

Tourism Impact Assessment for Katla Geopark, Iceland

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Introduction

Tourism impact assessments are important parts of managing natural resources. By drawing attention to the impacts of tourism on natural areas and highlighting ecologically sensitive areas, tourism impact assessments can play a guiding role in sustainable tourism development. Tourism is a significant industry in the South region, where Katla Geopark is located. This region accounts for 25.5% of Iceland's overnight stays in 2019 (Statistics Iceland, 2024). The high number of visitors to this area means that it is crucial to evaluate the impacts of these numbers on the ecological landscape of the park. As tourism in Iceland decreases in seasonality and widens temporally throughout the year, it is critical to consider impacts such as soil erosion, trampling of vegetation, and other tourism impacts when choosing locations for further tourism development.

This tourism impact assessment uses ArcGIS Pro 2.7 (Esri, 2021) to perform a multi-criteria evaluation (MCE) analysis on Katla Geopark to find areas that warrant protection measures and identify suitable areas for tourism development. This report outlines the impact that tourism has on the natural resources of Katla Geopark by combining ecological information from diverse datasets on tourism statistics, wilderness areas, soil types, land cover, elevation, hiking trail conditions, and ecologically sensitive regions. The recommendations given in this report may inform management decisions that can safeguard the valuable natural features of Katla Geopark while also allowing visitors to sustainably enjoy them.

Methodology

Study Area

Katla Geopark is a protected natural area and a tourist attraction located in the southern part of Iceland (Figure 1). It contains various land cover types, including wetlands, heathland, glaciers, and grassland. Katla Geopark covers 9,527km², or roughly 9% of Iceland.

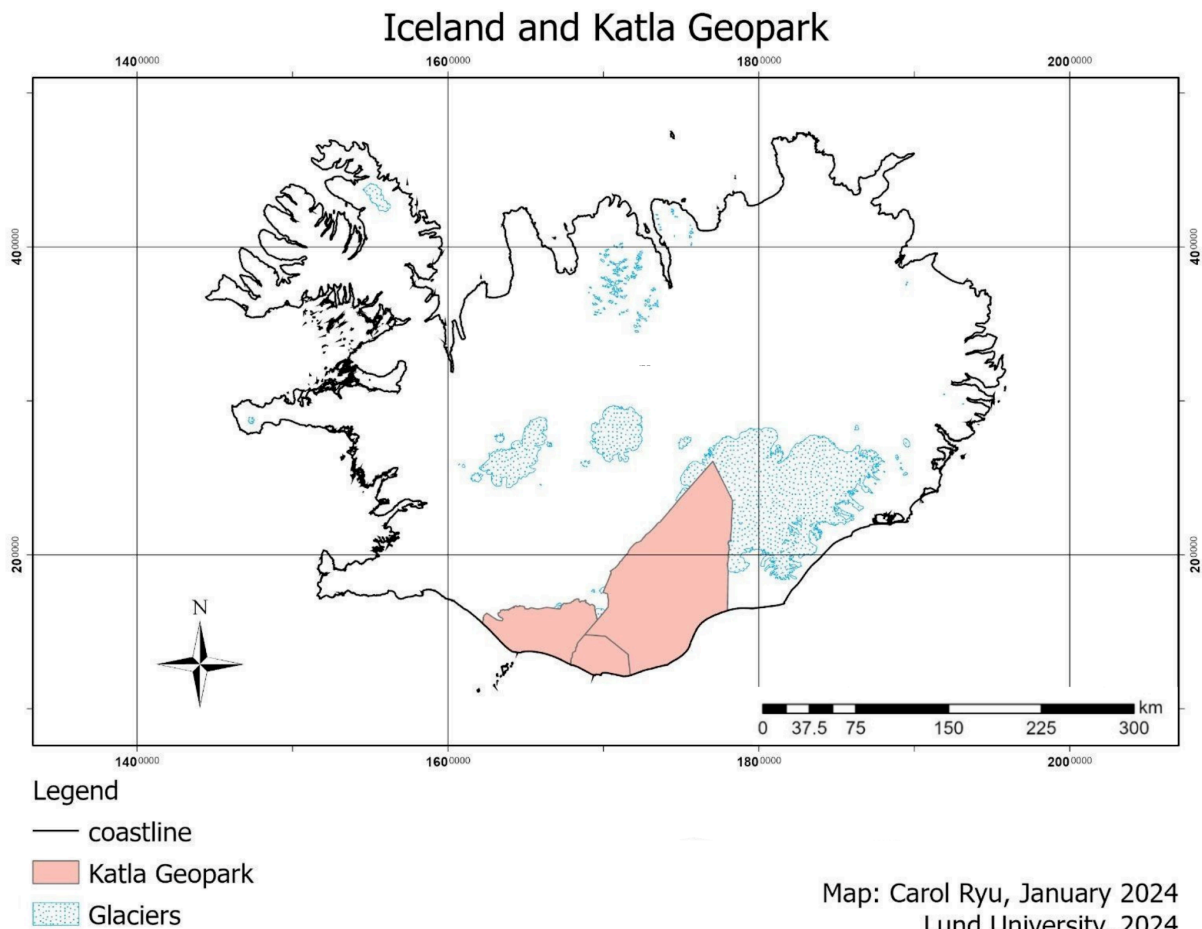


Figure 1. Map of Katla Geopark and its glaciers.

Data Analysis Methods

Tourism statistics: Tourism statistics for 2012-2022 for all of Iceland were downloaded from Statistics Iceland. Tourism statistics were analyzed in Excel to find the region with the highest overnight stays, the regional distribution and monthly distribution of overnight stays, the seasonality of various regions, changes in seasonality, and tourism growth between 2012 and 2022.

Ecological sensitivity: MCE was performed on datasets of slope, soil type, and land cover. Areas with steeper slopes, poorly vegetated heathland, moss heath, or moss land types, and sensitive soil cover (including HA, BA, GA-BA, BA-HA-GA, BA-HA-H, H-BA, and C-GA) contribute to higher ecological sensitivity. These datasets were classified into sensitivity rankings, which were overlaid through additive combination to identify the ecological sensitivity rankings of Katla Geopark.

Hiking trail conditions: Trail conditions in Thorsmark region was deduced by summing four impact factor classes, then divided into five trail condition classes. After spatial join, correlations between trail conditions and ecological sensitivity, soil type, slope angle, elevation, and land cover were analyzed.

Wilderness areas: Buffers were created around anthropogenic developments such as roads and settlements using proximity distances from Ólafsdóttir & Runnström (2011) and merged into one buffer. The Difference tool was used to identify only wilderness areas in Katla Geopark, from which the total wilderness area was deduced.

Protected areas & tourist attractions: Legally protected areas were ranked by protection level. Larger wilderness areas were given higher protection rankings. Then, a weighted combination was performed on protected areas, wilderness rankings, and ecological sensitivity rankings to identify suggested protection levels in Katla Geopark. Buffers of 500m, 1km, and 2km were created at tourist attractions and overlaid with suggested protection levels to determine the proximity of tourist attractions to different protection levels.

Results

Tourism statistics

Seasonality in Iceland is very high, which indicates a high reliance on the summer months for tourism income. June, July, and August have the highest tourism arrivals. In the summer of 2022, the South region experienced 28% of Iceland's total peak overnight stays. However, seasonality in the South region has decreased between 2012 and 2022 (Fig. 2), despite a 137% increase between 2012 and 2022 in the number of summer overnight stays in the region. This is in line with the trend towards less seasonality in all regions (Fig. 3).

Seasonality index of overnight stays in South region

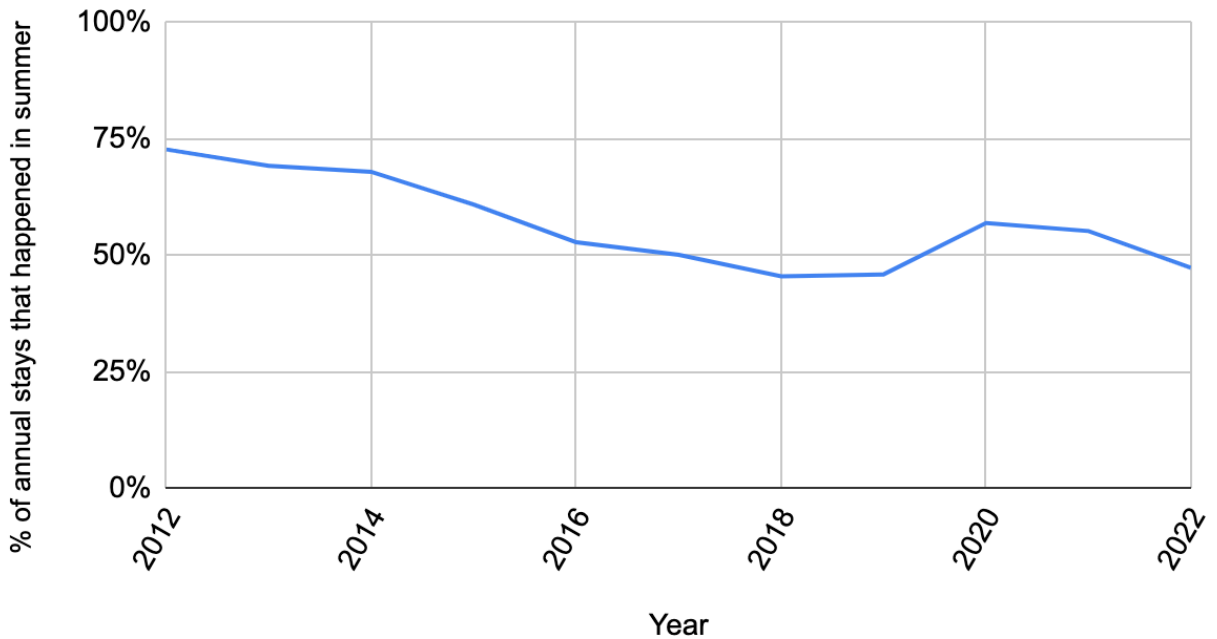


Figure 2. Percentage of annual overnight stays that occurred during June, July, and August in Iceland between 2012 - 2022.

Seasonality decrease between 2012 and 2022

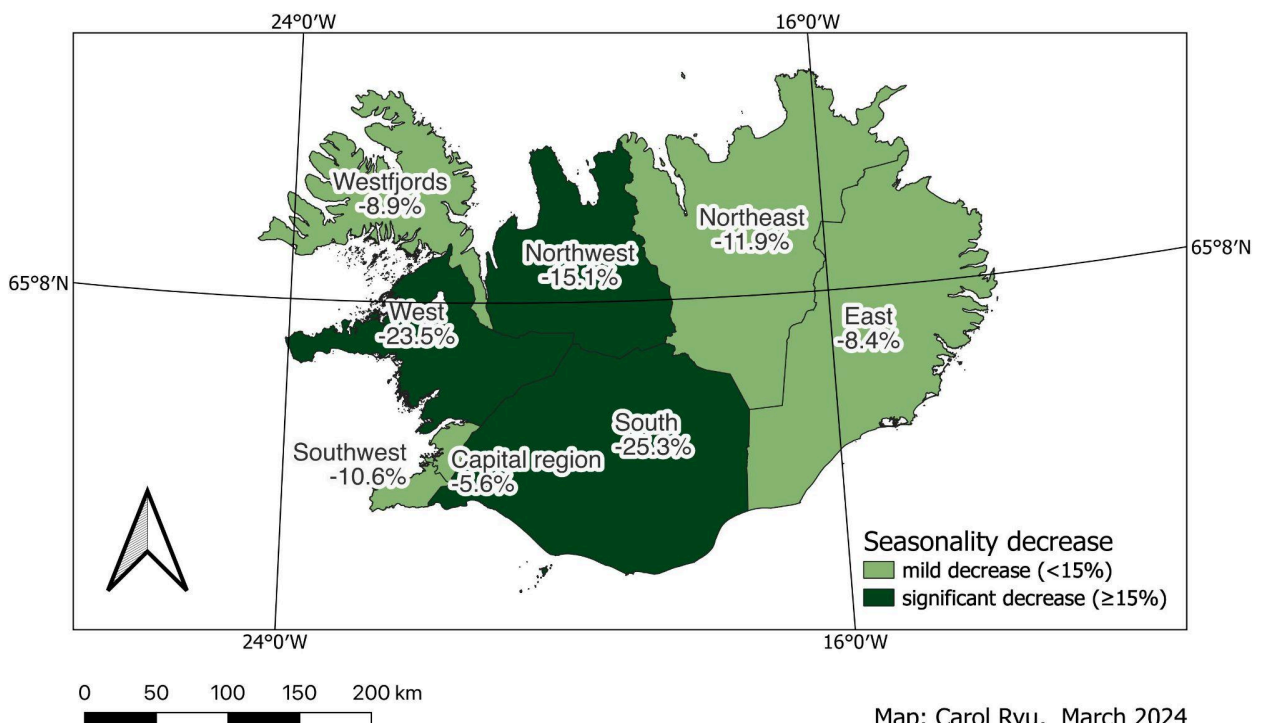
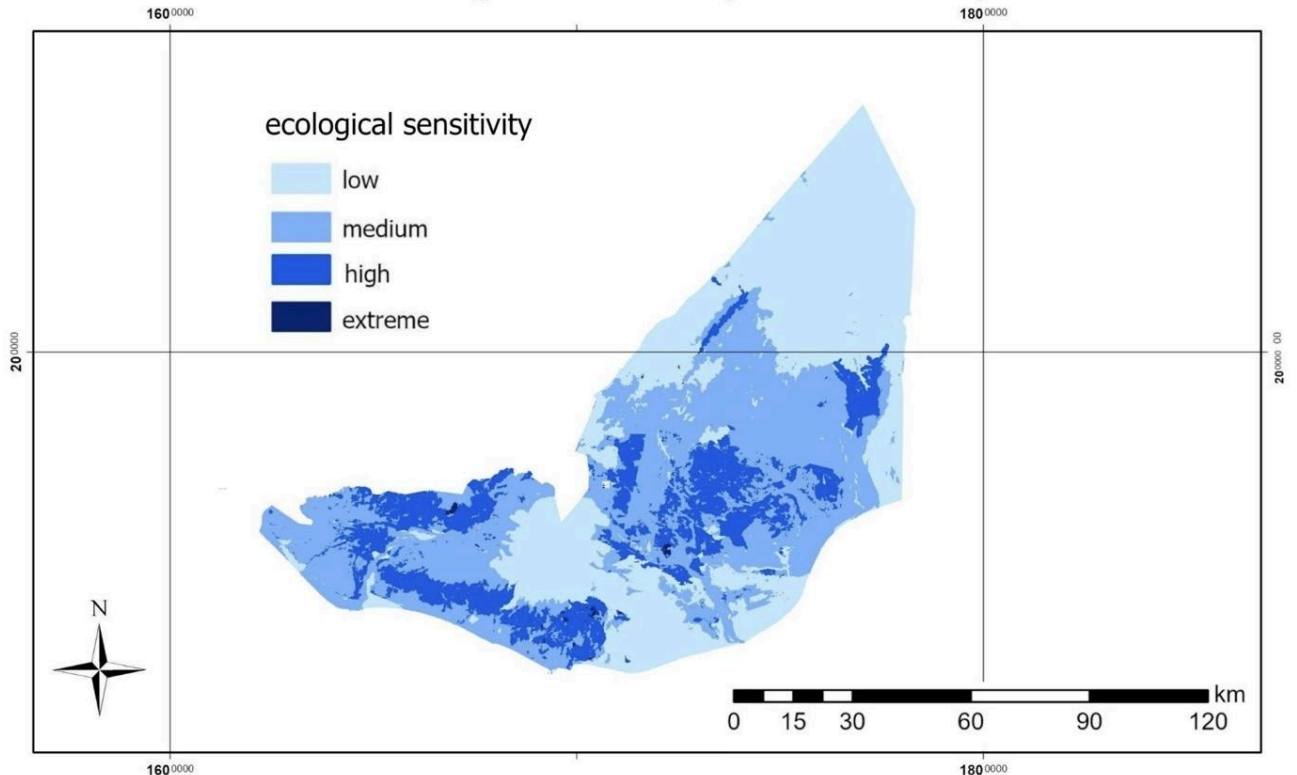


Figure 3. Seasonality changes between 2012 and 2022.

Ecological sensitivity

Regions of Katla Geopark with high ecological sensitivity are the central regions, the regions to the west of the southern glacier (Myrdalsjökull), and a strip that contains Lake Langisjor which lies southwest of the northern glacier (Vatnajökull). The extremely sensitive region is a patch south of the glacier in the southwest (Tinfjallajökull) (Fig. 4).

Overall ecological sensitivity in Katla Geopark



Map: Carol Ryu, January 2024
Lund University, 2024

EPSG:5325 - ISN2004 / Lambert 2004, Lambert Conformal Conic

Figure 4. Ecological sensitivity in Katla Geopark.

The low sensitivity zone has the largest area at 4,030km² (Table 1).

Table 1. Areas of the different sensitivity zones of Katla Geopark.

Ecological sensitivity	total area (km ²)	average area of a polygon (km ²)
low	4030.450557	0.06
medium	3828.221324	0.02
high	1642.814203	0.01
extreme	31.33203491	0.01

Hiking Trail Conditions

A general trend is observed of trail condition degrading in areas with steeper slopes (Fig. 5). Another notable trend is that grassland, shrub and forest, partly vegetated, and wetland areas have a wider range of trail conditions and a much lower area of trail samples classified as very good than the other land use classes do. The areas with lower ecological sensitivity have a higher portion of trails classified as very good than the areas with higher ecological sensitivity. Areas with higher soil sensitivity have decreasing trail conditions.

Hiking trail condition in Thorsmork, Katla Geopark

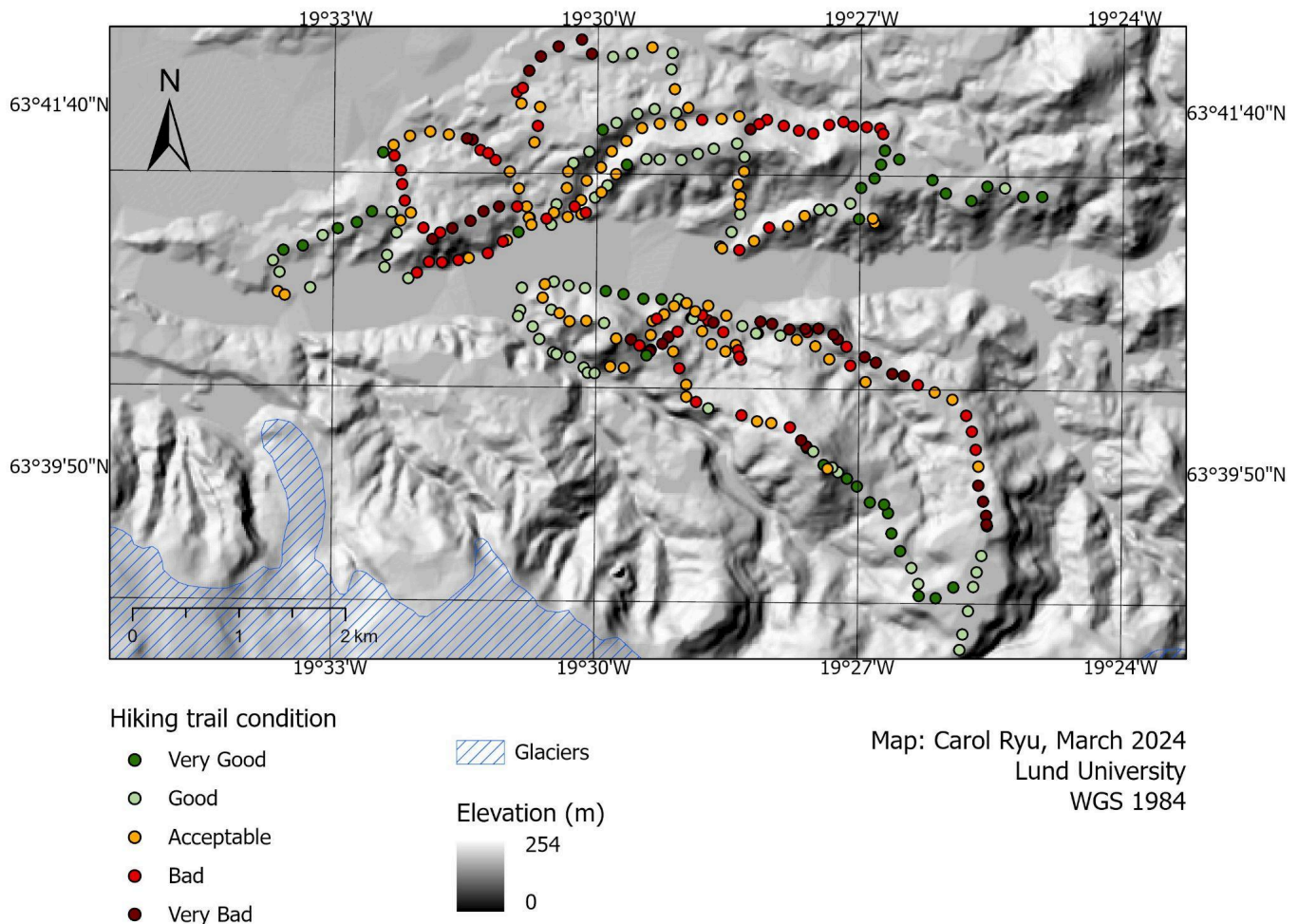


Figure 5. Trail condition index was mapped with elevation data in Thorsmork.

Wilderness assessment

15.3% of Katla Geopark is considered wilderness (Table 2).

Table 2. Wilderness statistics in Katla Geopark.

Area of Katla Geopark	9,524.2 km ²
Area of wilderness	1,461.6 km ²
Number of isolated wild area patches	19
% of Katla Geopark that is wilderness	15.3%

The two largest wilderness areas are in the glacial areas in the north and southwest (Fig. 6).

Wilderness areas of Katla Geopark, Iceland (sq km)

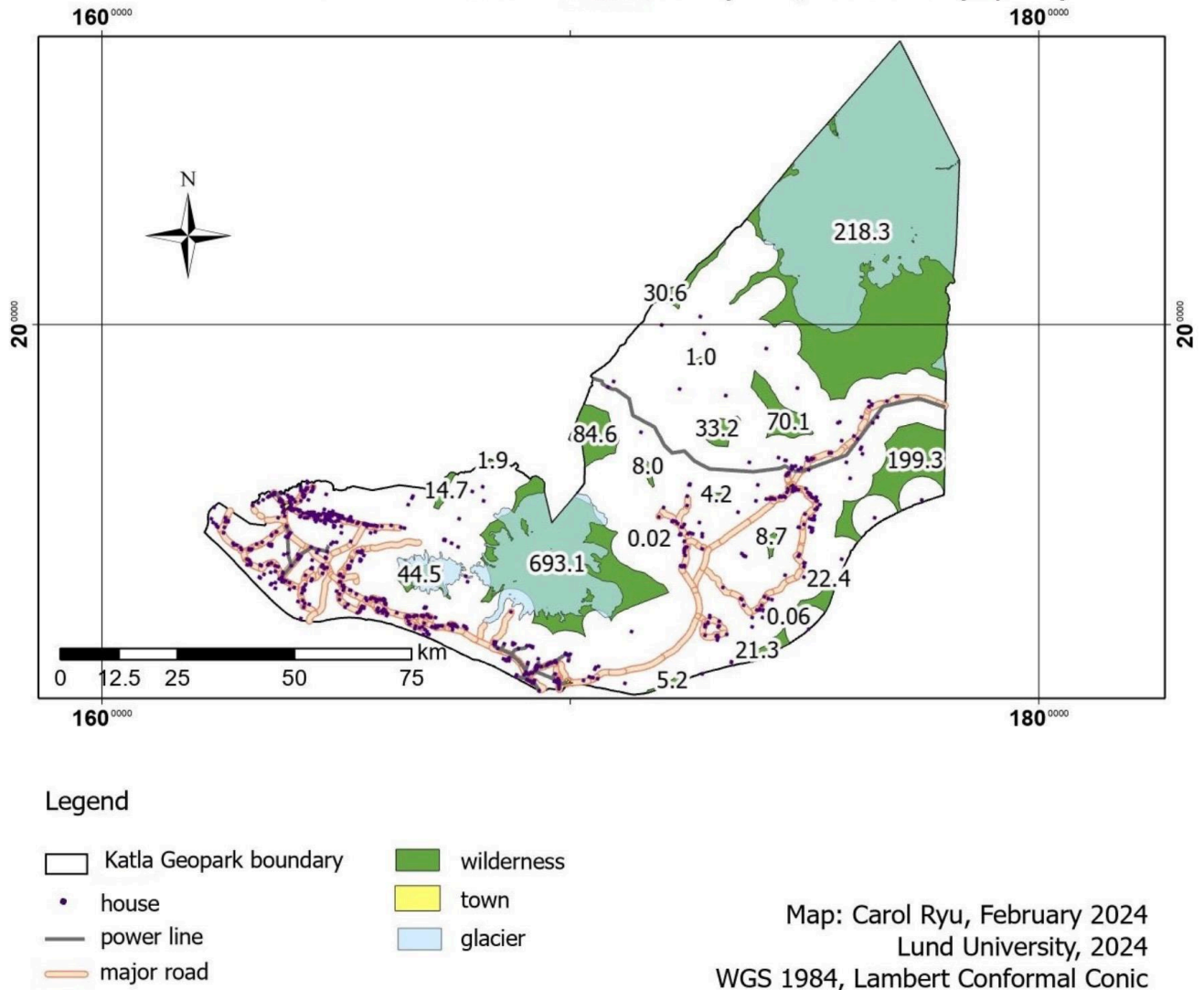


Figure 6. Wilderness areas of Katla Geopark and their areas (km²).

Protected areas and tourist attractions

The northern portion, including the glaciated area, of Katla Geopark warrants a high level of environmental protection. All high-protection attractions in Katla Geopark are in the north-central region (Fig. 7).

Highest protection levels in 2km radii around tourism attractions

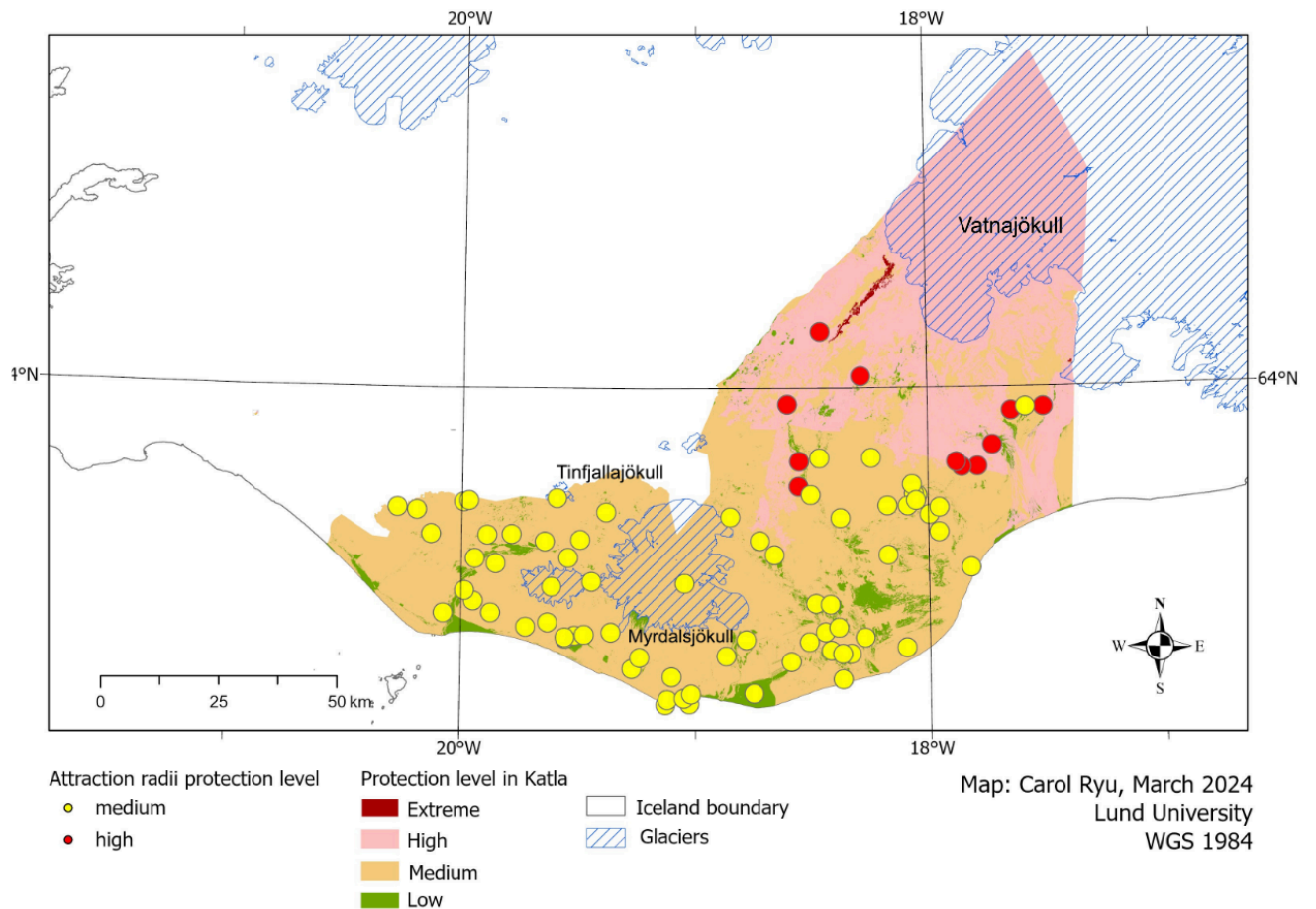


Figure 7. The highest protection level within 2km radii of attractions.

The only area recommended for extreme protection level has high ecological sensitivity due to its >30 degrees steepness and high soil sensitivity (poorly vegetated heathland, moss heath, or moss land). While only 6 attractions are located within a high protection zone, recommended protection levels at tourism attractions take into consideration the highest protection level within a 2km radius of attractions, which increases the number of high-protection attractions to 11 (Table 3).

Table 3. The number of attractions for each protection level.

	at attraction	within 0.5km	within 1km	within 2km
none	5	0	0	0
low	3	4	0	0
medium	67	71	71	70
high	6	6	10	11
extreme	0	0	0	0
total attractions	81	81	81	81

Discussion

The MCE analysis conducted on Katla Geopark reveals the regions of the park that warrant higher levels of protection from tourism impact. An area of concern is the strip that contains Lake Langisjor, lying southwest of the glacier Vatnajökull. This area has extreme ecological sensitivity and received an extreme recommended protection level. It has an extreme ecological sensitivity due to its >30 degrees slope and high soil sensitivity, which is often found in volcanic mountainous regions. More importantly, it is located in the largest protected area of Katla Geopark, which affords it a high legal protected area ranking, which heavily contributes to its extreme recommended protection level. This area should be prioritized for special protection measures.

Interestingly, despite having high ecological sensitivity, the area west of Myrdalsjökull and the patch south of Tinfallajökull is not recommended to have high protection rankings due to their lack of legal protection and low wilderness ranking. This mountainous region has moss land, vegetated heathland, and moss heath, which is vulnerable to trampling from activities such as hiking. However, lacking legal protection makes it more difficult to enforce high protection levels. Furthermore, the low wilderness ranking is based on their proximity to highways and villages, as well as to Thorsmork, which is a popular hiking region that experiences high tourist traffic. Thorsmork is an ideally located hiking hotspot due to its low land cover sensitivity, soil sensitivity, and slope, all contributing to a low overall ecological sensitivity.

Despite its low ecological sensitivity, the degradation of ecosystems from hiker disturbance has an impact on the Thorsmork region. Soil and vegetation in natural areas are affected by trampling and wear from tourism activities, such as biking and hiking. Visitors to natural attractions don't always stay on the trails provided, which can damage vegetation further. Additionally, tourists can track soil from other ecosystems nearby that they've visited, bringing it into new areas and changing the soil composition of the region. The initial ecological disturbance of the first ten or so nights of a tourist's stay has a great impact on change, and after that, the total change percentage rate decreases (Hammit & Cole, 1998). Additionally, even low levels of use in an area can have significant impacts (Cole, 2004). One of Iceland's most popular hiking trails, the Laugavegur Trail, ends in Thorsmork, so the area likely experiences heightened levels of hiker impact such as trampling of vegetation and soil erosion.

A general trend in Thorsmork is observed of trail conditions degrading in areas with steeper slopes, which may be attributed to higher rates of soil erosion in steeper areas due to hikers disturbing the soil. Large portions of the trails in Thorsmork, however, reach good and very good conditions at higher elevations. This may be due to a lower hiker visitation number at higher elevations due to the difficulty of access. Another notable trend is that grassland, shrub and forest, partly vegetated, and wetland areas have a lower portion of trail classified as very good than the other land use classes do. This may be due to the saturated ground in wetland areas that causes trail quality to degrade when faced with hiker disturbance.

Management recommendations for 2024-2034

Considering the increasing tourism numbers and decreasing seasonality of tourism in the South region, it is crucial to promote sustainable tourism development and assess the most suitable locations to do so in Katla Geopark. It is recommended that the protection level zonation recommended is implemented. Zonation is a key strategy for protected area management because it allows governing members to allocate various areas to specific activities or needs. In this way, activities and high volumes of tourists can be guided away from fragile, unique, or sensitive environments, protecting those environments from visitor impact. The impact on these environments is minimized by preventing overcrowding and unique ecosystems or features are preserved. Tourism

in the area of extreme protection level south of Vatnajökull should be prohibited completely. Additionally, infrastructural development such as villages, highways, and accommodations should be required to receive special permits to build in extreme and high protection areas of Katla Geopark. Furthermore, tourism activities in areas with high protection levels should be limited to activities that have a lower impact, such as hiking, camping, and kayaking. Meanwhile, high-impact activities such as off-road vehicles or jet skiing should be prohibited. The spectrum of recreation opportunities refers to a framework that emphasizes having a diverse range of nature-based activities to minimize impacts. If visitors all only do one activity, there is an intense concentration of impact on certain areas in certain areas. Spreading out the activity areas can also spread out the environmental impact. Designated areas in more resilient lower and medium protection level areas that can recover from high impact in the south of Katla Geopark should be set aside for such higher impact activities.

The low and medium protection areas in the southern region of Katla Geopark are the most suitable areas for tourism development. However, the visitor carrying capacity of these focal points should be identified so that tourism impact does not cross a threshold into irreversible damage. Finding the acceptable change can be done by using the Limits of Acceptable Change framework or Visitor Impact Management. Visitor statistics and ecological status should be monitored, and businesses operating in and around an area must adhere to standards that help enforce the carrying capacity. Researchers should be hired to monitor the area to make sure that the carrying capacity hasn't changed or that tourism activities are not negatively impacting the environment. By monitoring, the area use remains within the limits that allow for recovery. Ideally, there should be a buffer around the carrying capacity so that there is a safety buffer that prevents accidentally harming or changing an area.

Lastly, as tourism seasonality decreases in the south region and visitors during non-summer months increase, Katla management should limit visitor numbers when seasonally appropriate. During peak season, they may establish seasonal closures or more strict camping laws in fragile areas. When possible, local stakeholders should be consulted to create communal stewardship for Katla Geopark.

In conclusion, the predicted growth and expansion of the tourism industry in the South of Iceland requires a sustainable tourism management plan. MCE analysis offers insights to inform decisions park management makes to protect the ecology of the park and the economic resource that it is for local communities.

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