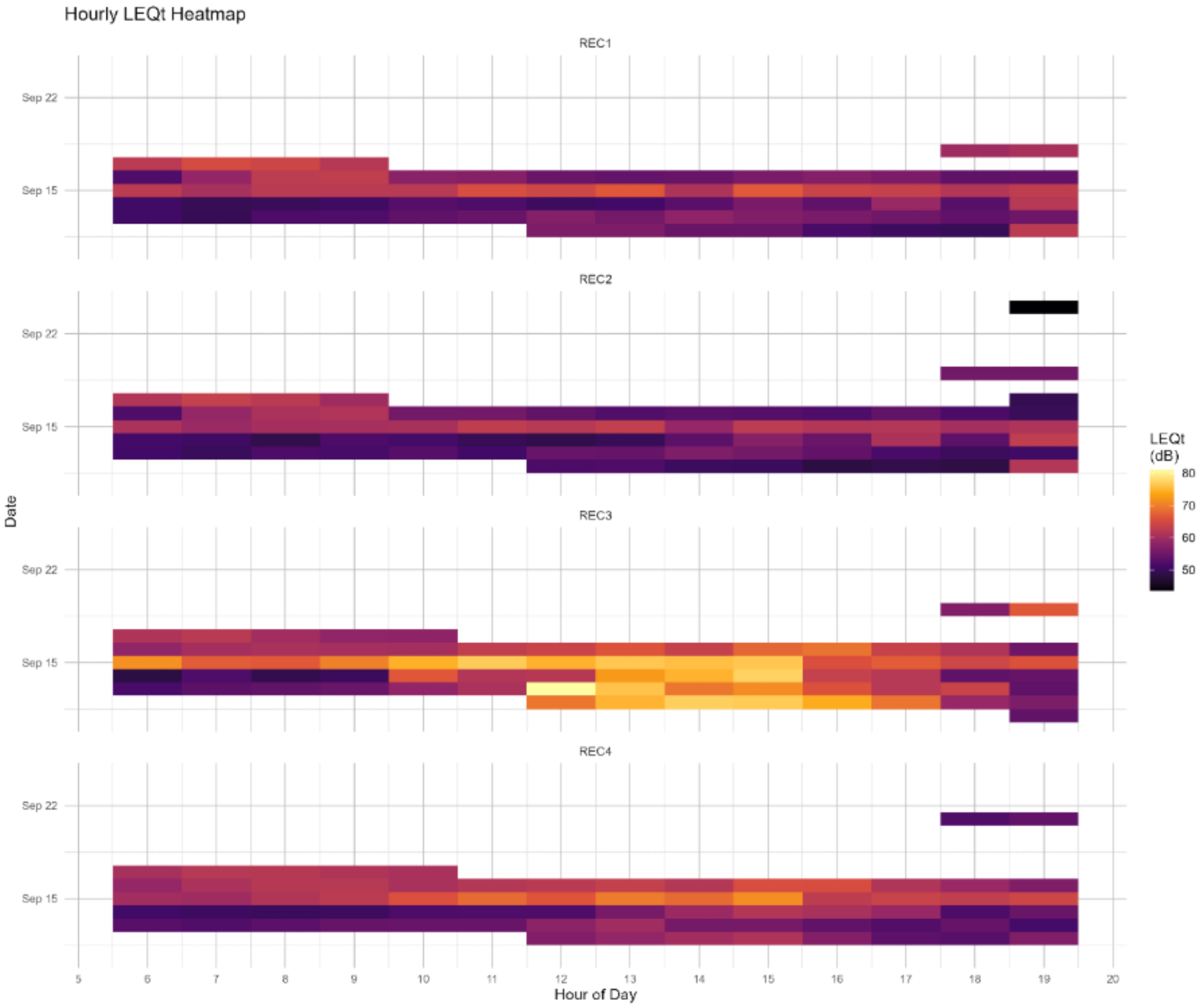

Figure 3.33 Plot of dB levels (LEQt) during a 24-hour cycle and over the duration of the recording period for the four recorder sites. Higher values equate to higher dB levels over the duration of the recording.

Figure 3.34 Plot of mean dB levels (LEQt) over the 24-hour cycle for the four recorder sites.

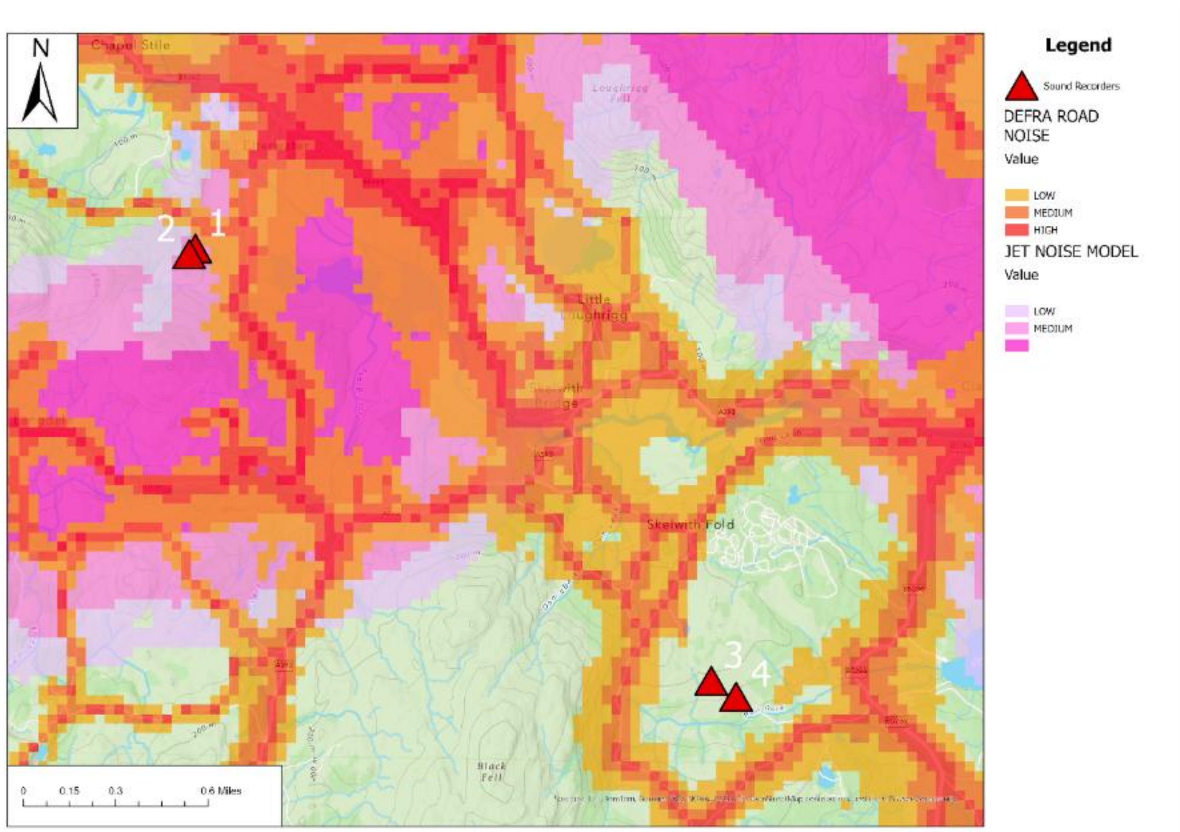

Figure 3.35 SM4 Sound recorder locations in relation to modelled road noise and jet noise.

Considering the challenges of bad weather that are an ever-present possibility in the LDNP – specifically high wind and rain - which also generates noise and can confound the dB values calculations, we used a follow-on acoustic analysis to explore in more detail what sound sources were driving the measure noise levels. This was based on the conceptual framework of the soundscape (Sueur and Farina 2015)[56] that divides the acoustic space into sounds based on (1) geophony, which denotes the sounds made by abiotic processes in the landscape, such as wind and rain; (2) biophony, the sounds of animals, birds and insects; and (3) anthrophony, the sounds of humans—although the term technophony (Gage and Axel 2014)[57] is increasingly used to differentiate the sounds of human speech from those of human machines.

Specific metrics are available within the scikit-maad package which can be used to measure for example whether sounds are of anthropogenic or biophonic origin, although they also require careful interpretation. The Normalized Difference Soundscape Index (NDSI) estimates the level of anthropogenic disturbance by computing the ratio of human-generated (anthrophony) to biological (biophony) acoustic components in field recordings (Kasten et al. 2012)[58] making it a critical complement to traditional sound pressure level metrics like LEQt when assessing tranquillity in protected natural areas.

The Acoustic Complexity Index (ACI) is specifically designed to quantify complex biotic sounds by measuring variability in sound intensities, remaining relatively insensitive to constant human-generated noise such as traffic or aircraft (Pieretti et al. 2011)[59] thus providing insight into biological acoustic activity that LEQt alone cannot capture. The number of peaks (NBPEAKS) has also been shown to have significant correlations with psychoacoustic outcomes including perceived calmness, pleasantness, and the identification of natural sounds (Lawrence et al. 2023)[60], offering a measure of acoustic richness and complexity relevant to tranquillity perception. Developing legislation and planning tools to protect tranquillity could be improved by integrating a broader understanding of soundscape management. Traditional noise monitoring, as used in urban planning and as typified by the DEFRA approach (see Figure 3.9) takes a decibel-focused approach to understanding the soundscape, but this approach alone fails to capture the quality of the acoustic environment, and the nuances of subjective human perceptions of these same soundscapes (Pheasant et al. 2008)[61].

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[56] Sueur, J. and Farina, A., 2015. Ecoacoustics: the ecological investigation and interpretation of environmental sound. *Biosemiotics*, *8*(3), pp.493-502. https://doi.org/10.1007/s12304-015-9248-x
[57] Gage, S.H. and Axel, A.C., 2014. Visualization of temporal change in soundscape power of a Michigan lake habitat over a 4-year period. *Ecological Informatics*, *21*, pp.100-109. https://doi.org/10.1016/j.ecoinf.2013.11.004
[58] Kasten, E.P., Gage, S.H., Fox, J. and Joo, W., 2012. The remote environmental assessment laboratory's acoustic library: An archive for studying soundscape ecology. *Ecological informatics*, *12*, pp.50-67. https://doi.org/10.1016/j.ecoinf.2012.08.001
[59] Pieretti, N., Farina, A. and Morri, D., 2011. A new methodology to infer the singing activity of an avian community: The Acoustic Complexity Index (ACI). *Ecological indicators*, *11*(3), pp.868-873. https://doi.org/10.1016/j.ecolind.2010.11.005
[60] Lawrence, B.T., Hornberg, J., Schröer, K., Djeudeu, D., Haselhoff, T., Ahmed, S., Moebus, S. and Gruehn, D., 2023. Linking ecoacoustic indices to psychoacoustic perception of the urban acoustic environment. *Ecological Indicators*, *155*, p.111023. https://doi.org/10.1016/j.ecolind.2023.111023
[61] Pheasant, R., Horoshenkov, K., Watts, G. and Barrett, B., 2008. The acoustic and visual factors influencing the construction of tranquil space in urban and rural environments tranquil spaces-quiet places?. The Journal of the Acoustical Society of America, 123(3), pp.1446-1457. https://doi.org/10.1121/1.2831735

By distinguishing between anthrophonic and biophonic components, indices like NDSI and ACI help identify what is driving overall noise levels measured by LEQt - whether elevated sound pressure originates from desired natural sources (bird chorus, wind, water) or undesirable anthropogenic intrusions (vehicles, aircraft, machinery). This distinction is essential for conservation management, as the acoustic quality of habitats is recognized as a vital dimension of conservation, with excessive human noise having direct deleterious effects on biodiversity through mechanisms such as acoustic masking, making the separation of biophony from anthrophony crucial for both visitor experience and ecological integrity (Bradfer-Lawrence et al. 2019; Dumyahn & Pijanowski 2011; Carruthers-Jones et al. 2025)[62]. We can see for example in the analysis of the data from our brief recording period in the LDNP that high noise levels – LEQt – map onto low NDSI values, indicating high levels of anthrophony. By also considering ACI levels we can see how the level of biophony in the soundscape varies through the day with a dawn chorus visible even during our September recording period. See Figure 3.36 and Figure 3.37.

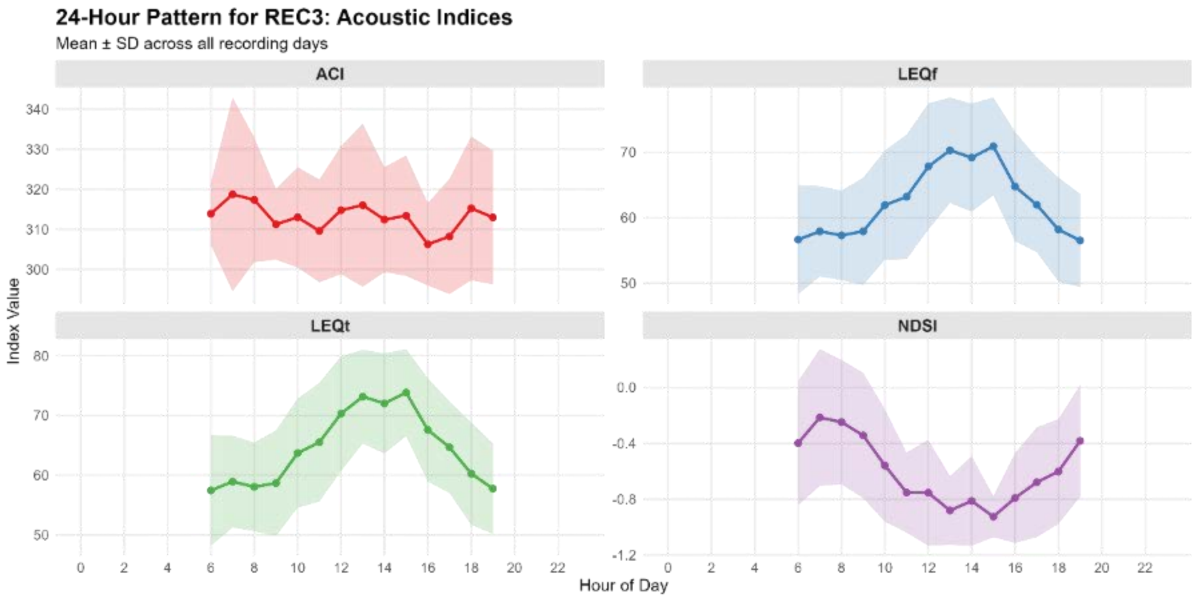

Figure 3.36 Plot of mean values for LEQt, LEQf (a frequency equivalent to LEQt), NDSI and ACI over the 24-hour cycle for recorder 3.

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[62] Bradfer-Lawrence, T., Gardner, N., Bunnefeld, L., Bunnefeld, N., Willis, S.G. and Dent, D.H., 2019. Guidelines for the use of acoustic indices in environmental research. *Methods in Ecology and Evolution*, *10*(10), pp.1796-1807. https://doi.org/10.1111/2041-210X.13254
Dumyahn, S.L. and Pijanowski, B.C., 2011. Soundscape conservation. *Landscape ecology*, *26*(9), pp.1327-1344. https://doi.org/10.1007/s10980-011-9635-x
Carruthers-Jones, J., Guetté, A., Carver, S., Lefebvre, T., Vallauri, D., Debeir, L., Aykroyd, T., Barthod, C., Cavallin, P., Vallée, S. and Benest, F., 2025. High-resolution naturalness mapping can support conservation policy objectives and identify locations for strongly protected areas in France. *Communications Earth & Environment*, *6*(1), p.279. https://doi.org/10.1038/s43247-025-02160-0

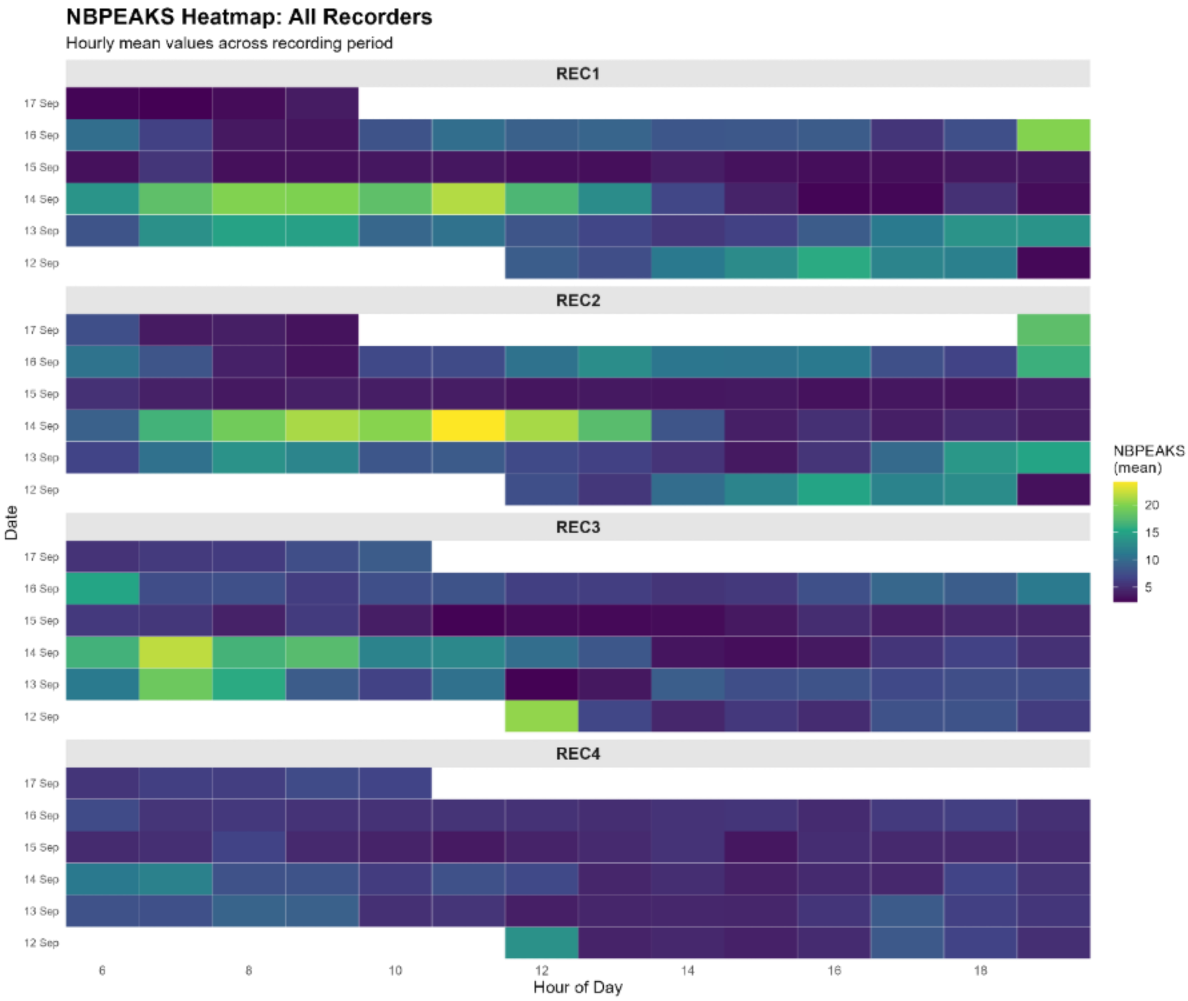
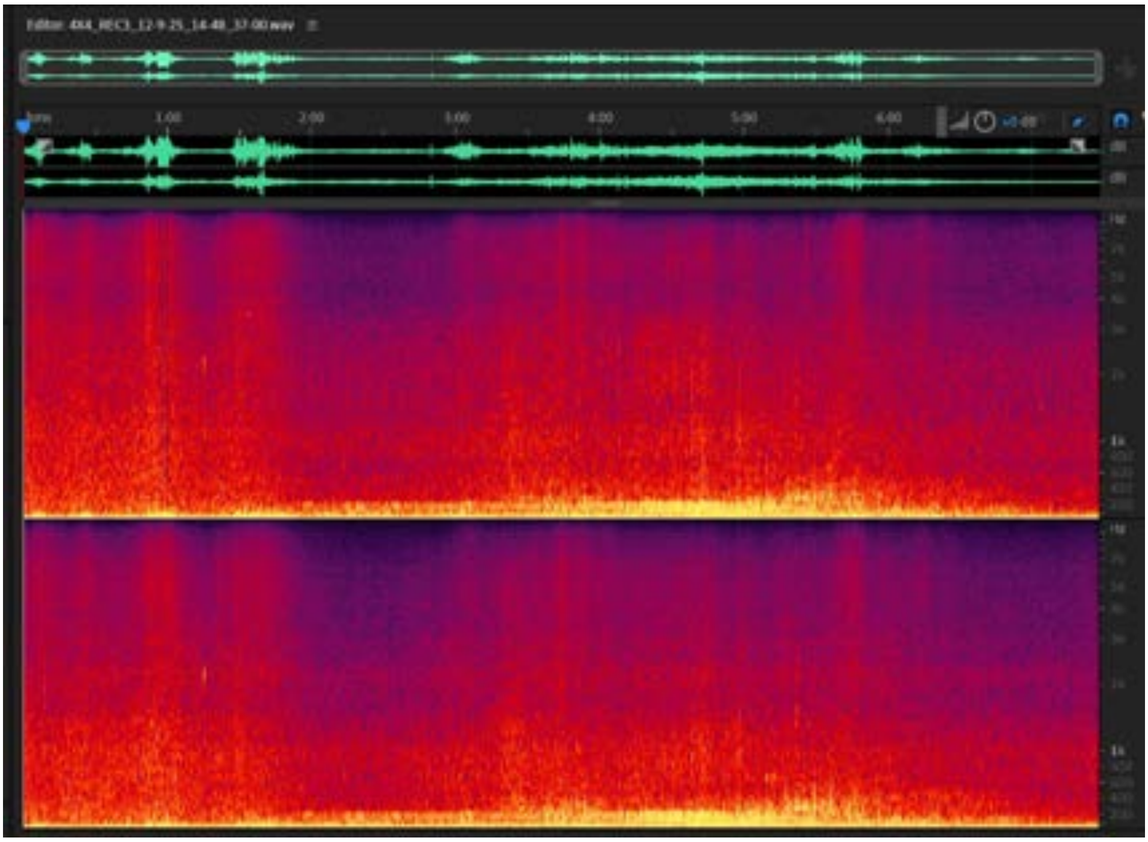


Figure 3.37 Plot of values for NBPEAKS over the daily recording cycle and the recorder deployment period for all four recorder sites.

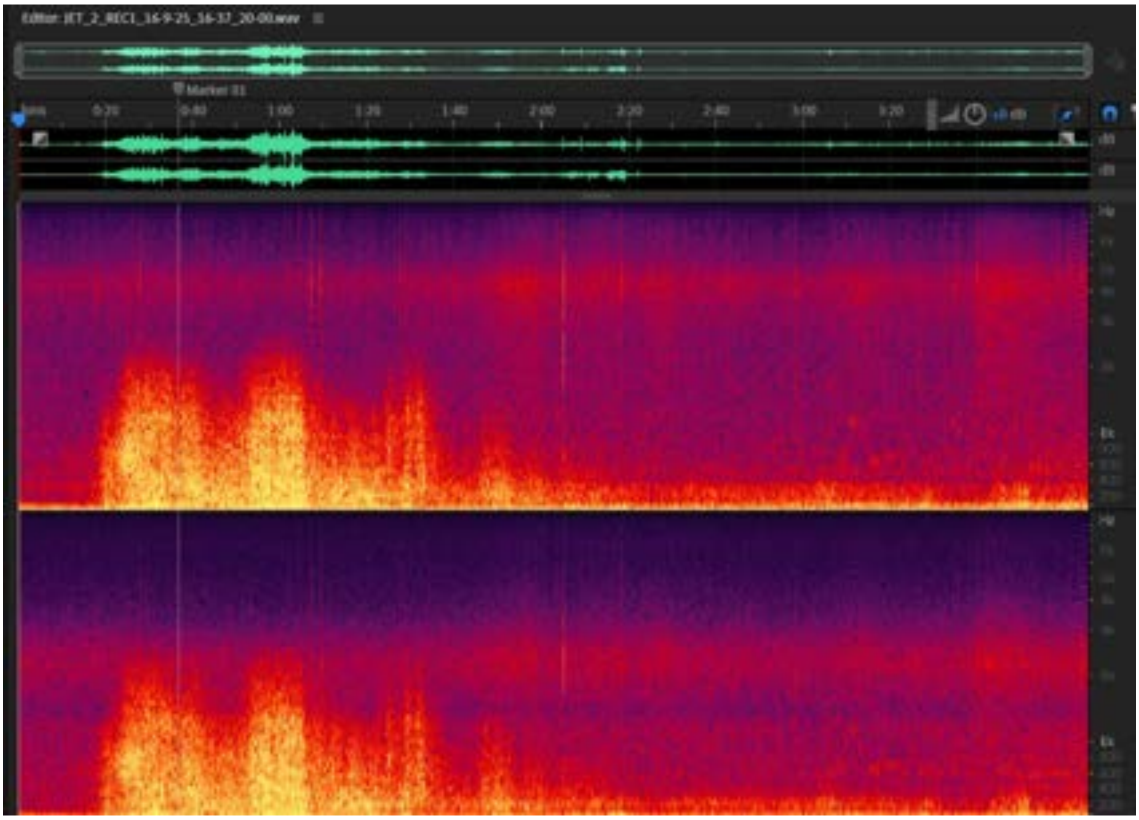
We believe that this hybrid approach to quantitatively monitoring the soundscape goes beyond the standard approach of measuring noise to provide key data that can inform conservation planning. This approach allows us to consider overall whether noise is coming from human, animal or natural sources. Whilst the current acoustic study for LDNP was constrained by challenges linked to recorder deployment we have made an initial classification of sound sources for the data collected. Noise sources were classified using a scoring system based on acoustic indices that distinguish anthropogenic from weather-related noise. Anthropogenic noise (vehicles, aircraft) was identified by elevated mid-to-high frequency energy (MFC, HFC), temporal variability (ACI), and positive NDSI values, while weather noise (wind, rain) was characterized by high low-frequency energy (LFC), elevated background noise (BGN), and low signal to noise ratio. Each time window was classified based on the dominant noise source score. See Figure 3.38.

Figure 3.38 Plot of dB levels (LEQt) over the daily recording cycle and the recorder deployment period for all four recorder sites. Dot colour denotes whether the noise had a likely cause (anthropogenic or weather) or whether the cause is unclear and would require auditioning. Noise sources were classified using acoustic indices: anthropogenic noise identified by mid-high frequency energy and temporal variability; weather noise by low-frequency energy and elevated background noise.

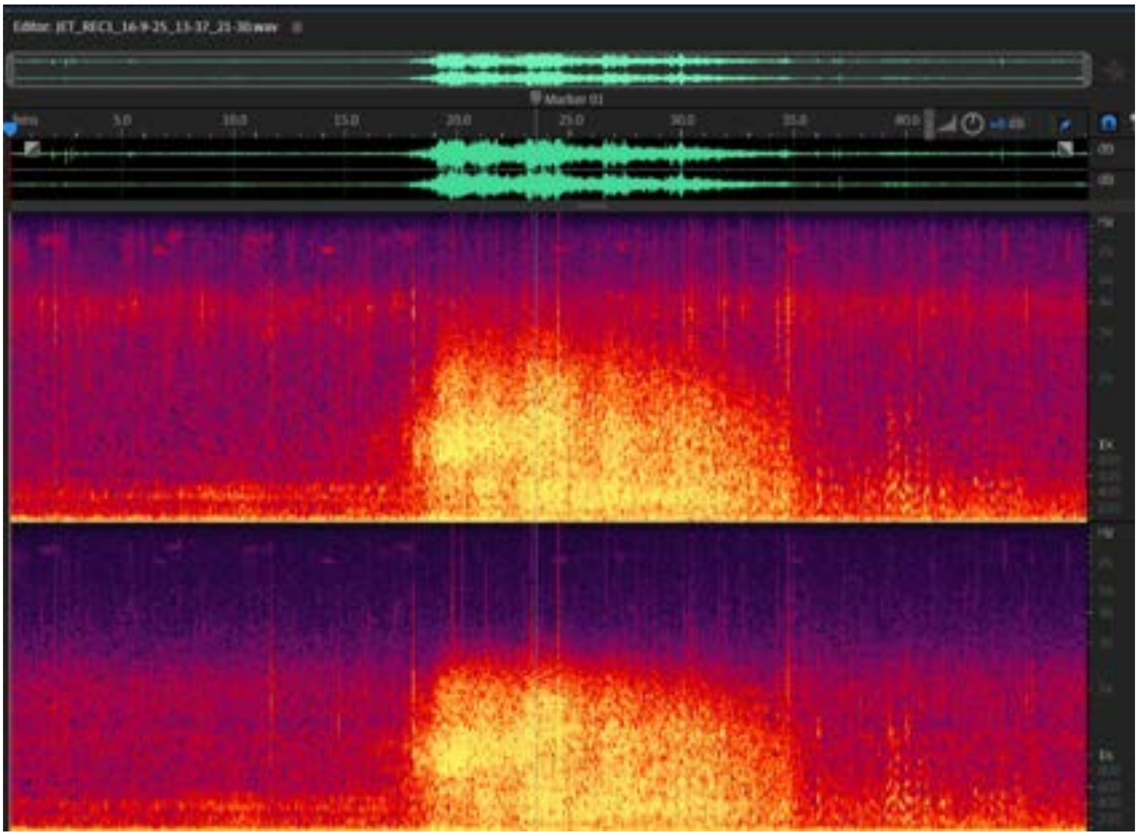
A key finding from this analysis is that when considering the average noise levels during the 1-minute sound recording segmentation approach that we used, the tranquillity threshold of ~40 dB is consistently exceeded highlighting the need to go beyond considering a single source (cars) as the only source of noise, into a wider consideration of diverse sound sources in the soundscape. We then used this analysis as a key to explore the individual sound recordings we have then extracted some sample sound clips and spectrograms from the data to illustrate some examples of what types of anthropogenic noise were behind the red dots in Figure 3.38. See Figure 3.39.



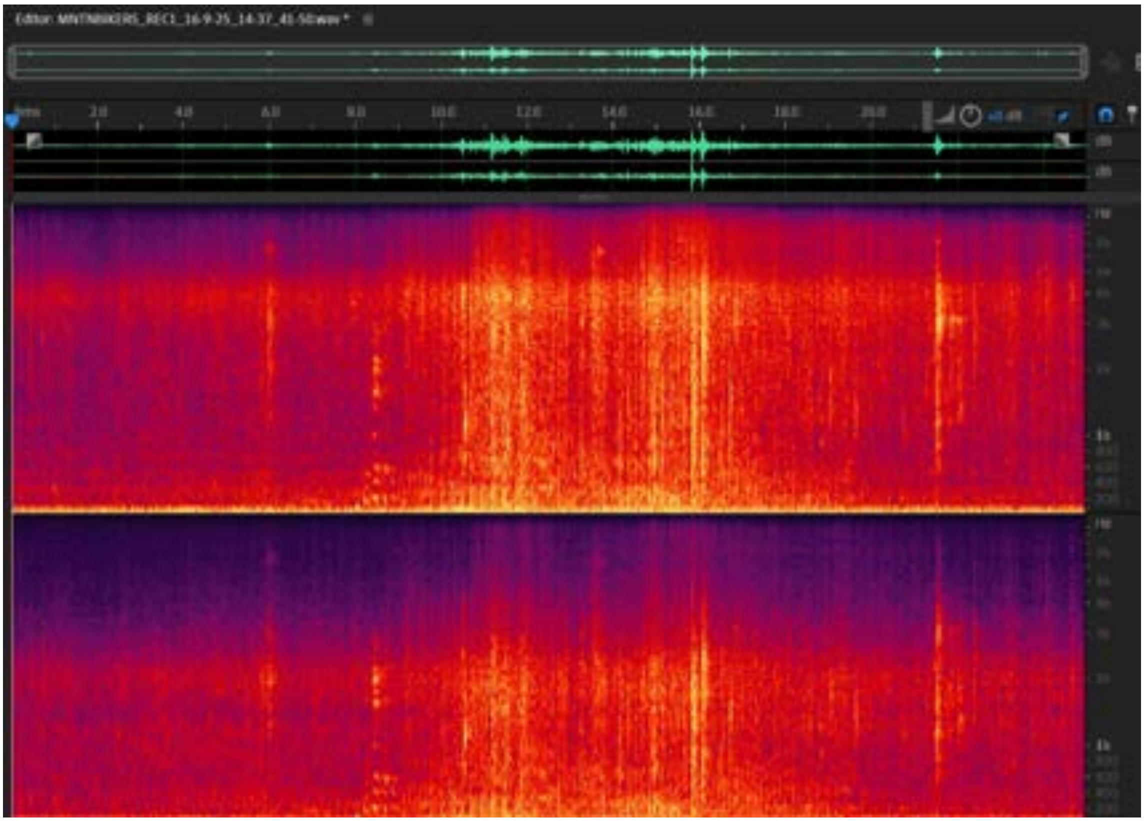
(i) 4X4 noise at recorder 3 (peak duration ~6 minutes)



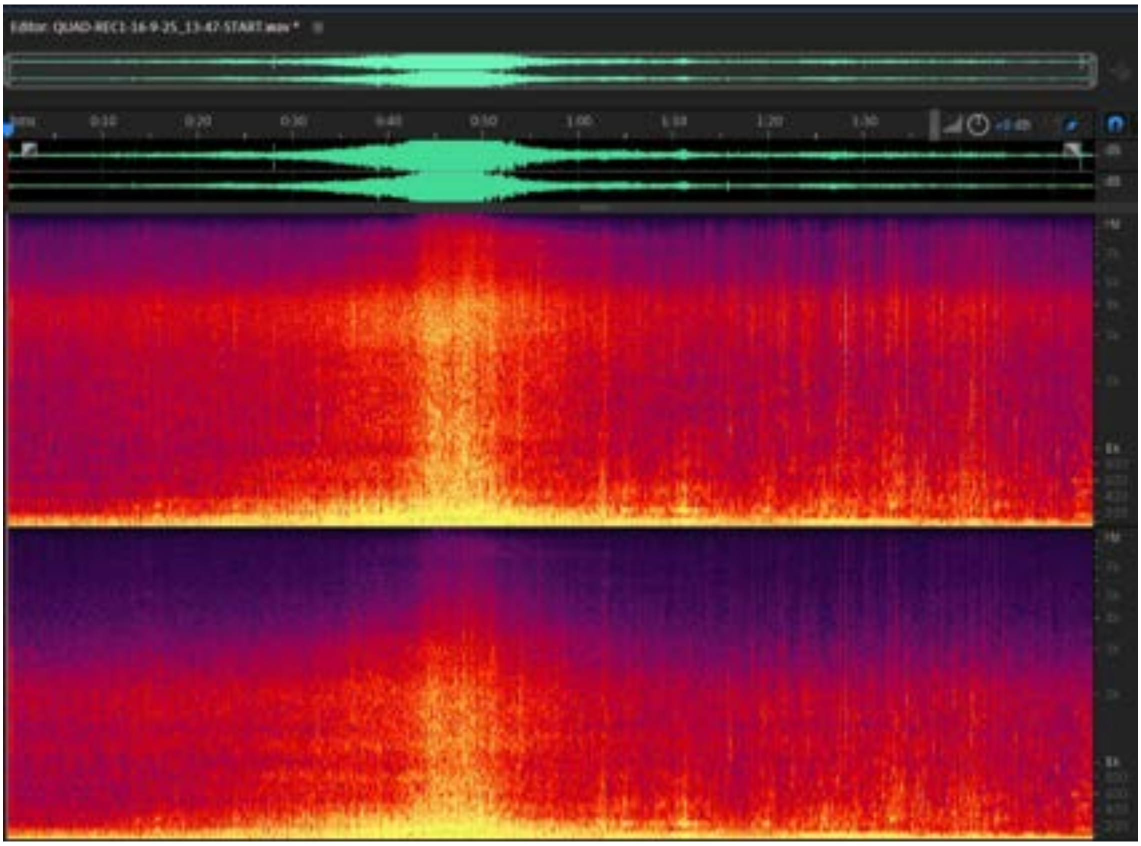
(ii) Jet noise 1 at recorder 1 (peak duration ~ 1 minute)



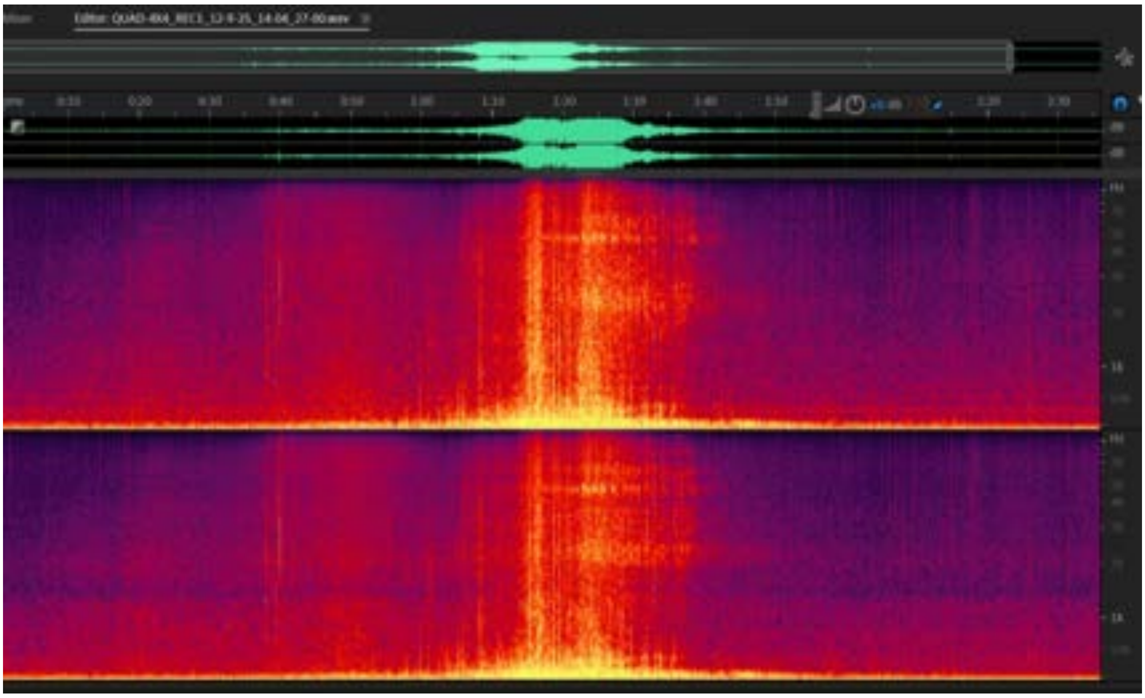
(iii) Jet noise 2 at recorder 1 (peak duration ~ 1 minute)



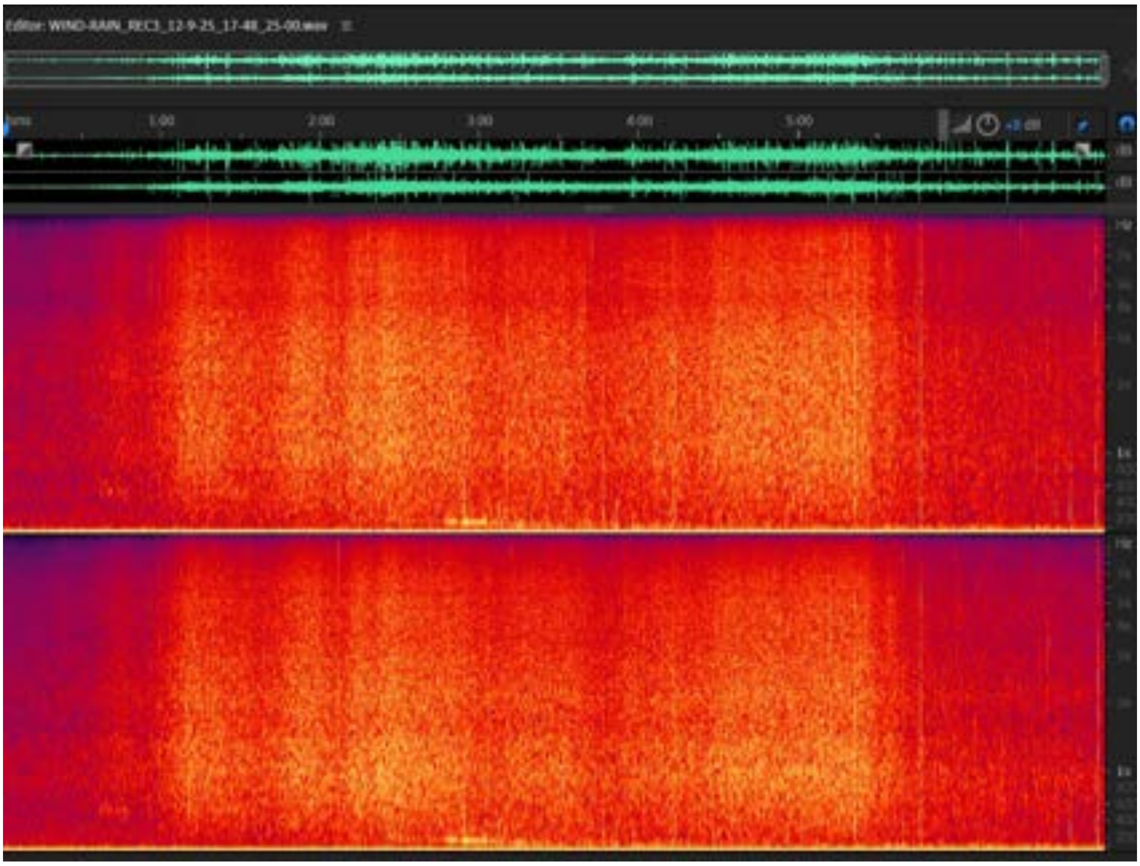
(iv) Mountain bike noise at recorder 1 (peak duration ~ 10 seconds)



(v) Quad bike noise at recorder 1 (peak duration ~ 1 minute 30s)



(vi) 4x4 or Quad bike noise at recorder 1 (peak duration ~ 1 minute 30s)



(vii) Wind and rain at recorder 3 (peak duration ~ 4 minute 30s)

Figure 3.39 Spectrograms i – vii showing how sound frequency varies from low (bottom) to high (top) over time for a sample of anthropogenic and biophonic noise sources recorded during the test deployment period.

3.3.3 Recommendations

We believe that longer term soundscape recording across a larger number of locations – along a precise spatial and altitude gradient – would allow us to provide critical information to support spatial planning with in the LDNP. If recorders were placed at several locations using a regular spacing every few hundred metres from a green lane area up the mountain side this would allow us to precisely measure how far different sounds travelled. Combining this sampling strategy with high resolution data on wind and rain for the recording locations would – as Figure 3.39 vii shows - allow us to filter out bad weather days from the data and therefore mitigate the effect of this broad-spectrum noise on our analysis. Combining this more detailed sampling approach, with a bad weather filter, could for example allow us to build and implement automated classifier systems to identify specific noise of interest such as that made by 4x4 vehicles and consider their impact. This would then allow us to more easily generate an accurate picture of these recreational acoustic events and begin to precisely quantify the percentage of the soundscape impacted both in terms of time and the spatial distance they cover. This type of information would be very useful for establishing a baseline monitoring system for the use of recreational vehicles in the park area, and meet key conservation targets, such as for example the specification within the UNESCO 2024 World Heritage Committee decision which requests in relation to recreational vehicle impacts "intensified monitoring with annual assessments on selected roads and a review within three years”.[63]

[63] https://whc.unesco.org/en/decisions/8860

3.4 Part D: Case Studies and Storytelling

This section of the report introduces five case studies, each designed to explore a distinct narrative regarding landscape character and tranquillity within the park. These reflect the diverse ways in which tranquillity is experienced across different landscapes and the visitor interactions experienced therein. Each case study has been chosen to reflect a specific location and set of characteristics, including disruptive sounds of 4x4 vehicles on green lanes and military jets in remote valleys. The selected sites include (1) Birker Fell and Devoke Water, (2) Wasdale Head and Wastwater, (3) Little Langdale and Tilberthwaite, (4) Ullswater (including Aira Force, Pooley Bridge, Glenridding and Hallin Fell), and (5) Portinscale, Catbells and Stair and the Newlands Valley (Figure 3.40). The case study areas offer a representative cross-section of the park's tranquillity dynamics, including both natural serenity and human-induced pressures such as traffic noise, over-tourism, and recreational congestion.

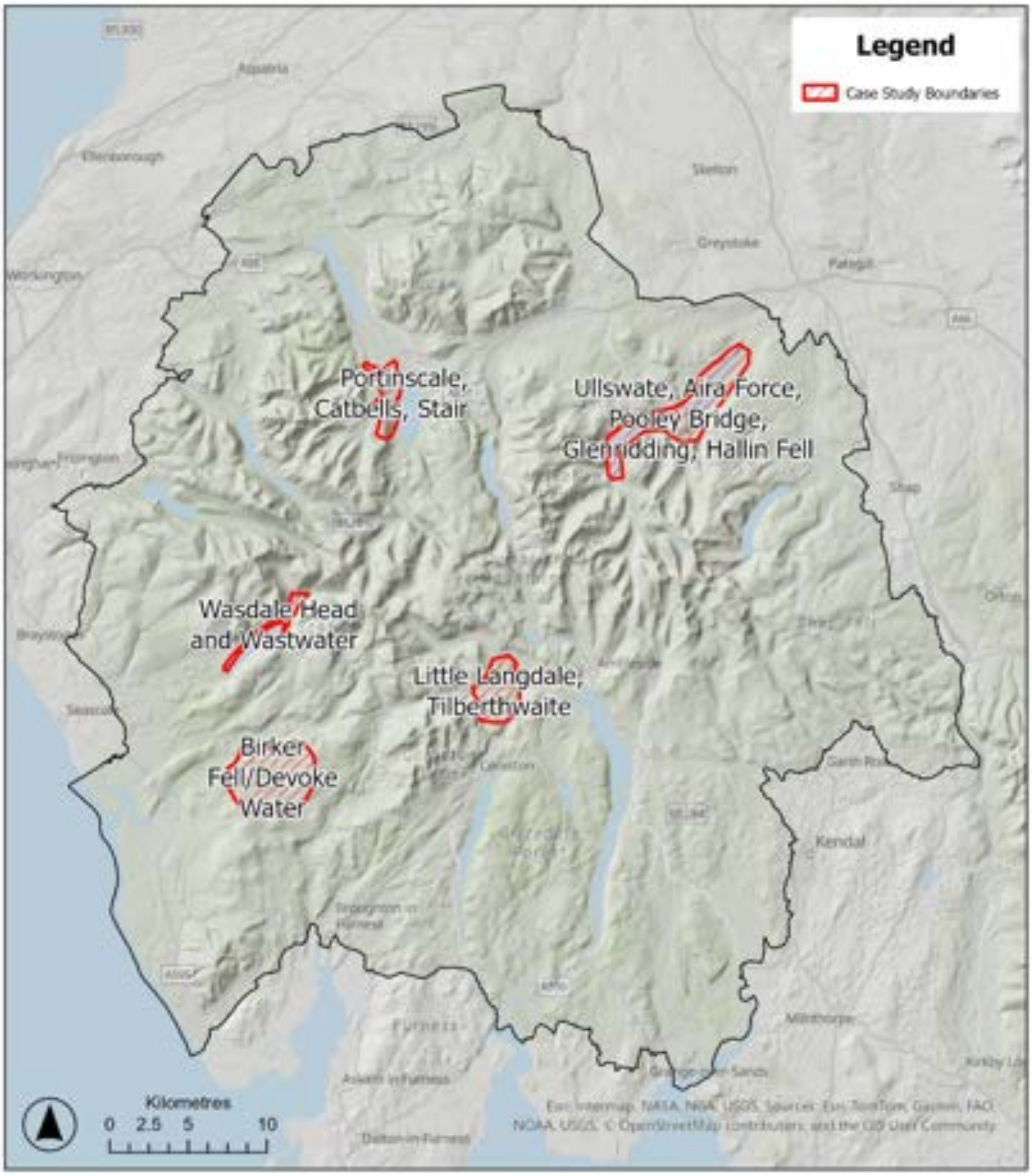


Figure 3.40 Case study locations

To bring these stories to life, the case studies integrate multiple data sources, including spatial mapping and modelling (Part A), participatory GIS insights (Part B), site-based photographs and sound recordings (Part C), and qualitative assessments from a variety of sources. This multi-method approach enables the creation of compelling “tranquillity stories” that combine analytical rigour with personal perspectives. Anonymised quotes and anecdotes are used where available to enrich the narratives, helping to build a vivid and emotionally resonant “rich picture” of tranquillity across the park. These stories not only highlight current challenges but also reveal opportunities for enhancing and protecting tranquillity in the future.

3.4.1 Case study 1: Birker Fell and Devoke Water

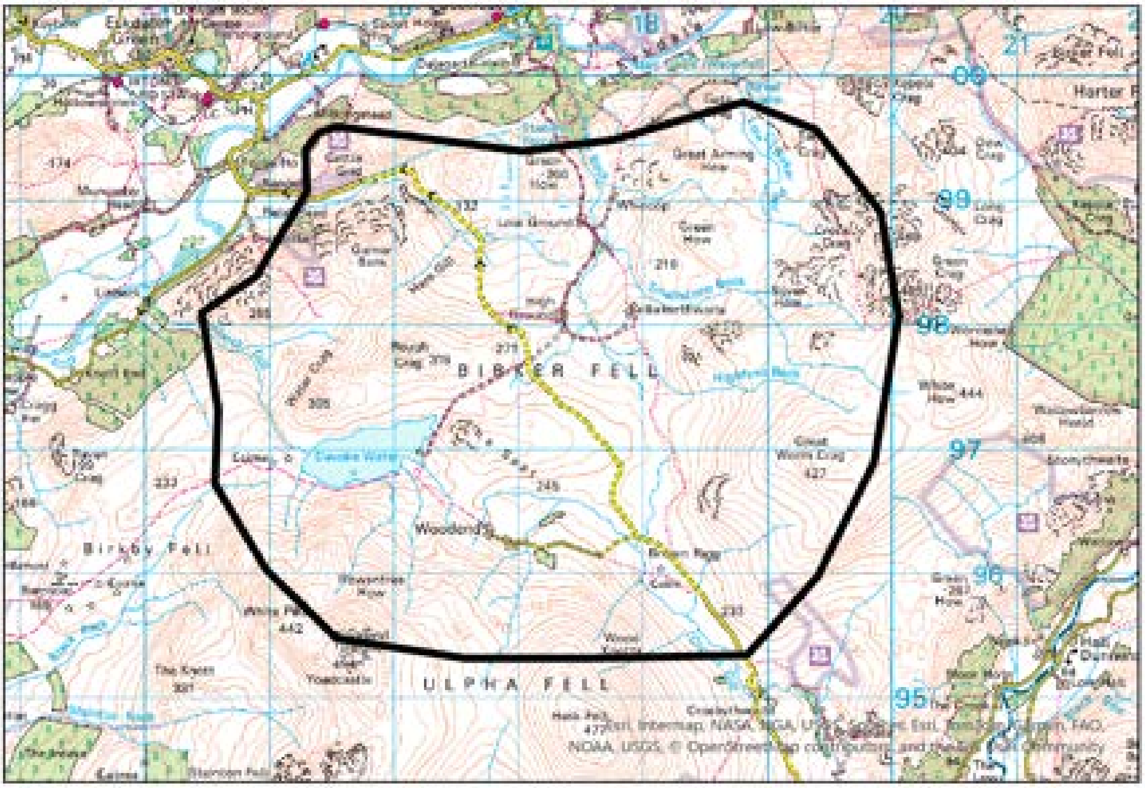


Figure 3.41 Birker Fell and Devoke Water (Source: Ordnance Survey 1:50,000 Landranger)

The Birker Fell and Devoke Water case study area is in the southwest corner of the LDNP on a ridge between Eskdale and Dunnerdale. It is composed most of “rugged/craggy volcanic high fell” with some minor elements of “upland valley” based on the Landscape Character Assessment (LCA). There is a single unclassified road bisecting the area roughly north-south.

Birker Fell

Topography: Birker Fell is a broad, undulating upland area rather than a single mountain. It covers approximately 6 km^2 and features a rugged landscape of crags, knolls, and shallow valleys. The highest point is Green Crag (489 m), with other notable summits including Crook Crag, White How, and Great Worm Crag.

Vegetation and Terrain: The fell is characterized by open moorland, boggy areas, and rocky outcrops. Bogs (locally called mosses) such as Tewitt Moss dominate the wetter areas, contributing to the fell's wild and uneven appearance.

Hydrology: Numerous small streams (locally called becks or gills) crisscross the fell, many originating from the mosses. These watercourses feed into larger streams like Crosby Gill and Stanley Force, the latter forming one of the Lake District's most dramatic waterfalls.

Geology: Birker Fell is geologically significant as the type locality of the Birker Fell Formation, part of the Borrowdale Volcanic Group. The area is composed mainly of andesite and dacite lava flows from the Ordovician period, formed by ancient volcanic activity.

Figure 3.42 Views of Birker Fell

Devoke Water

Location and Size: Situated on the western edge of Birker Fell, Devoke Water is the largest tarn in the Lake District. It lies at an elevation of 236 m (774 ft) and measures about 1.2 km long and 0.4 km wide.

Landscape Features: The tarn is surrounded by heather moorland, rocky outcrops, and grassy slopes, giving it a remote and wild feel. The boathouse and ruined stable on its shore add a touch of historical character and photographic interest.

Views and Surroundings: From the surrounding fells like Rough Crag and Water Crag, there are panoramic views of the Scafell range, the Irish Sea, and even the Isle of Man on clear days. The area is characterised by big skies.

Accessibility: Despite its remote feel, Devoke Water is accessible via a bridleway from the Birker Fell road, making it a popular spot for walkers and photographers.

Figure 3.43 Views of Devoke Water

Tranquillity assessment

Figure 3.44 demonstrates significant patches of high (top 10% and 20%) tranquillity across the Birker Fell and Devoke Water case study area. The highest tranquillity patches are Devoke Water itself (1), Brantrake Moss (2), Brown Rigg/Crosby Beck (3) and Lower Birker Pool (4). There are no patches of low tranquillity.

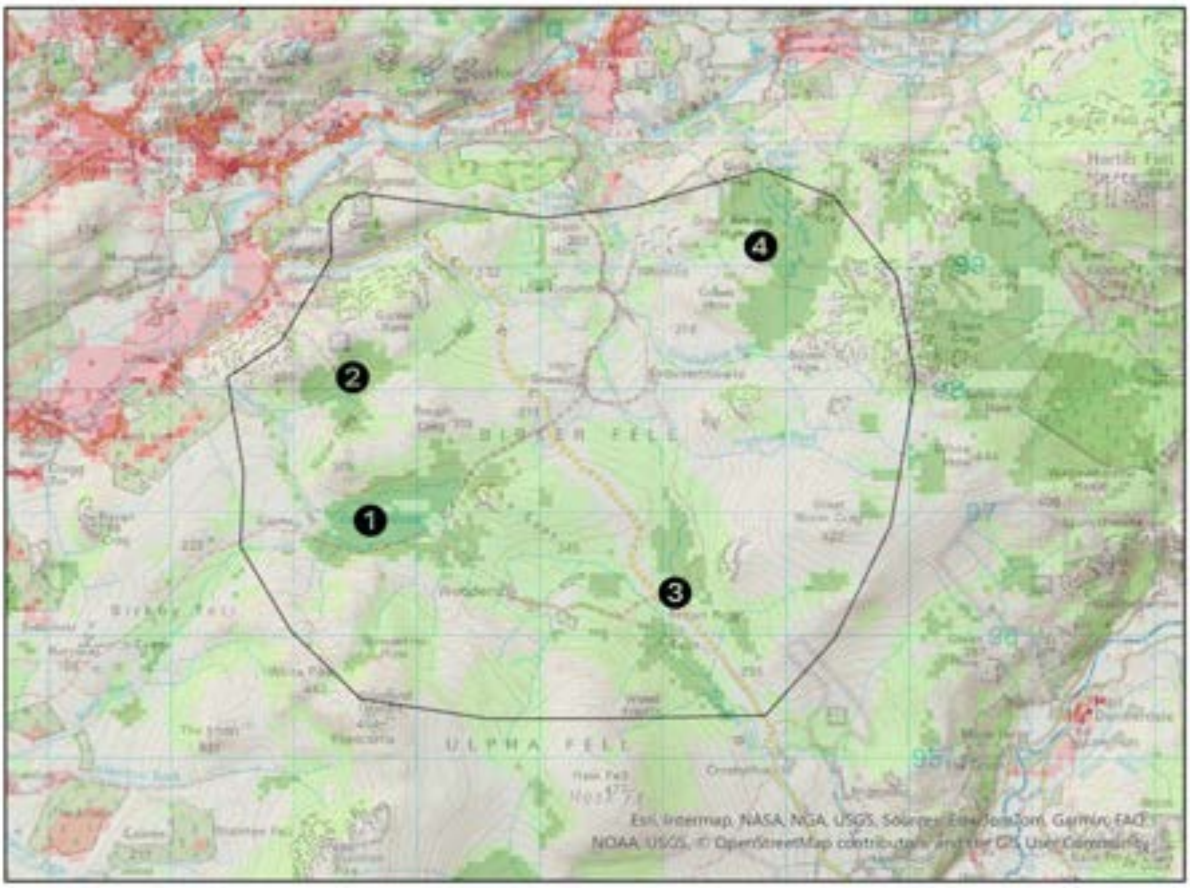


Figure 3.44 Tranquillity across Birker Fell and Devoke Water

The Birker Fell and Devoke Water area offers a strong sense of tranquillity due to its remote, open landscapes with minimal evidence human intrusion. Birker Fell's broad, undulating topography of crags, knolls, and shallow valleys creates a rugged, wild character, reinforced by its open moorland, boggy mosses, and rocky outcrops. The presence of numerous streams and dramatic features like Stanley Force waterfall adds dynamic natural sounds, which can enhance the feeling of natural isolation notwithstanding the recent installation of a viewing platform at Stanley Force which has led to heavy footfall in this location albeit slightly outside the area shown in Figure 3.41. Devoke Water amplifies this tranquillity with its expansive tarn surrounded by heather moorland, low crags and big skies. However, accessibility via a bridleway and its popularity with walkers and photographers introduce intermittent human activity, slightly reducing solitude. This is evidenced by the Strava heatmap data shown in Figure 3.45 which shows significant concentrated use along the paths and tracks and more dispersed use over surround fells and crags as well as some evidence of the use of the tarn for water sports.

Overall, the interplay of rugged terrain, water features, and far-reaching views fosters a strong perception of wildness and calm, with minor impacts from recreational use despite popularity of the main tracks and paths.

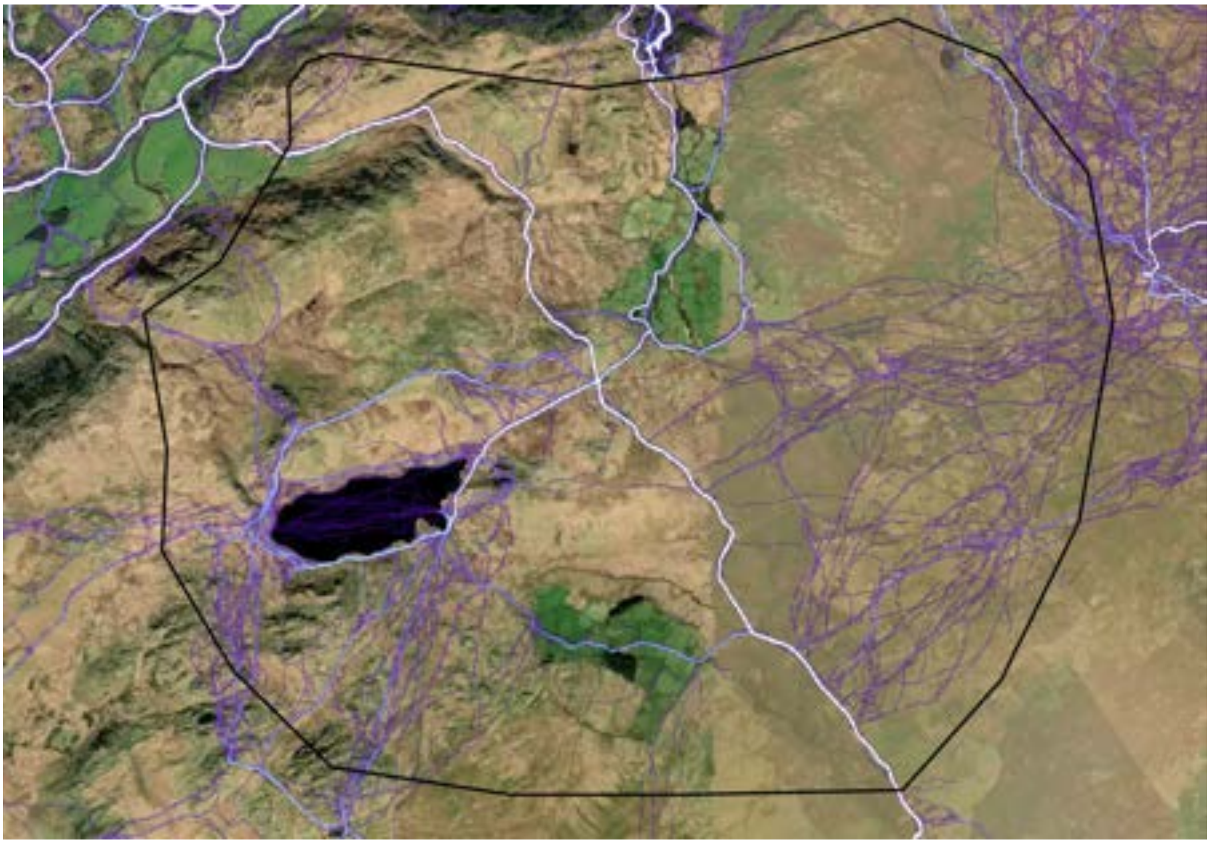


Figure 3.45 Strava heatmap for Birker Fell and Devoke Water

3.4.2 Case study 2: Wasdale Head and Wast Water

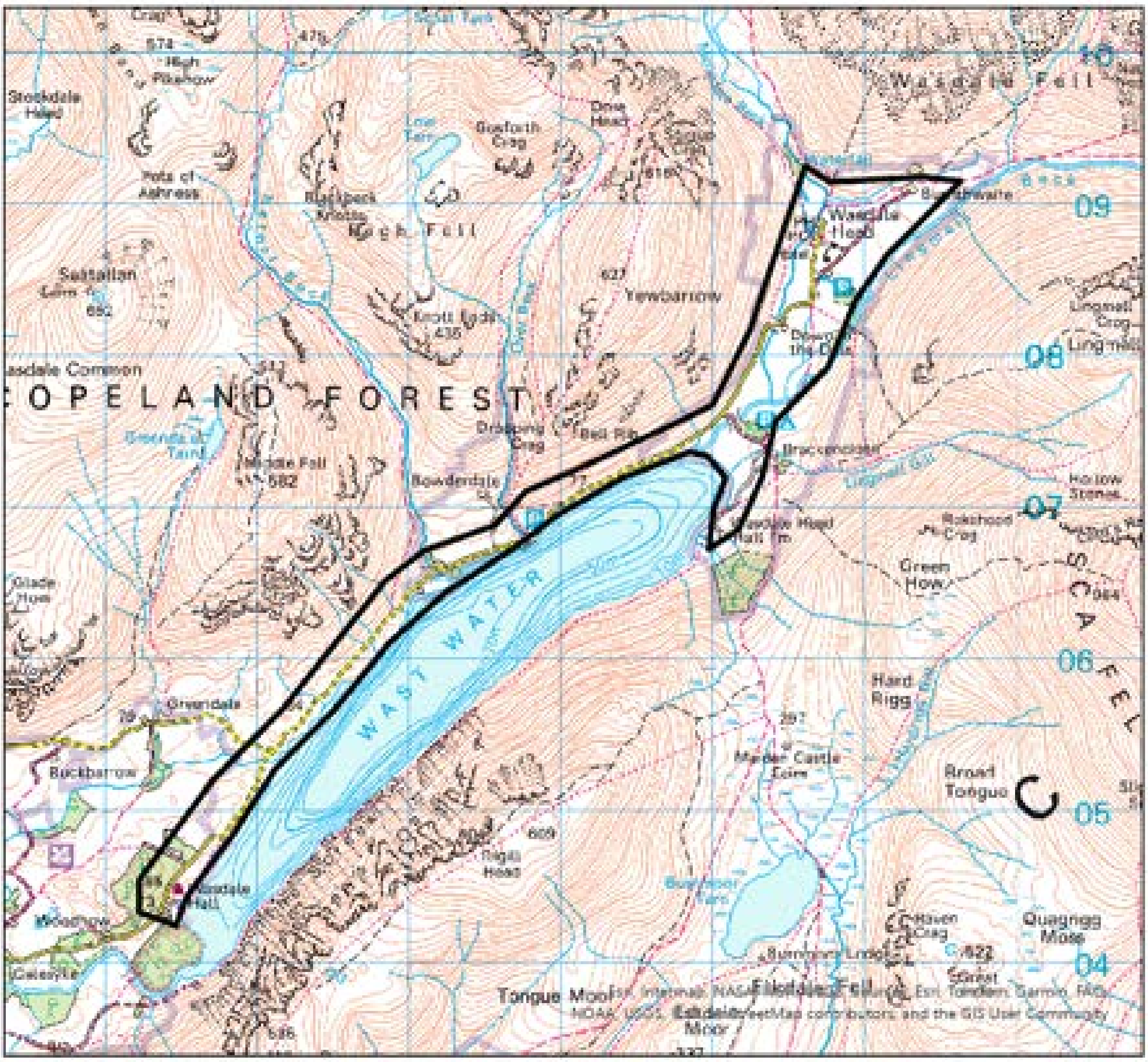


Figure 3.46 Wasdale Head and Wast Water (Source: Ordnance Survey 1:50,000 Landranger)

The Wasdale Head and Wast Water case study area is in the west of the LDNP in a deep glacial trough. It is composed most of “upland valley” based on the Landscape Character Assessment (LCA). There is a single unclassified road running along the north shore of the lake to access the car parks at Wasdale Head and Brackenclose.

Wasdale Head

Topography: Wasdale is a glacially carved U-shaped valley in the western Lake District, known for its dramatic and rugged terrain. It is a popular base for climbing England’s highest mountain, Scafell Pike (978 m), and is flanked by other towering fells such as Great Gable, Kirk Fell, Yewbarrow, and Lingmell.

Vegetation and Land Use: The valley transitions from jagged volcanic fells to gentler, wooded lowlands as it approaches the coast. Traditional Herdwick sheep farming remains a key land use, with a long history dating back to the medieval period.

Cultural Significance: Wasdale is a historic hub for rock climbing and fell walking, with the Wasdale Head Inn serving as a base for climbers since the 19th century. The valley is also home to St Olaf's Church, one of England's smallest churches.

Atmosphere: Often described as wild, remote, and brooding, Wasdale's mood can shift dramatically depending on the weather. This ever-changing character makes it a favourite among landscape photographers, walkers and climbers alike.

Figure 3.47 Views of Wasdale Head

Wast Water

Location and Size: Located within Wasdale, Wast Water is England's deepest lake, reaching depths of 258 feet (79 m). It stretches about 4.8 km long and 0.8 km wide, with a stark, narrow profile that mirrors the valley's glacial origins.

Geological Features: The valley that the lake occupies was shaped by Ice Age glaciers, which sculpted the steep-sided valley and left behind striking features like The Screes – steep slopes of shattered rock that plunge into Wast Water. These were formed by frost-shattering during the last glaciation, creating dramatic fan-shaped cones of debris.

Surrounding Landscape: The lake is surrounded by some of the Lake District's most iconic peaks—Scafell Pike, Great Gable, Red Pike, and Yewbarrow. The Wast Water Screes dominate the southeastern shore, rising nearly 2,000 feet from the lake's edge and creating a dramatic, almost fjord-like appearance.

Atmosphere and Conditions: Wast Water is known for its raw, elemental beauty. The lake is rarely calm due to coastal winds, often resembling a seascape more than a tranquil inland lake. This ruggedness adds to its allure and makes it a challenging but rewarding subject for photography.

Recreation and Access: The lake is popular for walking, climbing, and even scuba diving. The Corridor Route is a popular hiking routes offering scenic views and waterfalls. There is evidence of littering and outdoor toileting associated with "Three Peak" traffic and 24-hour use with some anti-social behaviour from mass events. This said, one participant in the Part B surveys suggests that "Sitting by the lakeside, half way along Wast Water, and opposite the Wast Water screes … watching the mountains at the end of the lake (Yewbarrow, Great Gable)" as one of their named tranquil areas.

Recognition: In 2007, the view from the southwestern end of Wast Water was voted Britain's Favourite View, highlighting its national significance and visual impact.

Figure 3.48 Views of Wast Water: Britain's Favourite View (left) and The Screes (right)

Tranquillity assessment

Large areas of the Wast Water road corridor and Wasdale Head are of medium tranquillity (neither high nor low) yet afford views out over high tranquillity areas such as Wast Water itself (1), The Screes (2), up wild and remote valleys such as Nether Beck (3) and Mosedale Beck (4). Small areas of low tranquillity standout where built structures are found and in locations of high visitor concentration such as Wasdale Head Inn and car park (5) and at the south end of the lake around Wasdale Youth Hostel (6) and beyond towards Nether Wasdale village as shown in Figure 3.49.

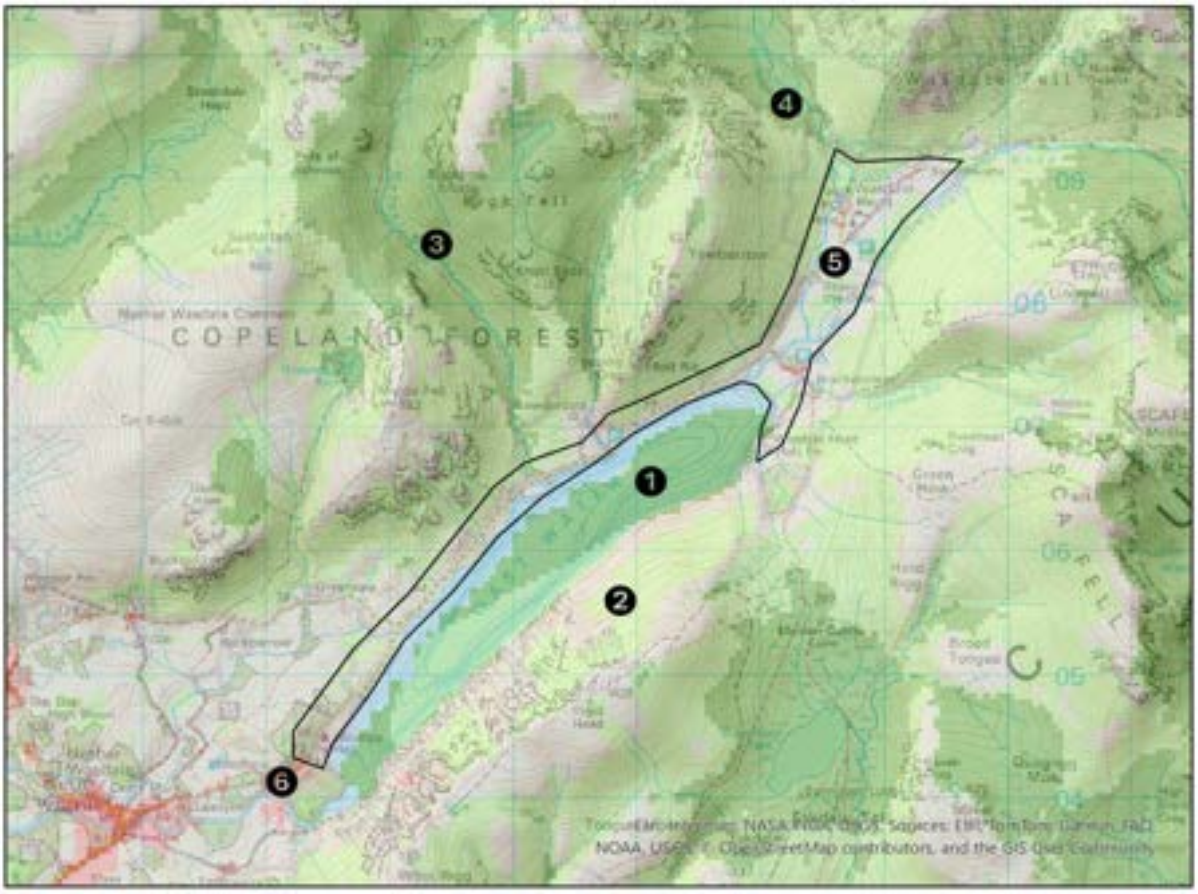


Figure 3.49 Tranquillity across Wast Water and Wasdale Head

The area's tranquillity is shaped by the dramatic mountain setting and cultural significance, with both enhancing and diminishing influences. The valley, framed by towering fells like Scafell Pike and Great Gable, creates a sense of grandeur and isolation, while traditional farming and historic landmarks such as St Olaf's Church and Wasdale Head Inn add depth and focus without overwhelming the landscape. The lake intensifies this wild character with its stark, narrow profile and steep screes that plunge directly into the water. This evokes a raw, elemental atmosphere and engenders feelings of remoteness and awe. The area's popularity for climbing, walking, and general tourism introduces regular human presence, reducing solitude at peak times through traffic, crowded parking facilities and large numbers of visitors along the valley corridor. Accessibility and its status as "Britain's Favourite View" have exacerbated this problem, making tranquillity highly dependent on season and timing. The Strava heatmap in Figure 3.50 illustrates the problem by highlighting popular and over-used hiking routes such as those up Sca Fell and Scafell Pike. There is a significant water sports presence on the lake, mainly from kayaking, paddle boarders and wild swimming. Overall, the interplay of rugged topography, iconic vistas, and cultural heritage fosters a powerful sense of wildness, tempered by recreational activity.

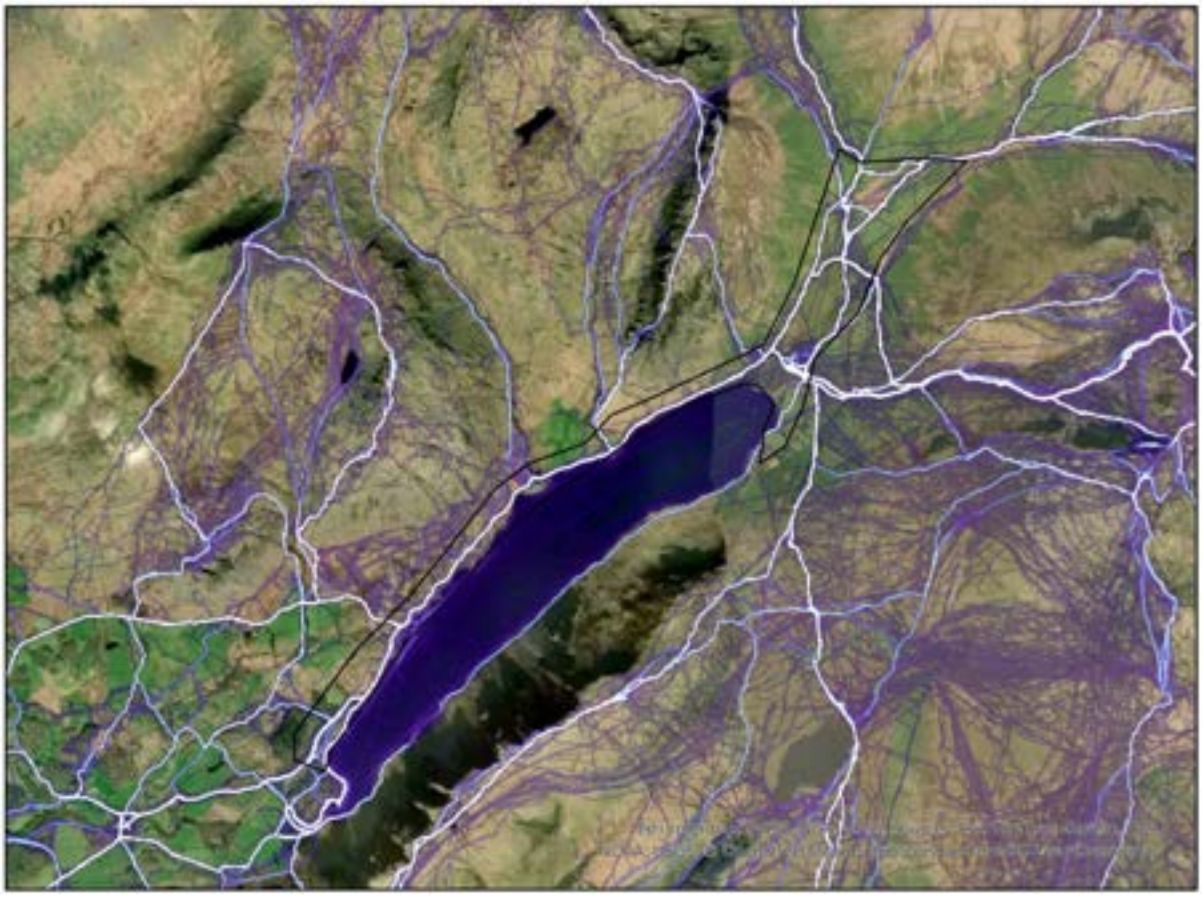


Figure 3.50 Strava heatmap data for Wast Water and Wasdale Head

3.4.3 Case study 3: Little Langdale and Tilberthwaite

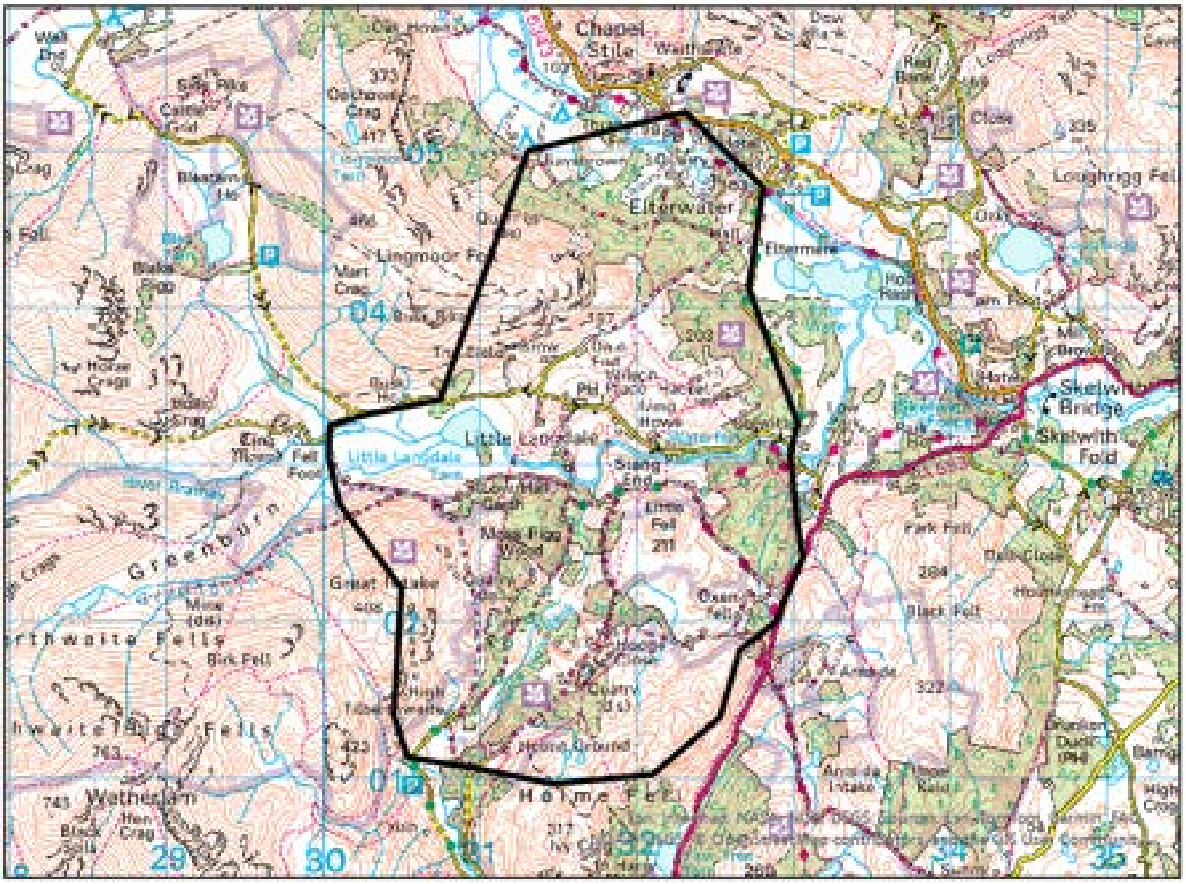


Figure 3.51 Little Langdale and Tilberthwaite (Source: Ordnance Survey 1:50,000 Landranger)

The Little Langdale and Tilberthwaite case study area is in the central area of the at the confluence of the Great and Little Langdale valleys. It is composed most of “upland valley” and “rugged/craggy volcanic high fell” based on the Landscape Character Assessment (LCA). There is a single unclassified road and several green lanes and other rough roads bisecting the area and several hamlets and homesteads/farms as well as marks of current and past histories of quarrying and plantation forestry.

Little Langdale

Topography: Little Langdale is a pastoral valley nestled between the more dramatic Great Langdale and the Coniston Fells. It is flanked by Wetherlam and Swirl How to the south and Lingmoor Fell and Pike of Blisco to the north. The valley descends gently to meet Great Langdale above Elterwater.

Geological and Historical Features: The valley is shaped by glacial activity and centuries of human use. The main water body is Little Langdale Tarn. The area is rich in slate and copper mining history, and is known for Slater Bridge, a 16th-century packhorse bridge built from local slate.

Vegetation and Land Use: The valley is a mixture of grazing pastures, dry stone walls, and coppice woodland, with traditional Herdwick sheep farming still active. The National Trust owns much of the land, preserving its historic and ecological value.

Atmosphere and Accessibility: Little Langdale has a tranquil, secluded feel, with narrow lanes and footpaths connecting it to surrounding valleys. It is popular with walkers and cyclists, offering scenic routes and historical interest. The Three Shires Inn serves as a local landmark and base for exploration. One participant from Part B surveys explicitly mentions Little Langdale, stating that "Areas restricted to cars makes walking a pleasure and through Fletchers Wood."

Figure 3.52 Views of Little Langdale

Tilberthwaite

Topography and Terrain: Tilberthwaite lies just south of Little Langdale and is characterized by rugged upland terrain, rocky gills, and quarry-scarred fellsides.

Industrial Heritage: The landscape is deeply marked by its industrial past, especially slate and copper mining. These quarries have left behind dramatic rock faces, tunnels, and caverns that are now popular with walkers and explorers.

Natural Beauty and Wildlife: Despite its industrial scars, Tilberthwaite is considered one of the loveliest areas in Lakeland, with a blend of natural regeneration and historic intrigue. The area is known for its scenic walks and photographic opportunities.

Access and Recreation: Tilberthwaite is accessible via a narrow road from the A593 and has a small car park. It serves as a starting point for circular walks linking to Little Langdale, Cathedral Cavern, and Slater Bridge. The terrain is uneven and rocky, making it ideal for adventurous walkers.

Figure 3.53 Views of Tilberthwaite
(Images courtesy of Allan Hassey and Ian Rollins)

Tranquillity assessment

The tranquillity of Little Langdale and Tilberthwaite is generally low as shown in Figure 3.52, this being compromised by settlement, roads and quarry infrastructure. There are few smaller patches of higher tranquillity associated with woodland in Sawrey's Wood (1) and Moss Rigg Wood (2). There are views into high tranquillity land up Greenburn and into Tilberthwaite Fells (3), but the clustered settlement around Elterwater/Chapel Stile (4) and farmsteads around Oxen Fell (5) and views out over Skelwith Bridge (6) are areas of low tranquillity.

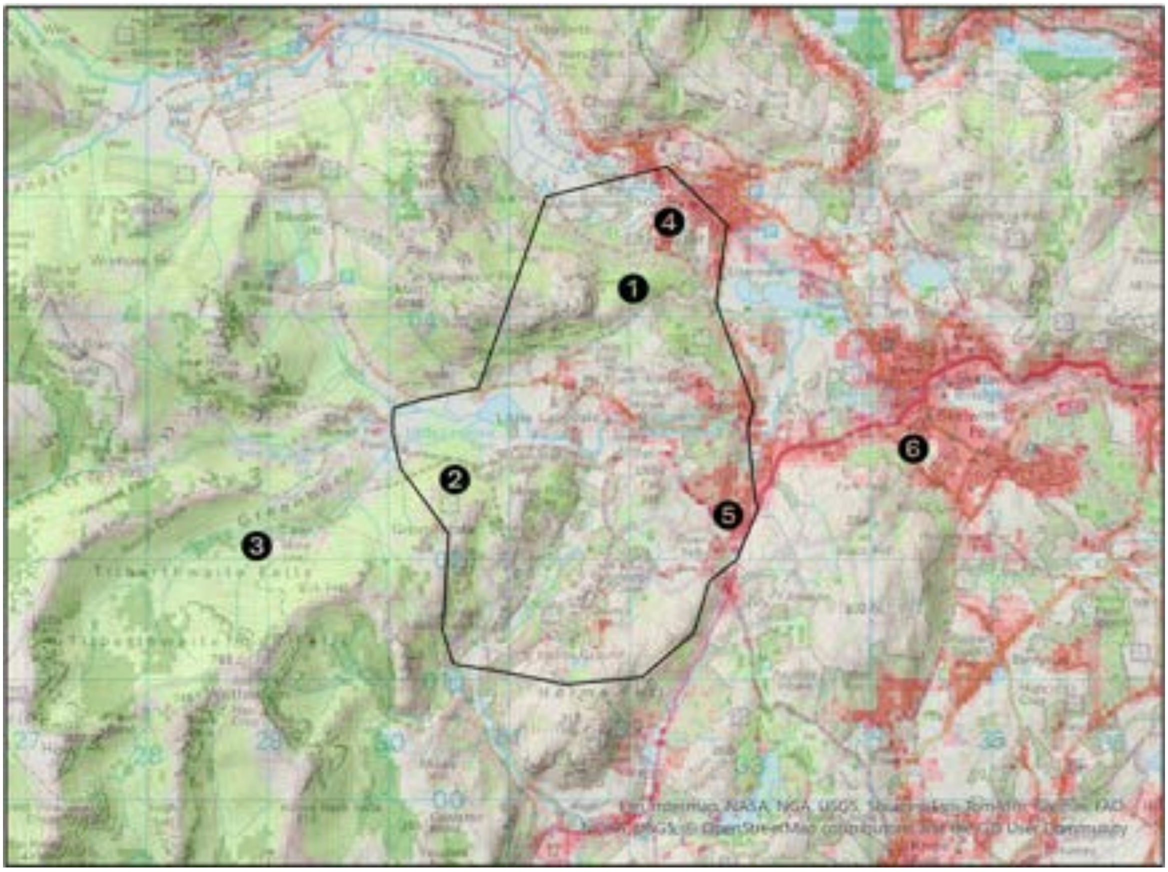


Figure 3.54 Tranquillity across Little Langdale and Tilberthwaite

The area exhibits contrasting yet complementary influences on tranquillity, shaped by their physical character and cultural/industrial heritage. Little Langdale's pastoral valley is framed by surrounding fells, creating a sheltered and intimate atmosphere that is enhanced by traditional land uses such as grazing pastures separated by dry stone walls. Historic features and remnants of mining activity add depth without overwhelming the natural setting. Narrow lanes and footpaths maintain a sense of seclusion, though the area's popularity with walkers and cyclists introduces occasional human presence, slightly diminishing solitude. In contrast, Tilberthwaite's rugged upland terrain and quarry-scarred slopes evoke a wilder, more dramatic feel. Its industrial heritage, marked by rock faces and caverns, adds visual intrigue but also signals past human intervention. However, natural regeneration and scenic views have restored much of its tranquillity, while accessibility and recreational use including use of 4x4 and trail bikes on green lanes bring intermittent activity and disruptive noise. Overall, the area provides a balance of historic character and natural beauty, with tranquillity primarily influenced by landscape openness, cultural features, and the degree of visitor presence. The Strava heatmap in Figure 3.55 demonstrates varied access with much activity around the narrow lanes and footpaths together with key attractions such as Cathedral Cavern.

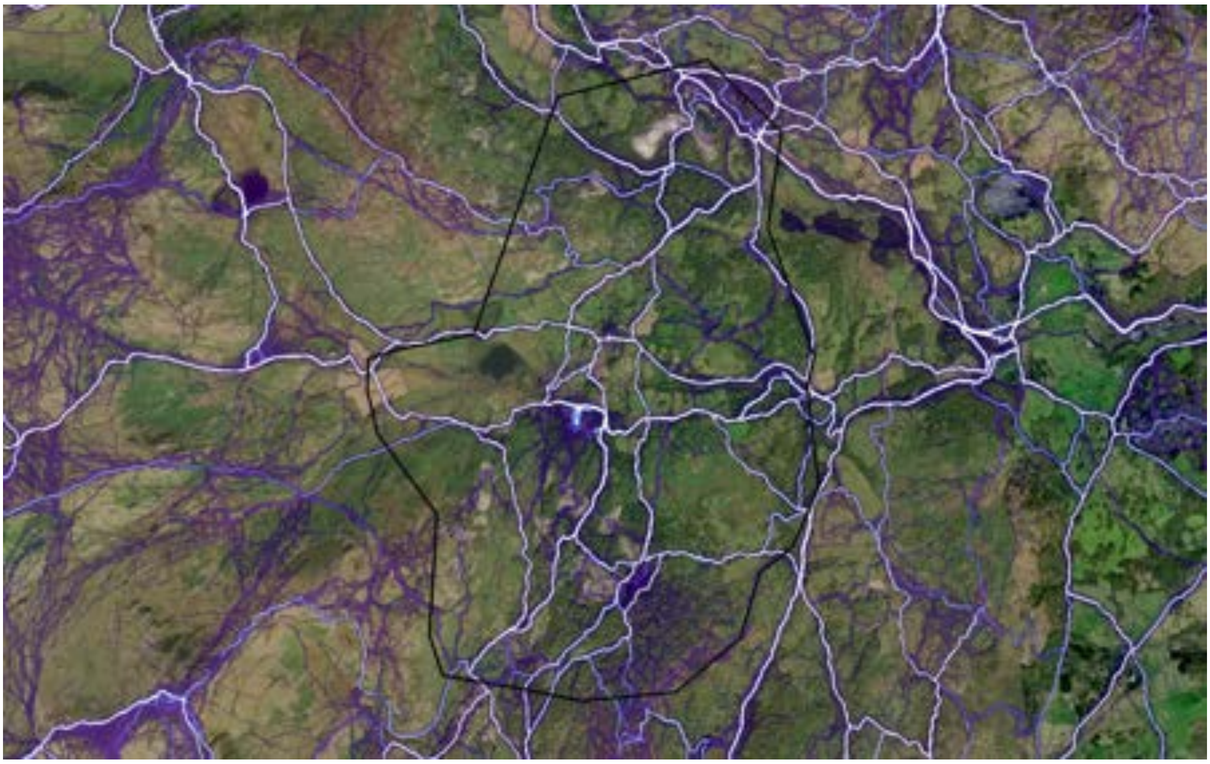


Figure 3.55 Strava heatmap data for Little Langdale and Tilberthwaite

3.4.4 Case study 4: Ullswater

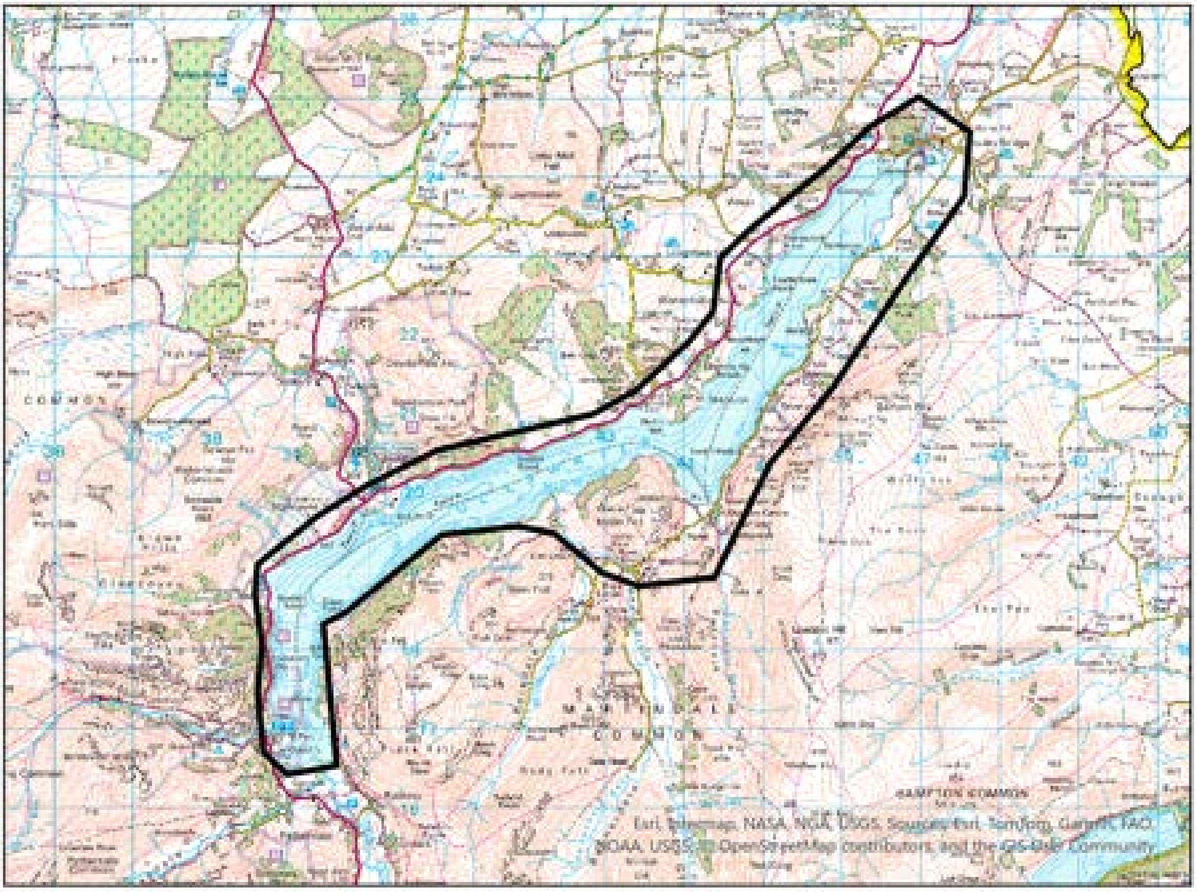


Figure 3.56 Ullswater (Source: Ordnance Survey 1:50,000 Landranger)

The Ullswater case study area is in the northeast of the LDNP in a long deep bow-shaped glacial trough that has its western end in the high fells and its eastern end in the gentler terrain of the Eden Valley. It is composed most of “upland valley” based on the Landscape Character Assessment (LCA) with elements of “rugged/craggy volcanic high fell” and “high fell fringe”. The main A592 Penrith to Windermere road skirts the northern side of the lake heading over Kirkstone Pass. A single unclassified road running along the south shore of the lake connects Howtown and Martindale to Pooley Bridge. Throughout the case study area there is evidence of littering and outdoor toileting associated with high levels of use with some anti-social behaviour from mass events.

Ullswater

Topography and Formation: Ullswater is a classic ribbon lake, formed by glacial activity around 10,000 years ago. It stretches approximately 14.5 km (9 miles) in a roughly serpentine shape, with a distinctive dog-leg bend near Howtown caused by a geological fault. It is the second largest and second deepest lake in the Lake District, reaching depths of over 60 metres.

Surrounding Landscape: The lake is flanked by a dramatic mix of rugged fells, woodlands, and pastoral lowlands. The southern end near Glenridding is mountainous, while the northern end near Pooley Bridge opens into the gentler Eden Valley. The lake is fed by numerous becks and tarns. One participant in Part B surveys specifically mentions Ullswater as a tranquil location.

Ecology and Heritage: Ullswater is a Site of Special Scientific Interest and a National Nature Reserve, home to unique species like the Schelley fish. The area has inspired artists and poets, including William Wordsworth, whose famous poem "Daffodils" was inspired by the flowers at Gowbarrow Park.

Figure 3.57 Views of Ullswater

Aira Force

Waterfall and Woodland: Aira Force is a 65-foot (20-metre) waterfall set in a dramatic wooded gorge on the western shore of Ullswater. The waterfall is fed by Aira Beck, which tumbles through mossy rocks and ancient trees before joining the lake.

Landscaped Grounds: The area around Aira Force was developed in the 18th century as a picturesque pleasure ground, with stone bridges, viewing platforms, and an arboretum. It is now managed by the National Trust and includes Gowbarrow Park, offering scenic walks and wildlife spotting, including red squirrels.

Atmosphere: The combination of lush woodland, thundering water, and historic features creates a magical, almost fairy-tale ambiance, making it one of the most visited natural attractions in the Lake District. One participant in Part B survey mentions Aira Force as "stunning" and remarks that the "further up you go the calmer and more peaceful" it becomes, while another says that "Aira Force is not tranquil as there are so many cars and people, and it is near a major road."

Figure 3.58 Views of Aira Force

(Images courtesy of Alex Hannam and Ron Kenyon)

Pooley Bridge

Village Setting: Located at the northern tip of Ullswater, Pooley Bridge is a charming village with traditional stone buildings, tea shops, and a vibrant community atmosphere. It serves as a gateway to the lake and is a hub for Ullswater Steamers. One participant in the Part B surveys suggests that "The Pooley Bridge area is one of the least tranquil places in the National Park…".

Landscape and Views: The area features rolling hills, meadows, and wooded shores, offering a softer, more pastoral contrast to the rugged southern end of the lake. The new stainless-steel bridge, replacing the historic one lost in 2015 floods, is a modern landmark.

Recreation: Popular for walking, cycling, and boating, Pooley Bridge is also the starting point for scenic routes like the Pooley Bridge to Howtown Circular Walk, which offers panoramic views of the lake and surrounding fells.

Figure 3.59 Views of Pooley Bridge

Glenridding

Location and Terrain: Nestled at the southern end of Ullswater, Glenridding lies at the foot of the Kirkstone Pass and is surrounded by towering fells, including Helvellyn, St Sunday Crag, and Place Fell.

Outdoor Hub: Glenridding is a major base for walkers and climbers, especially those tackling Helvellyn via Striding Edge. The village also offers access to Ullswater Steamers, kayaking, and paddleboarding.

Historical Significance: Once a centre for lead mining, the village retains remnants of its industrial past, notably the Greenside Mine. Today, it blends heritage with tourism, offering a mix of adventure and tranquillity.

Figure 3.60 Views of Glenridding

Hallin Fell

Topography: At 388 metres, Hallin Fell is one of the smaller Wainwrights, but it offers exceptional panoramic views over Ullswater and the surrounding fells. It is located on the eastern shore, near Howtown and Martindale.

Accessibility: The fell is easily accessible from St Peter's Church, with a short but steep ascent. It's a popular choice for families, first-time fell walkers, and those seeking a quick, rewarding hike.

Scenic Value: The summit offers 360-degree views of the lake, Helvellyn, Place Fell, and the Martindale valley. It's especially popular for sunset walks and photography.

Figure 3.61 Views of Hallin Fell

Tranquillity assessment

Overall, tranquillity values around Ullswater are generally low, particularly at the eastern end of the lake where it is more developed. Areas with moderately high tranquillity are behind Hallin Fell with views into the remoter valleys penetrating Martindale Common (1). Similar views into more tranquil landscapes can be found at the western end of the lake at Glencoyne (2). Glenridding and Patterdale at the far southwestern end of the lake are relatively well-developed settlements and popular tourist attractions giving low tranquillity scores (3). The car park and road access to Aira Force is an area of typical congestion and low tranquillity around this popular visitor attraction (4). The steamer pier, hotel, and outdoor centre at Howtown (5) is another location of low tranquillity. Pooley Bridge at the far northeastern end of the lake is a focus and arrival point for many visitors which together with the settlement, roads, marina and steamer departure point make for very low tranquillity along with large campsites which influence tranquillity due to presence of tents and campervans with associated noise/disturbance and lights. During the summer months there is enhanced visitor use from these sites in the lake including swimming and paddling (6). This activity and infrastructure extends along both shores of the eastern end of the lake is a band of very low tranquillity as shown in Figure 3.62.

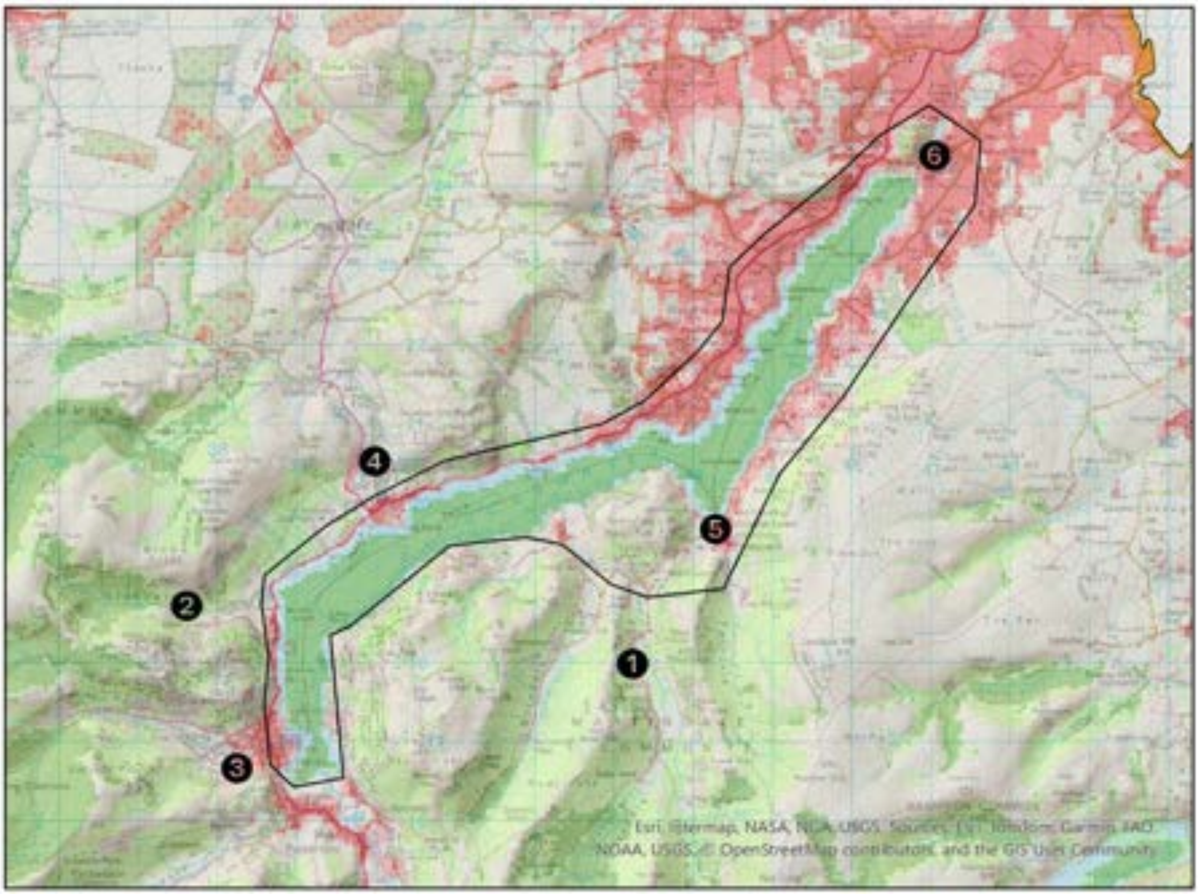


Figure 3.62 Tranquillity across Ullswater including Aira Force, Pooley Bridge, Glenridding and Hallin Fell

Ullswater's tranquillity is shaped by its natural setting, cultural heritage, and recreational use. The lake's serpentine form, flanked by rugged southern fells and softer northern lowlands, creates a varied sense of enclosure and openness contrasting both ends of the lake. Surrounding woodlands, pastoral slopes, and panoramic viewpoints such as Hallin Fell enhance scenic value and feelings of remoteness. Historic and ecological features, including Gowbarrow Park and Aira Force, reinforce its special character. However, tranquillity is moderated by human activity: villages like Pooley Bridge and Glenridding/Patterdale act as hubs for boating, walking, and climbing, introducing seasonal congestion. Attractions such as Aira

Force, with landscaped grounds and visitor facilities, draw significant vehicular traffic and footfall, creating localized noise and movement. Despite these pressures, the lake's scale and opportunities for quiet exploration maintain a strong sense of calm, particularly away from popular access points (Figure 3.63).

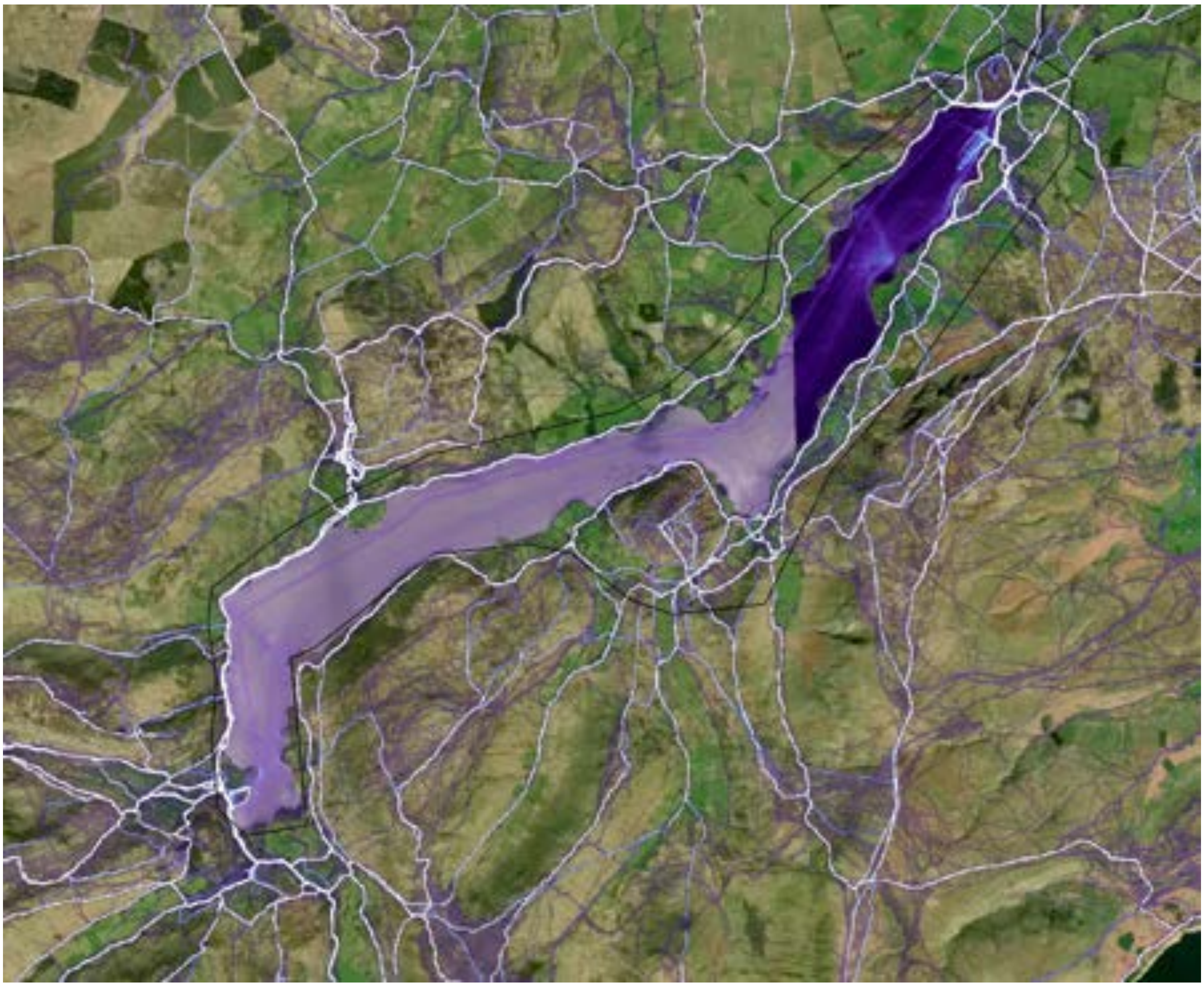


Figure 3.63 Strava heatmap data for Ullswater

3.4.5 Case study 5: Portinscale, Catbells and Stair and the Newlands Valley

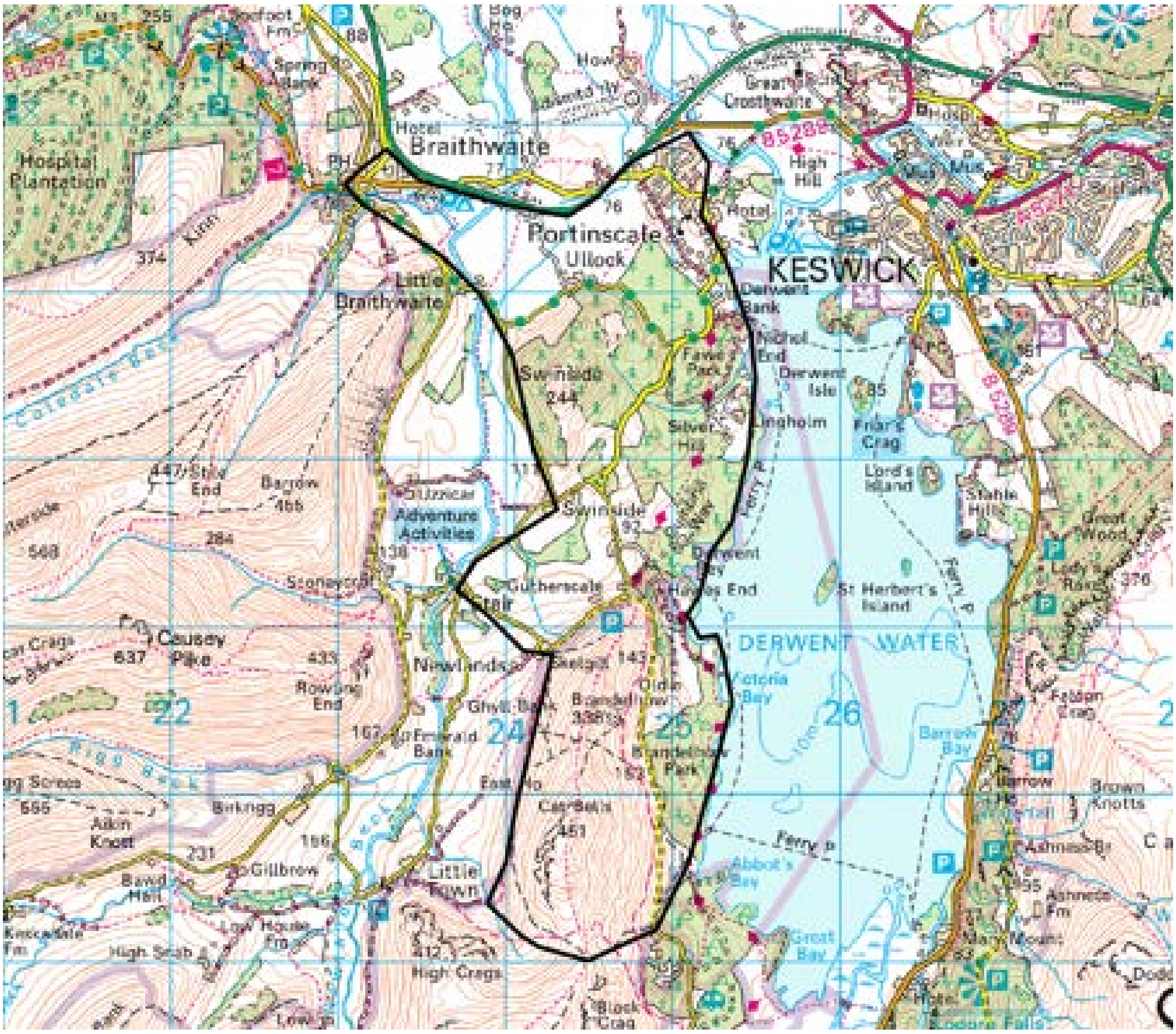


Figure 3.64 Portinscale, Catbells and Stair and Newlands Valley (Source: Ordnance Survey 1:50,000 Landranger)

The Portinscale, Catbells and Stair and the Newlands Valley case study area is in the north of the LDNP adjacent to Derwent Water and the town of Keswick. It is composed most of “upland valley” and “rugged angular slate high fell” according to the Landscape Character Assessment (LCA). Unclassified roads give access to the cat Bells car park and the hamlets of Stair and Newlands.

Portinscale

Location and Setting: Portinscale is a charming Lakeland village located just west of Keswick, on the northwestern shore of Derwentwater. It lies at the entrance to the Newlands Valley, making it a strategic base for exploring the surrounding fells and lakes.

Landscape Features: The village is surrounded by rolling pastures, wooded slopes, and lake views, with easy access to Derwentwater via Nichol End Marina. The area is rich in walking routes, including paths to Brandelhow and Catbells.

Cultural and Historical Interest: Portinscale has historical connections to Beatrix Potter, who spent summers at nearby Lingholm Estate, said to have inspired “Mr. McGregor’s Garden.” The village also has archaeological significance, with prehistoric tool-making sites discovered nearby.

Atmosphere: Portinscale offers a peaceful, community-oriented feel, with tearooms, a pub, and marinas. It's ideal for those seeking a tranquil retreat with access to both lake activities and fell walking.

Figure 3.65 Views of Portinscale

Catbells

Topography and Elevation: Catbells is a distinctive fell rising to 451 metres (1,480 feet) on the western shore of Derwentwater. It features a graceful ridgeline and is part of the Newlands Valley range.

Views and Vistas: Despite its modest height, Catbells offers panoramic views of Derwentwater, Keswick, Skiddaw, and the Borrowdale Valley. The summit provides a 360-degree perspective of the surrounding fells and lakes. Skelgill bank on the Catbells ridge is associated with Beatrix Potter's hedgehog character Mrs Tiggy-Winkle. One participant in the Part B survey specifically mentions views across Derwent Water from Cat Bells towards Walla Crag and away from traffic noise as their tranquil location, while others suggest "The Keswick/Portinscale/Catbells area is untranquil due to the number of visitors and vehicles" and "Portinscale and Catbells are far too busy in Summer … cars parked everywhere".

Trail Characteristics: The ascent from Hawse End is a moderate hike, with well-defined paths, steep sections, and minor scrambling. It's considered a family-friendly fell, suitable for beginners and children with some walking experience. There is evidence of littering and outdoor toileting associated with the popularity of cat Bells as an 'easy' Lake District fell.

Geological and Ecological Features: The fell is composed primarily of slate, and its slopes support heather, bracken, and upland wildlife. The area is popular with photographers and nature lovers.

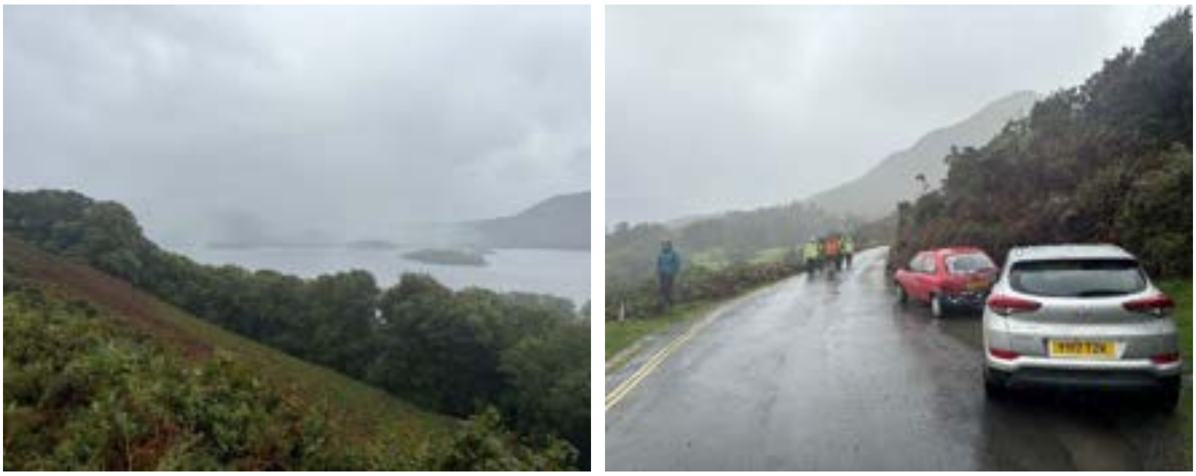


Figure 3.66 Views of Catbells

Stair and the Newlands Valley

Valley Setting: Stair is the main settlement in the Newlands Valley, a secluded and picturesque glacial valley west of Derwentwater. The valley is framed by towering fells such as Catbells, Causey Pike, Robinson, and Dale Head.

Landscape Features: The valley is known for its emerald pastures, stone farmsteads, and meandering becks like Newlands Beck. It retains a timeless, pastoral charm, often described as an "Arcadia" by Alfred Wainwright.

Cultural and Literary Connections: The valley inspired Beatrix Potter's The Tale of Mrs. Tiggy-Winkle, with Littletown and Newlands Church featured in her illustrations. The area also has Viking place names and a history of mining, notably at Goldscope Mine.

Recreation and Access: Stair is a hub for walking, including the Newlands Round, and adventure activities via the Newlands Adventure Centre. The Swinside Inn, dating to the 17th century, is the valley's only pub.

Tranquillity assessment

Portinscale, Catbells and Stair and the Newlands Valley is a popular and well-frequented area of the park, partly because of its close proximity to Keswick and outlying settlements of Portinscale, Braithwaite and Newlands/Stair. Catbells (1) with its views towards Rigg beck and Causey Pike (2) and the woods around Silver Hill/Lingholm (3) provide the only points of higher tranquillity within the case study area. The settlements of Newlands/Stair (4) and Portinscale/Ullock are very low tranquillity. Views from Catbells over Derwent Water provide a key focal point of high tranquillity (Figure 3.67).

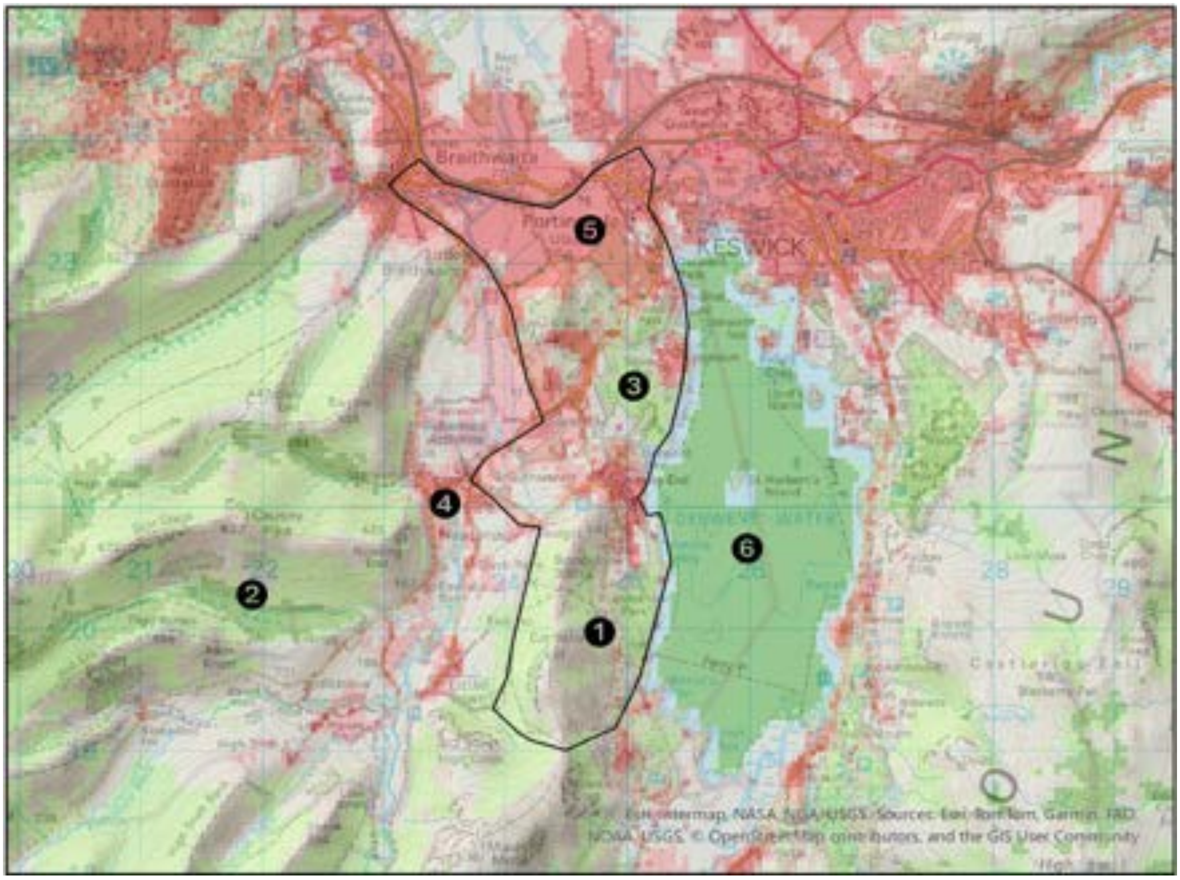


Figure 3.67 Tranquillity across Portinscale, Catbells and Stair and the Newlands Valley

Portinscale, Catbells, and the Newlands Valley collectively offer a tranquil setting shaped by their scenic landscapes, cultural heritage, and recreational use. Portinscale's village character, framed by rolling pastures, wooded slopes, and lake views, creates a peaceful, community-oriented atmosphere, though proximity to Keswick and lake activities introduces some human presence. Catbells, with its graceful ridgeline and panoramic vistas over Derwentwater, is a major draw for walkers and families. This popularity brings foot traffic and localized noise. In contrast, the Newlands Valley and Stair settlement evoke deep tranquillity through their secluded valley setting, pastoral charm, and historic associations with Beatrix Potter and mining heritage. Adventure hubs and walking routes like the Newlands Round make the valley popular with walkers. Overall, tranquillity here is driven by dramatic views, cultural resonance, and pastoral landscapes, but moderated by views of urban areas, visitor activity concentrated around key access points and popular trails as seen in the Strava data in Figure 3.68.

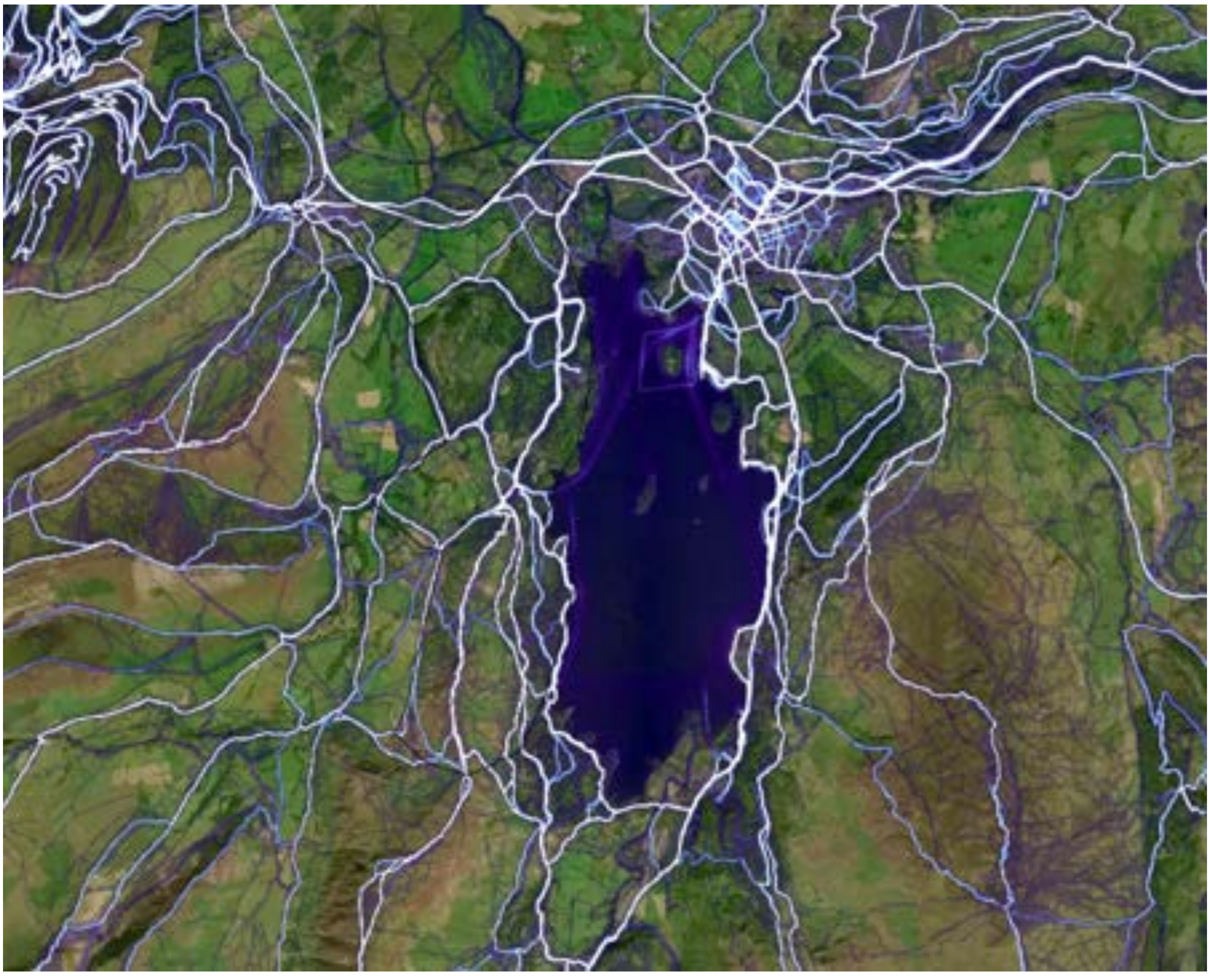


Figure 3.68 Strava heatmap data for Portinscale, Catbells and Stair and the Newlands Valley

3.4.6 Other tranquillity indicators

While the spatial modelling work described in Part A provides a robust foundation for mapping tranquillity, it cannot fully capture the experiential qualities that define a truly peaceful landscape. Factors such as topographic openness, dark skies, and remoteness from roads and public transport play a critical role in shaping our perceptions of tranquillity. These measures influence how visitors experience the sense of scale, isolation, and sensory immersion in the natural environment.

Topographic openness affects visual enclosure and the sense of vastness or intimacy within a landscape, contributing to feelings of freedom or refuge. This is calculated from terrain model data in QGIS and described the amount of sky visible from any location with wide open landscapes and the summits of fells and along ridges providing the greatest views. Conversely, the views experienced from inside deeper valleys and glacial corries provide a more enclosed and closer perspective on the surrounding landscape. The patterns in openness are shown in Figure 3.69 and highlights a familiar pattern of summits and ridges intersected by deep glacial valleys and corries and a apron of more open landscapes surrounding the central fells.

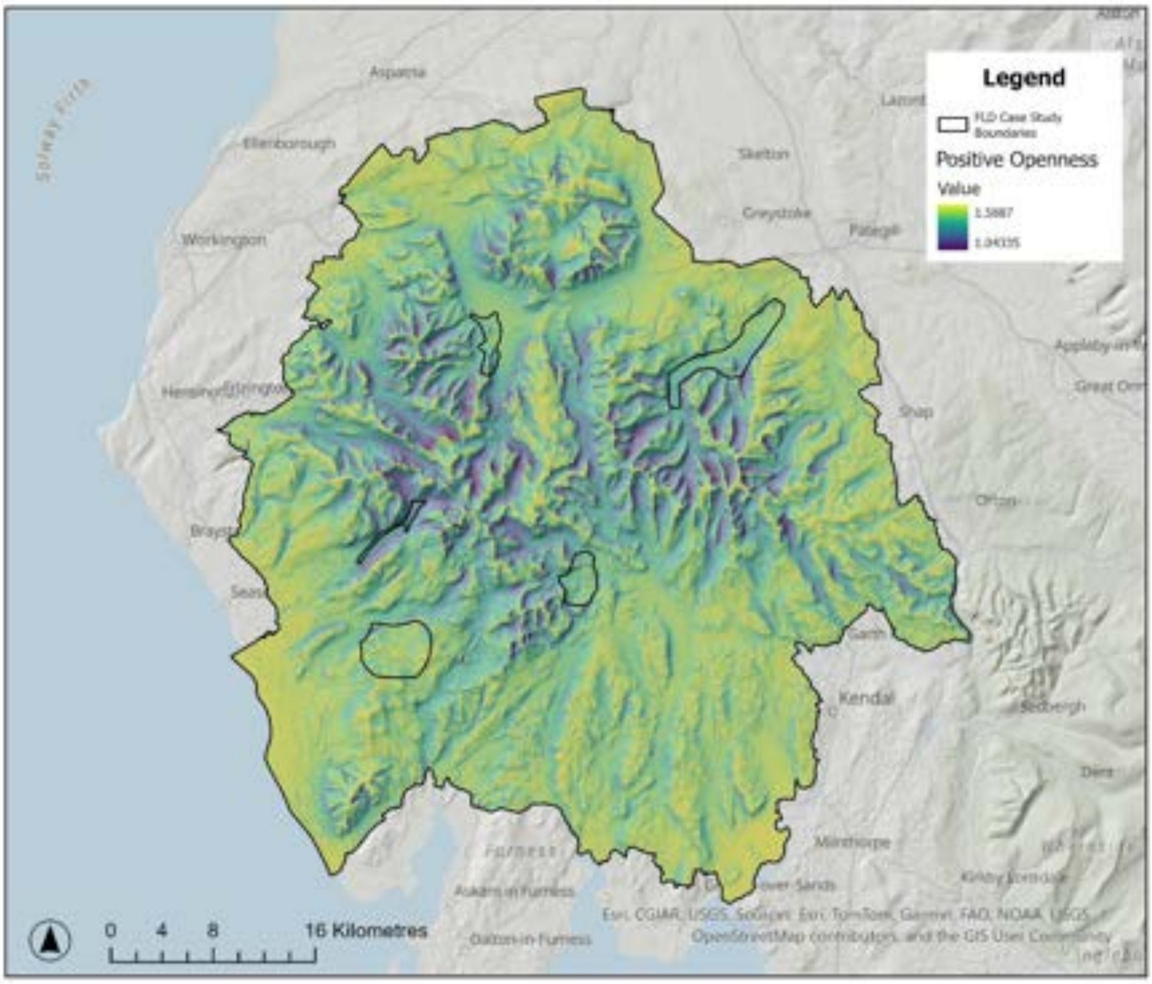


Figure 3.69 Openness

Dark skies enhance night-time tranquillity by reducing light pollution and enabling stargazing, which is viewed as an increasingly valued cultural ecosystem service. The map shown in Figure 3.70 is derived from NASA data on Nighttime Lights. The higher values in this map indicate higher values in the nighttime lights data. Hotspots in nighttime lights can be seen around the main settlements of Keswick, Ambleside, and Windermere with light pollution from major towns just outside the park boundary including Cockermouth, Penrith, Kendal and Grange-over-Sands. Light pollution from the Sellafield nuclear site can clearly be seen in the west of the park.

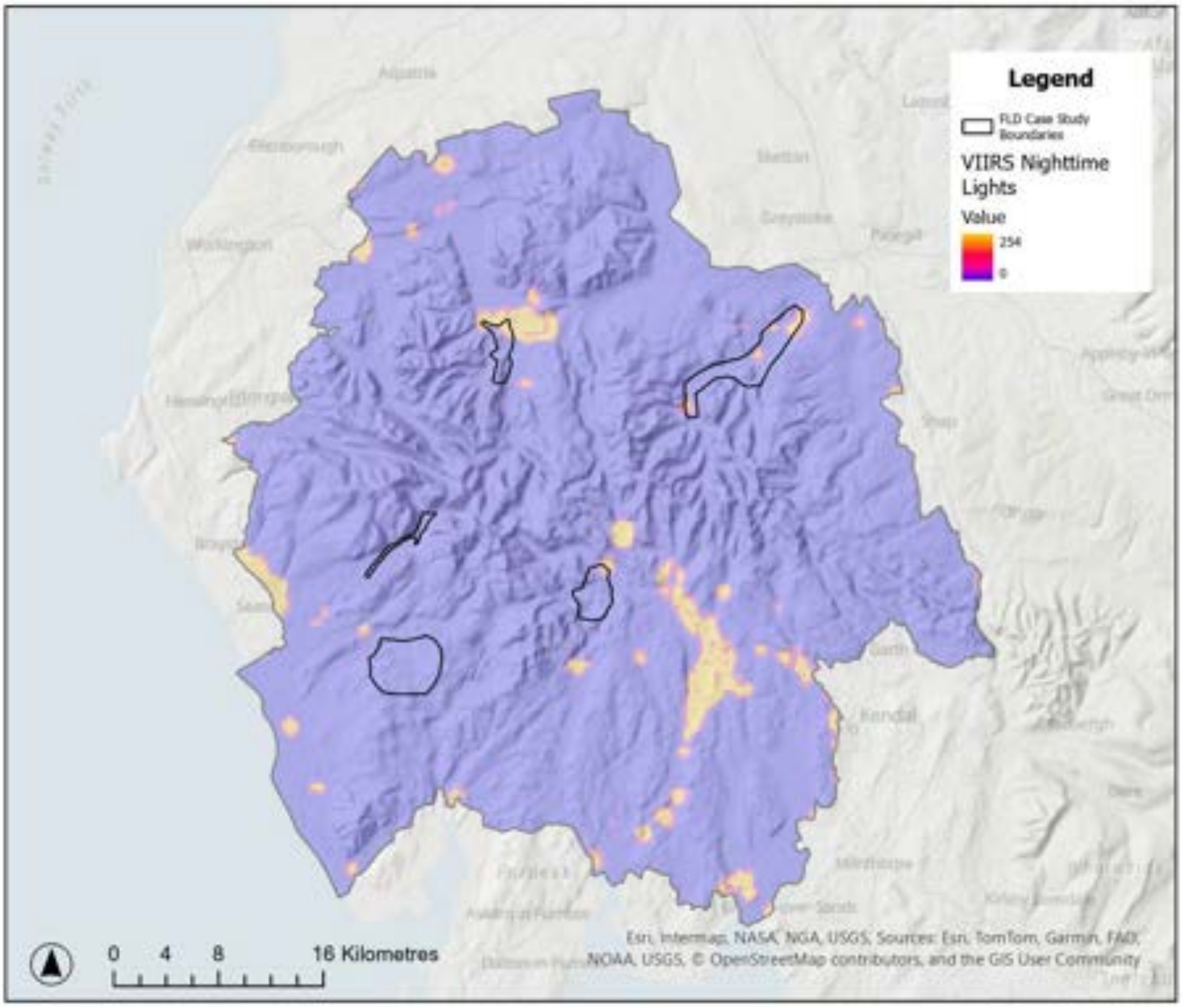


Figure 3.70 Dark skies

Remoteness from roads and bus stops determines the likelihood of encountering traffic noise or crowds, reinforcing opportunities for solitude and escape. While this is related to the Strava heatmap data used in the spatial models, it is best viewed as a park-wide indicator of landscape character. Figures 3.71 and 3.72 show remoteness from roads and bus stops respectively. These are modelled based on walking times using Naismith's Rule that takes horizontal distance, relative slope, land cover and barrier features into account.

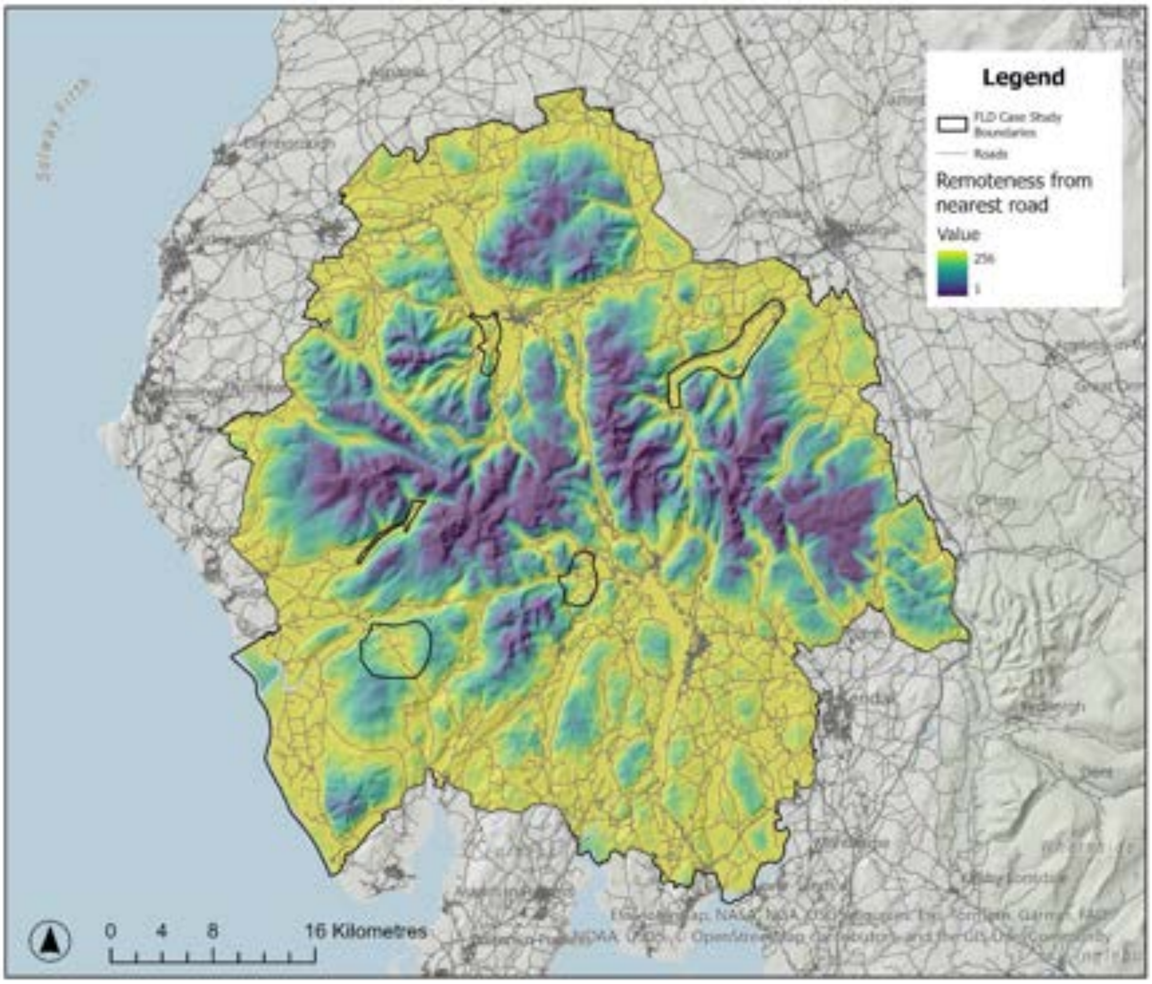


Figure 3.71 Remoteness from nearest road

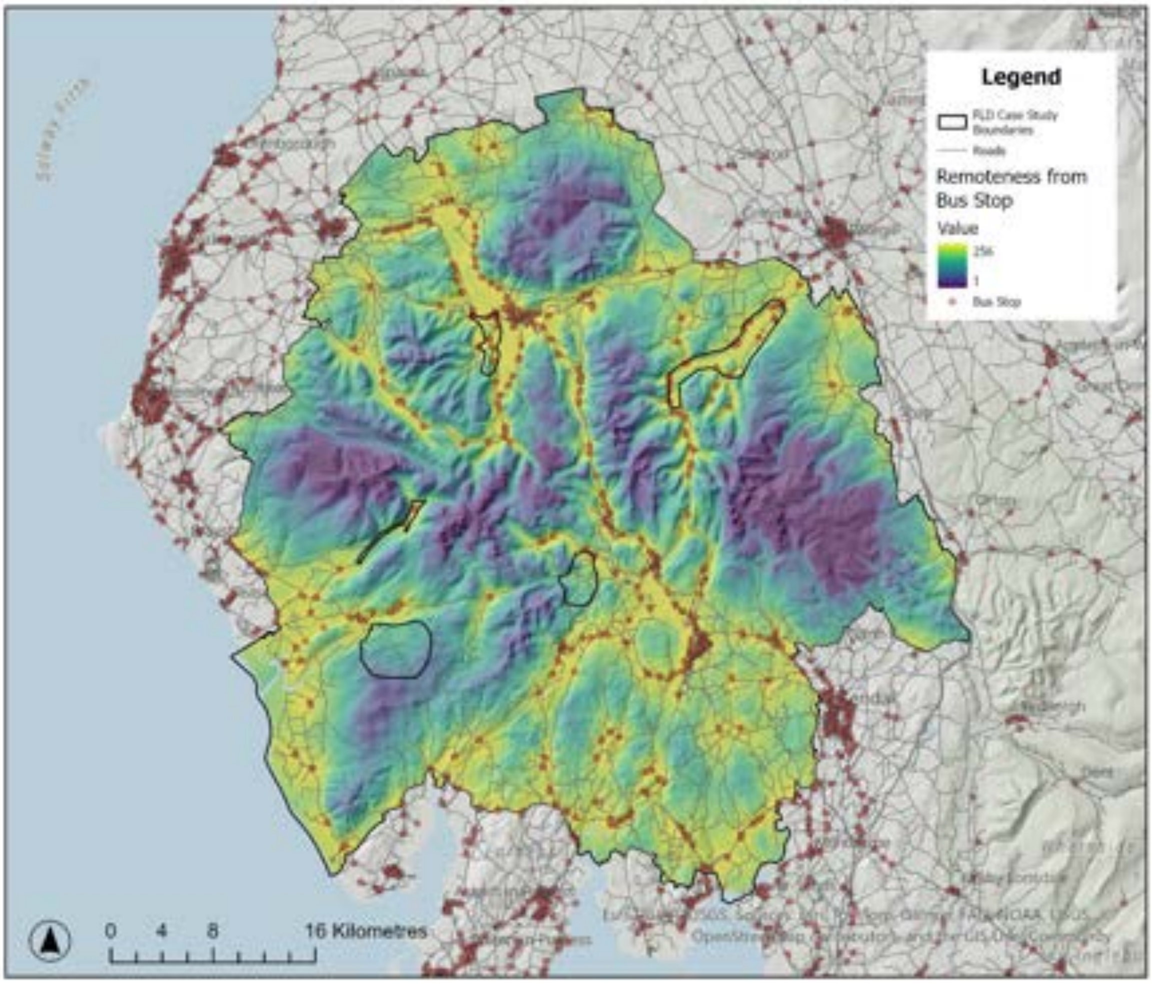


Figure 3.72 Remoteness from nearest bus stop

4. Innovation and Improvements

The work carried out for this report involves several technical and methodological innovations and improvements when compared to existing approaches to tranquillity mapping. These include combined visual and acoustic modelling employing advanced tools and open-source data and software, use of public input for crowd sourcing tranquillity perceptions and model verification and ensuring repeatability.

4.1 Combined Visual and Acoustic Modelling

The project advances tranquillity mapping by integrating visual and acoustic dimensions into a unified spatial model. Traditional approaches often rely on binary viewsheds or fixed buffer zones, oversimplifying the nuanced experience of tranquillity. Here, visibility is modelled using advanced viewshed tools (Viewshed Explorer) with distance decay and partial occlusion, while acoustic impacts are assessed using DEFRA noise models and then validated through eco-acoustic monitoring in the field. This dual approach captures both what people see and hear, acknowledging that tranquillity is shaped by the interplay of visual openness and natural/human soundscapes. Supplementary layers such as remoteness, dark skies, and topographic openness enrich the model, creating a holistic representation of sensory qualities across the Lake District National Park.

4.2 Use of Public Input in a Rigorous and Quantitative Way

Recognising the subjectivity of tranquillity, the project employs Participatory GIS (PGIS) tools, in the form of Map-Me and Paper2GIS, to gather local knowledge and lived experiences. Unlike scraping social media for relevant information/data, these methods ensure diverse representation and context specific insights captured directly from participants. Participants identify tranquil and non-tranquil areas using intuitive map interfaces and provide qualitative descriptions and confidence ratings in linked text boxes. To overcome the challenge of quantifying public opinion, the study applies Dempster-Shafer theory, generating probabilistic tranquillity surfaces that account for uncertainty, confidence levels, and spatial weighting. This rigorous framework enables meaningful comparison between modelled outputs and public perceptions, ensuring that decision-making reflects both scientific analysis and community values.

4.3 Employment of Advanced Tools and Open-Source Software

The methodology described here uses cutting-edge GIS and acoustic technologies alongside open-source platforms to ensure accessibility and transparency. Viewshed Explorer and OS Terrain 50 underpin advanced visual modelling, while acoustic analysis uses Scikit-Maad, an open-source Python package designed to support the analysis of large-scale environmental audio datasets. Additional datasets, such as Strava heatmaps which identifies recreational intensity and NASA dark skies data, introduce innovative proxies for human presence and nocturnal serenity. By relying on publicly available data and open-source tools, the project reduces costs, enhances reproducibility, and aligns with best practices in collaborative environmental science.

4.4 Repeatability and Citizen Science

A key innovation of the work described here lies in designing a monitoring framework that is robust, repeatable, and adaptable for long-term use. Outputs are provided in accessible formats (e.g., GeoTIFFs) compatible with platforms like QGIS, enabling stakeholders and volunteers to update and refine maps over time. Detailed documentation supports replication, while participatory tools encourage ongoing community engagement. Ground-truthing through site visits and acoustic monitoring validates the model, ensuring reliability for future applications. This emphasis on repeatability and citizen science transforms tranquillity mapping from a one-off exercise into a dynamic, evolving process that empowers local communities to safeguard the Lake District's unique sense of peace.

5. A Monitoring Framework

5.1 Monitoring Framework for Tranquillity

The monitoring framework for tranquillity presented here aims to provide a systematic approach to tracking changes affecting tranquillity in mixed and varied landscapes such as those found in the Lake District National Park. It combines spatial datasets, participatory mapping, and acoustic monitoring to ensure comprehensive coverage of both contributors and detractors that positively and negatively influence measures of tranquillity. Spatial datasets such as land cover, roads, and noise maps should be updated every five years or following major infrastructure changes as and when mapping allows. Participatory mapping data requires regular updates to capture seasonal and perceptual variations and can be repeated every five years alongside the spatial models. Acoustic monitoring should also be repeated at key sites every five years or after significant changes in traffic or recreational use. This multi-layered approach ensures that both physical and experiential aspects of tranquillity are accurately represented.

5.2 Data Sources and Quality Control

Reliable data sources are essential for robust monitoring. Publicly available datasets such as OS Terrain 50, OpenStreetMap, DEFRA noise maps, and NASA dark skies data form the backbone of the spatial analysis presented here. Recreational intensity can be assessed using Strava heatmaps, though demographic bias should be acknowledged. Validation involving ground-truthing through site visits and eco-acoustic monitoring should be carried out on a rolling five-year basis. To ensure scientific rigor, sensitivity analyses such as Monte Carlo bootstrapping and jack-knifing should be applied to test the robustness of model weights and criteria. These measures help maintain data integrity and confidence in the resulting tranquillity assessments.

5.3 Citizen Science and Community Engagement

Citizen science plays a vital role in enriching tranquillity monitoring with local knowledge and perceptions. Participatory GIS tools like the Map-Me and Paper2GIS tools used here enable residents and visitors to identify tranquil and disturbed areas based on detailed local knowledge, providing confidence ratings and qualitative descriptions for added context. Engagement strategies include workshops and outreach events to encourage participation, alongside training in both digital and paper-based tools to ensure inclusivity. Integrating citizen-generated data with scientific models requires probabilistic frameworks such as Dempster-Shafer theory, and normalization techniques should be applied to prevent bias from highly active contributors. This collaborative approach fosters community ownership and enhances data diversity.

Some ‘in-the-field’ citizen science approaches to capture seasonal and perceptual variations, as well as more detailed information at specific locations, such as the case study areas or where particular changes have taken place (e.g. a new development or event) is also envisaged. This will supplement the information from participatory mapping surveys.

5.4 Long-Term Use and Expansion

For long-term rigour and sustainability, the framework must be scalable and adaptable. Outputs should be delivered in open formats like GeoTIFF and shapefiles, ensuring compatibility with platforms such as QGIS. Detailed workflow documentation will support replication by other national parks and conservation bodies. Tranquillity maps can inform development control, visitor management, and conservation priorities, embedding tranquillity indicators into planning frameworks as part of cultural ecosystem service assessments. Future expansion could include mapping adjacent landscapes to understand wider drivers of detractors such as noise.

Exploring a similar analysis with other protected areas would also provide insights into the differences and similarities inherent to protected areas across the UK including national parks, national landscapes, World heritage Sites and Heritage Coasts. Integrating emerging data sources such as social media geotags and mobile sensor networks could also enrich the approach and support development of mobile apps for real-time reporting which could enable continuous citizen science contributions, making the monitoring system dynamic, responsive and inclusive.

Studies such as those described here could be replicated across other national park authorities and associated landscapes such as the whole of Cumbria and into the Yorkshire Dales National Park with which the Lake District National Park shares a common boundary. Other nearby protected areas might include National Landscapes such as Forest of Bowland, Nidderdale and North Pennines.

6. Conclusions and recommendations

National and local authorities are empowered to embed tranquillity indicators within statutory planning and environmental policies including recognizing tranquillity as a cultural ecosystem service and integrating it into biodiversity strategies and visitor management plans. Policies should prioritize limiting noise pollution, control light spill, and managing traffic in sensitive areas such as national parks. Incentives for low-impact tourism and sustainable transport options can further protect tranquil landscapes yet require proper funding streams. Clear policy frameworks will ensure that tranquillity is treated as a measurable and enforceable environmental quality and so protect tranquil areas for future generations.

Mapped tranquillity data can be used to inform development control and infrastructure planning as follows:

- Areas identified as highly tranquil should be identified as priority zones for conservation, with strict limits on new roads, housing, or energy projects and minimise impacts in other areas as far as is possible.
- Planning authorities should use tranquillity maps alongside noise and visual impact assessments to guide planning decisions.
- Visitor facilities should be in less sensitive areas, while access routes should minimize disturbance.
- Incorporate tranquillity mapping into local plans to help balance economic and other development with the conservation of peaceful landscapes that make them attractive to inward investment and visitors in the first instance.
- Integrate tranquillity mapping into landscape character monitoring as a key integral landscape quality.

The comparison of the findings of Part A and Part B (Figure 3.30) highlights possible mismatch between the contributor and detractor weights used in Part A and the perceptions of the participants in Part B. It is quite plausible that this would be the case, as the weights used in Part A were derived from a national-scale study, and so might not adequately capture the thoughts and feelings of participants in the Lake District. Of particular importance is the relative importance of the presence of people in the landscape (particularly tourists), which appears to have been the dominant detractor for Part B participants, whereas many of the other detractors (e.g. motorway, railways) do not appear to have had as much impact as might be expected. Further research into this would therefore be beneficial, including:

- The collection of additional PPGIS data in regions of high uncertainty, particularly the west coastal plain, to gain probability of tranquillity values with lower uncertainties.
- A new study to understand the role of various contributors and detractors in the specific context of the Lake District, with a particular focus on the role and impact of people and tourism on perceptions of tranquillity.

Further research is also needed to understand the cumulative impacts of recreational pressure, climate change, and technological developments on tranquillity including:

- Use of low-cost and non-invasive methods to implement acoustic monitoring within LDNP. The establishment of long-term acoustic monitoring within the park along a precise spatial and altitudinal gradient, can provide critical information to support spatial planning within the LDNP. It would allow us to establish a baseline for existing noise pollution and recreational noise impacts in the park, inform the development of management strategies to mitigate these, and provide an evaluation method for monitoring their success over time.

- Expanding tranquillity mapping and monitoring to adjacent landscapes beyond the Lake District, as well as other UK national parks and other protected areas which could support future mapping efforts to avoid edge effects such as spill-over of light pollution.
- Use of emerging data sources such as social media geotags and mobile sensors that offer opportunities for dynamic monitoring and validation. This could include 'scraping' or harvesting of data from social media streams such as facebook, bluesky and Flickr especially where these are geotagged to specific locations.
- Prioritising protection in zones where tranquillity is most vulnerable to infrastructure expansion or visitor growth, ensuring proactive management before degradation occurs. One approach might be to explore the use of the Limits of Acceptable Change (LAC) model in assessing, monitoring and actioning approaches to halting and minimising loss of tranquillity thereby maintaining opportunity for quiet enjoyment across the park but particularly in core tranquil areas identified in this report.

Effective protection of tranquillity within the Lake District requires strong collaboration between the Lake District National Park Authority (LDNPA), Friends of the Lake District (FLD) and other partners such as the National Trust. Both organizations share complementary roles: LDNPA provides statutory planning and policy oversight, while FLD brings community engagement, advocacy, and volunteer networks. Joint initiatives should focus on integrating it into biodiversity strategies, local plans, and other plans, such as those for WHS interpretation, visitor management and wider protected landscapes management. This can include co-developing bespoke tranquillity maps, hosting participatory workshops, and coordinating citizen science programs to capture public perceptions of tranquillity. Policies should prioritise factors such as limiting noise and light pollution and managing traffic, particularly in sensitive areas such as national parks. It is important to engage landowners, both private and public, in this process since they ultimately hold sway of activities that take place on land across much of the park.

Regular communication channels such as bi-annual coordination meetings and shared data platforms will ensure alignment on monitoring priorities and emerging threats. Collaborative outreach campaigns can raise awareness among visitors and residents about the importance of preserving peaceful landscapes. Additionally, both organizations should work together to secure funding for long-term monitoring and technological innovations. By pooling expertise and resources, LDNPA and FLD can create a unified approach that safeguards tranquillity as a defining characteristic of the Lake District for future generations.

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Appendices

Appendix 1 – PPGIS Demographic Survey

By completing this survey, you are indicating your consent to participate in this research. Your participation is voluntary, and you can withdraw at any time should you wish.

Age (please circle)

18-30 31-40 41-50 51-60 61-70 71+

Gender (please circle)

Female Male Non-binary Transgender Prefer to self-describe

How long have you lived in the Lake District? (please tick)

- ☐ I do not live in the Lake District
- ☐ I have lived in the Lake District my whole life
- ☐ I have lived in the Lake District more than 20 years
- ☐ I have lived in the Lake District more than 5 but less than 20 years
- ☐ I have lived in the Lake District less than 5 years
- ☐ I live in Cumbria (outside of the Lake District)
- ☐ I live in Cumbria (outside of the Lake District) but work in the Lake District

What is your postcode?

……

How often do you visit the Lake District? (please tick)

- [ ] I live in the Lake District
- [ ] I visit the Lake District daily
- [ ] I visit the Lake District weekly
- [ ] I visit the Lake District monthly
- [ ] I visit the Lake District at least once every year
- [ ] I visit the Lake District less than once a year
- [ ] I have visited the Lake District once
- [ ] I used to visit the Lake District regularly

How do you mostly spend time in the Lake District? (please tick)

- [ ] I walk/swim/cycle/climb in the Lake District
- [ ] I visit shops/cafes/attractions in the Lake District
- [ ] I visit heritage sites in the Lake District
- [ ] I visit friends/family in the Lake District

How connected do you feel to the landscape of the Lake District? (please tick)

- [ ] I feel no connection with the Lake District landscapes
- [ ] I feel some connection with the Lake District landscapes
- [ ] I feel a strong connection with the Lake District landscapes
- [ ] I feel a very strong connection with the Lake District landscapes

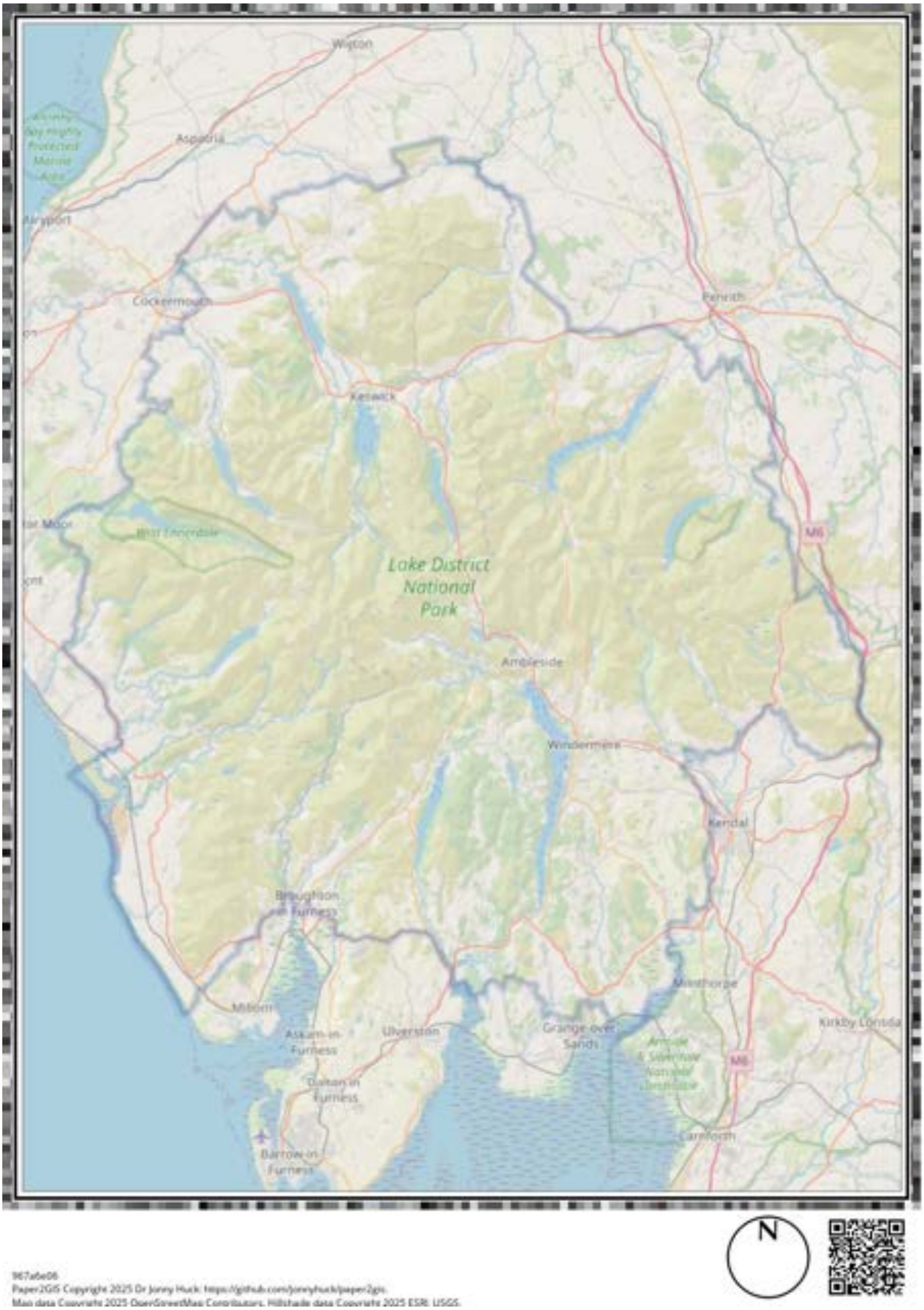
Are you a member of Friends of the Lake District (FLD) or any other organisations related to the landscape (i.e. National Trust, RSPB, etc.)? (please tick)

- [ ] Yes, just FLD
- [ ] Yes, FLD and another/other organisations
- [ ] Yes, another/other organisations
- [ ] None

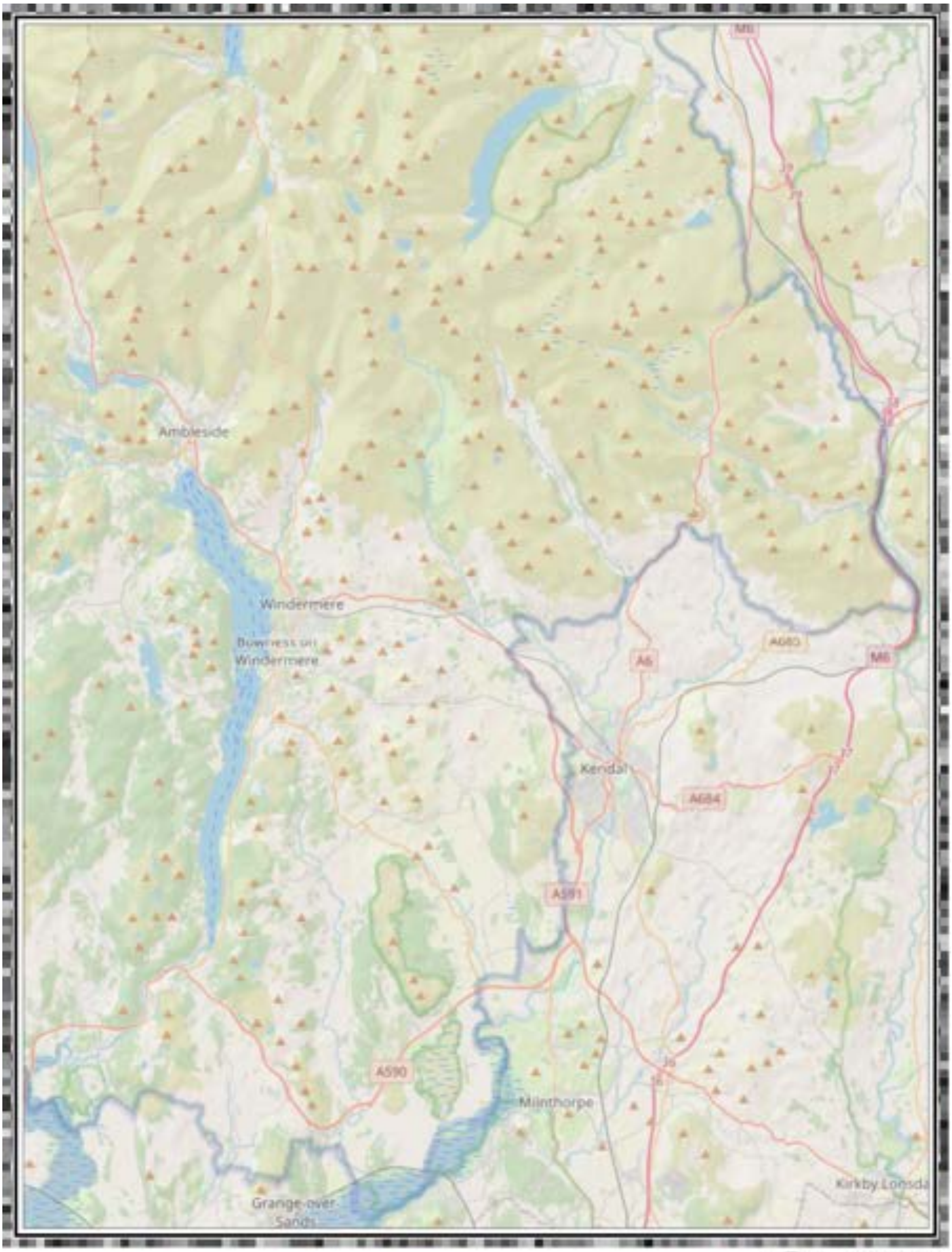
What does tranquillity mean to you? What do you think of when you hear the term?

Thank you for completing this questionnaire.

Appendix 2a. Paper2GIS map (default smaller scale option)



Appendix 2b. Paper2GIS map (larger scale option)



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