Hvalá Power Plant Proposal
Review of impacts on wilderness

A report by the Wildland Research Institute for ÓFEIG náttúruvernd
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Contents

Executive summary

This report has been prepared on behalf of ÓFEIG náttúruvernd by the Wildland Research Institute, University of Leeds. The report assesses the potential impacts of the proposed Hvalá power plant (Hvalárvirkjun) in terms of likely changes to the overall patterns of wilderness quality in the local area and across the Drangar Peninsula as a whole.

The work presented here builds on previous mapping projects carried out for both the European Union and the Scottish Government. The Wilderness register and indicator for Europe (Kuiters et al., 2013) provides both a compilation of existing designated wilderness areas across Europe, using databases such as the EEA and WDPA, and a map of wilderness and wild areas in Europe based on appropriate definitional and habitat criteria. This report and associated mapping shows that the total area of the top 1% wildest land across the whole of EU/EEA is 56,810km^2 of which 24,063km^2 is found in Iceland which accounts, in other words, for a little over 42% of the top 1% wildest land in Europe. The mapping methods used involve the integration of digital spatial datasets on land cover, land use and remoteness from settlements and mechanised access. A similar and more detailed approach was used to map wildness and wild land areas across Scotland and its national parks. This has allowed the Scottish Government to identify 42 Wild Land Areas for use in supporting policy on landscape protection and decision making about large scale developments such as renewable energy infrastructure. Work at these regional and national levels allows the use of high-resolution spatial data and detailed analyses to accurately model and predict the geographical extent of impacts from existing and proposed development on changes to natural land cover, reductions in remoteness and increased visual impact, which together can be used to map wilderness quality in a rigorous, robust and repeatable manner. Similar methods and approaches to those used in Scotland are applied here. These are modified and adjusted to take local datasets and environmental conditions found in Iceland into account.

The proposed Hvalá powerplant lies inside the Ófeigsfjörður area of the Drangar Peninsula, NW Iceland. The construction of the power plant would involve upgrades to existing access roads to allow for heavy construction vehicles and material transport, the construction of further access roads, building dams, overflows, tunnels and other infrastructure, the raising of lake levels on the Eyvindarfjarðarvatn, Hvalávatn and Nyrðra/Syðra Vatnalautavatn lakes and reduced flows in the Rjúkandi, Hvalá and Eyvindarfjarðará rivers (and corresponding impacts on waterfalls), the construction of a work camp, and the construction of either an overhead or underground power line to connect to the existing grid network. Analyses developed as part of this report show that a development of the scale proposed would have a significant adverse impact on the qualities of this area of wilderness, with the likely outcome that if the development goes ahead the area of wild land in the vicinity would be reduced by between **26,300-28,400ha** or **45-48.5%.**

This analysis is based on a mapping of four commonly used attributes of wilderness quality across the entire Drangar Peninsula north of Road 61 Djúpvegur. These are: naturalness of land cover, remoteness from mechanised access, absence of modern human artefacts, and ruggedness. Naturalness of land cover takes satellite-based maps of land cover into account and measures the degree of human modification through agriculture, grazing and construction where these occur. Remoteness measures the time taken to walk from any point of mechanised access including roads usable by 2WD and 4WD vehicles and the scheduled boat landing points around the peninsula taking terrain, land cover and barrier features such as lakes and large rivers into account. Absence of modern human artefacts measures the visual impact from built features in the landscapes such as buildings, roads, power lines, dams and other structures taking size, distance and intervening terrain into account. Ruggedness is measured directly from the topography and is a key aspect of wilderness quality that provides a measure of both scenic quality/interest and the challenging nature of the terrain. All four attributes are combined using multi-criteria evaluation (MCE) methods to provide an overall measure of wilderness quality and its spatial pattern and variability across the study region. By inserting the proposed powerplant and its associated infrastructure and landscape modifications into the model, this approach can provide rigorous and robust estimates of the level of impact on patterns of wilderness quality in the locality of the powerplant and across the Drangar Peninsula.

The Drangar Peninsula is an area which is at present largely free from visual impact and currently contains almost no modern human infrastructure except for a few small farms and summer dwellings at certain points along the coastal margins. The analyses presented here show that construction of the Hvalá powerplant, should it be consented, would impact significantly on this “impact free” area. It is acknowledged that two further powerplants are envisaged in the area, and that these combined would have significant and lasting impacts on the region, its landscape and its wildlife.

The 2013 Nature Conservation Act No.60/2103 which entered in to force in November 2015, introduces the management objectives for wilderness protected areas in Iceland as follows: *"The protection should aim to safeguard the characteristics of the areas e.g. to maintain diverse and unusual landscapes, panoramas and/or conserve complete large ecosystems, and ensure that present and future generations can enjoy therein solitude and nature without disturbance from man-made infrastructures or traffic from motor vehicles*“. This follows closely those objectives as stated in the IUCN standards and guidelines for Category 1b Wilderness Areas. Article 5 of the Nature Conservation Act 2013 provides some basic numeric criteria to help highlight potential wilderness areas in Iceland. These are: *“ An area of uninhabited land that is usually at least 25 km^2 in size or so that one can enjoy solitude and nature without disturbance from man-made structures or the traffic of motorized vehicles and at least 5 km away from man-made structures and other evidence of technology, such as [power lines] power stations, reservoirs and main [elevated] roads”*. These numeric criteria are not absolute thus giving rise to the need for more robust mapping approaches. Wilderness protection is also mentioned within the new National Planning Strategy (Landsskipulagsstefna) that was adopted by a Parliament Resolution in March 2016. This states that: *“The Planning Agency and the Environment Agency are responsible for regularly updating maps of the extent and development of wilderness in the central highlands. This includes setting criteria for assessing the extent of the wilderness based on planning considerations and having regularly updated maps on the extent of the wilderness accessible to the planning work of local and other parties“.* While this currently applies only to the Central Highland Region, it is to be expanded to other wilderness areas such as the Drangar Peninsula in future.

While the development of policy and legislation for the protection of wilderness qualities in the landscapes of Iceland is in its infancy and much of the existing focus has been on the Central Highland Region, the government has a duty of care to help preserve this important resource across the island. Work presented here will help inform further development of government policy on wilderness and associated planning and protection measures.

The Wildland Research Institute (WRi) is an independent academic institute with specialist knowledge in wilderness, policy advice, mapping and landscape assessment. WRi have detailed, in-depth knowledge of the wilderness mapping processes and are the originators of the original wilderness methodology developed for the two Scottish National Parks and have acted as technical advisors to the Scottish Government during their national wild land mapping process. In addition, WRi are co-authors of the EU Wildness Register and mapping programme (2013) and are currently helping the IUCN map wilderness quality across France. They have also worked on mapping wilderness character for the US National Park Service and wilderness quality and intactness in China. WRi are authors of the much-cited report on "The Status and Conservation of Wilderness in Europe" commissioned by the Scottish Government.

1. Introduction

1.1 This report has been prepared on behalf of ÓFEIG náttúruvernd. The report provides an overview of the national policy and planning frameworks on wilderness in Iceland and the mapping methods used to define areas of wilderness and further reviews the status of wilderness in the vicinity of the proposed development. The report assesses the potential impacts of the proposed Hvalá power plant proposal by Verkís in terms of wilderness as defined by the 2013 Nature Conservation Act No.60/2103.

1.2 It is recognised here that hydro power will continue to make a significant contribution to Iceland's power generation capacity along with other forms of electrical energy production. These include geothermal and future wind energy potential. This will strengthen Iceland’s position as a potential global supplier of electrical energy to other countries[1], providing electrical energy for high-demand industries such as aluminium smelting, silicon metal production and data centre operations, and exceeding national demand. However, it is noted that further expansion of hydro power generation capacity does not come without environmental impact. This is especially true where new hydro power generation capacity is located within areas with little or no other human presence in terms of roads, settlement or other associated infrastructure. Previous large-scale hydro power projects in previous wild areas have generated controversy and protest[2].

1.3 The report examines the Hvalá power plant proposal in the context of its potential and likely impacts on wilderness within the Drangar Peninsula. This is supported by mapping carried out by WRi using rigorous, robust and repeatable techniques to show how the proposed development would reduce the total area of wilderness around Hvalá and how the proposed development would significantly compromise the wilderness quality and values across the Drangar Peninsula and surrounding areas. The study area and its location is shown in Figure 1.1.

1.4 The details on the proposed Hvalá power plant and its connection to the national grid are drawn from data provided by Verkís as either GIS Shapefiles[3] or from the documentation accompanying the proposal. The only detailed spatial data provided by Verkís is for the proposed access roads, while the rest of the power plant layout including buildings, dams, power lines and other structures was captured from maps in the environmental impact assessment[4]. The layout of the proposed power plant is shown in Figure 1.2.

1.4 This report has been prepared by the Wildland Research Institute (WRi), an independent academic institute with specialist knowledge in wilderness, geographical information systems (GIS) and landscape assessment[5]. WRi have detailed, in-depth knowledge of the wilderness mapping processes. WRi are the originators of the original wilderness mapping methodology developed for the two Scottish National Parks[6,7] and have acted as technical advisors to Scottish Natural Heritage (SNH) and the Scottish Government during

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[1] For example, the Atlantic Superconnection http://www.atlanticsuperconnection.com/

[2] For example, the Kárahnjúkar Hydropower Plant northeast of the Vatnajökull.

[3] Shapefiles are machine-readable map data files for using GIS analyses and mapping.

[4] Verkís, and the proponent Vesturverk, refused to provide access to the detailed engineering CAD/GIS files despite repeated requests. A plan to connect the proposed plant to the national grid has not yet been adopted and design is not available. The site layout for all features other than the proposed access roads had to be captured from the maps provided Figures 4.24.5 and 4.11 in the 2016 Environmental Impact Statement “Hvalárvirkjun í Ófeigsfirði. Matsskýrsla” using georectification and on-screen digitising. The data derived in the manner will not be as accurate as the engineering drawings but will be more than enough for the scale of the GIS analyses presented in this report (https://www.skipulag.is/media/attachments/Umhverfismat/1215/13029003-4-SK-0126-Hvalarvirkjun-MS_Hluti1%20(1)%20(1).pdf).

[5] http://www.wildlandresearch.org

[6] http://www.geog.leeds.ac.uk/groups/wildland/Cairngorm2008.pdf

[7] https://www.lochlomond-trossachs.org/wp-content/uploads/2016/07/Research_WildnessStudy2011.pdf

their original Phase I mapping process[8]. In addition, WRi have been contracted, together with partners Alterra and PAN Parks, by the European Union Environment Agency (EEA) to extend the methodology to the whole of the Europe[9][10]. This approach has also been adopted in a modified form for use in mapping wilderness character by the US National Park Service within national park wilderness areas in the United States[11][12] and has also been applied in China[13]. WRi are also the authors of the much-cited report on "The Status and Conservation of Wilderness in Europe" commissioned by the Scottish Government[14]. WRi are currently working for IUCN France to develop a map of Haute Naturalité (High Naturalness)[15] again based on modifications to the mapping approaches developed in Scotland.

[8] Carver, S., Comber, A., McMorran, R., & Nutter, S. (2012). A GIS model for mapping spatial patterns and distribution of wild land in Scotland. *Landscape and Urban Planning*, *104*(3), 395-409.
[9] Europe's ecological backbone: recognising the true value of our mountains. EEA Report No 6/2010
[10] Wilderness register and indicator for Europe Final report 2013 (draft) Contract N°: 07.0307/2011/610387/SER/B.3
[11] Tricker, James; Landres, Peter; Dingman, Sandee; Callagan, Charlie; Stark, John; Bonstead, Leah; Fuhrman, Kelly; and Steve Carver. 2012. Mapping wilderness character in Death Valley National Park. Natural Resource Report NPS/DEVA/NRR-2012/503. National Park Service, Fort Collins, Colorado. 82p.
[12] Carver, Steve; Tricker, James; and Peter Landres. 2013. Keeping it wild: mapping wilderness character in the United States. *Journal of Environmental Management,* 131 (2013) 239-255. doi:10.1016/j.jenvman.2013.08.046
[13] Cao, Yue, Steve Carver, and Rui Yang. "Mapping wilderness in China: Comparing and integrating Boolean and WLC approaches." Landscape and Urban Planning 192 (2019): 103636.
[14] Fisher, Mark; Carver, Steve; Kun, Zoltan; Arrell, Katherine and Mitchell, Gordon. A review of the status and conservation of wild land in Europe. Report prepared for the Scottish Government, November 2010. http://www.scotland.gov.uk/Topics/Environment/Countryside/Heritage/wildland
[15] Projet CARTNAT Cartographie de la Naturalité Rapport intermédiaire phase II.

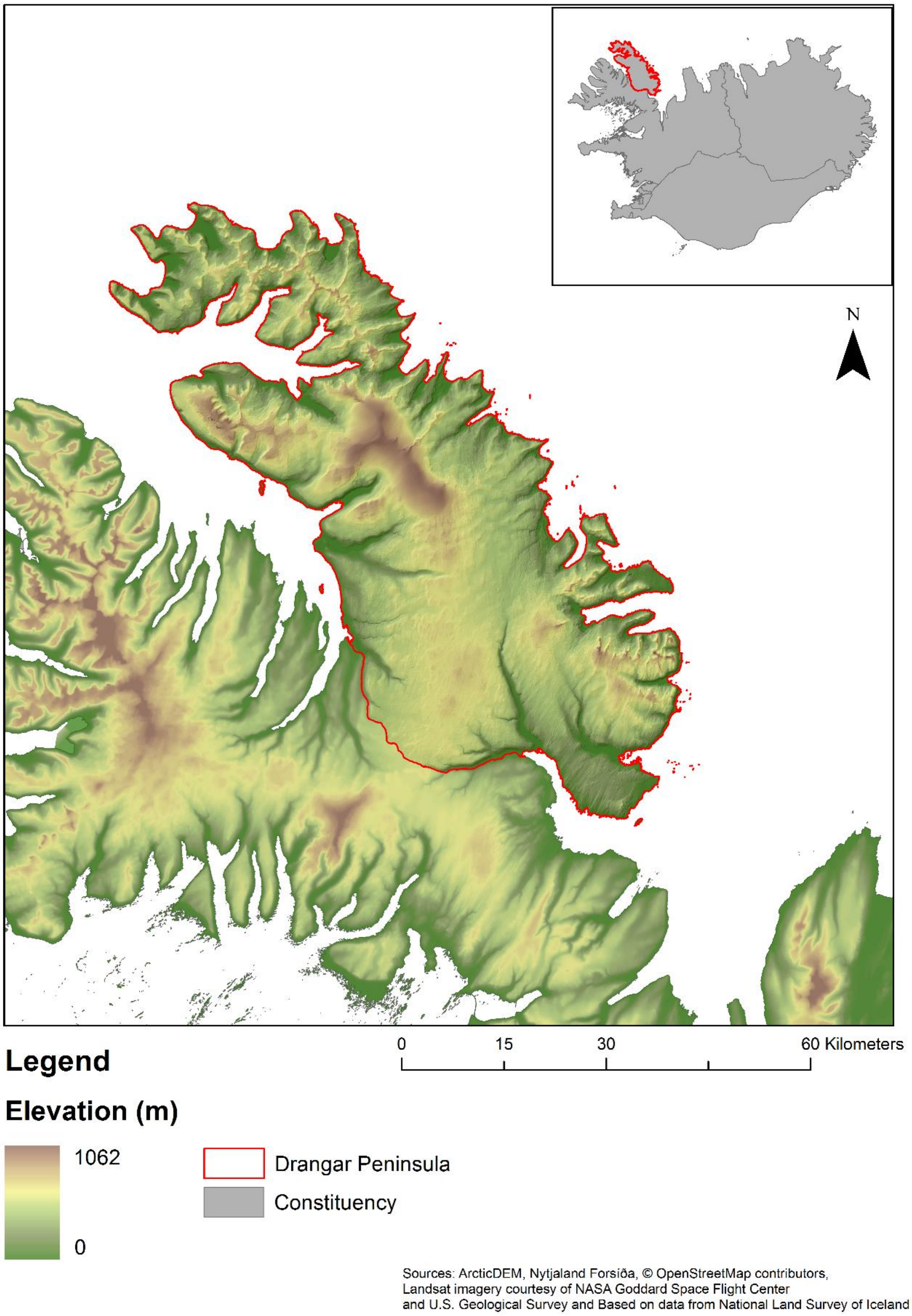

Figure 1.1 Study area location

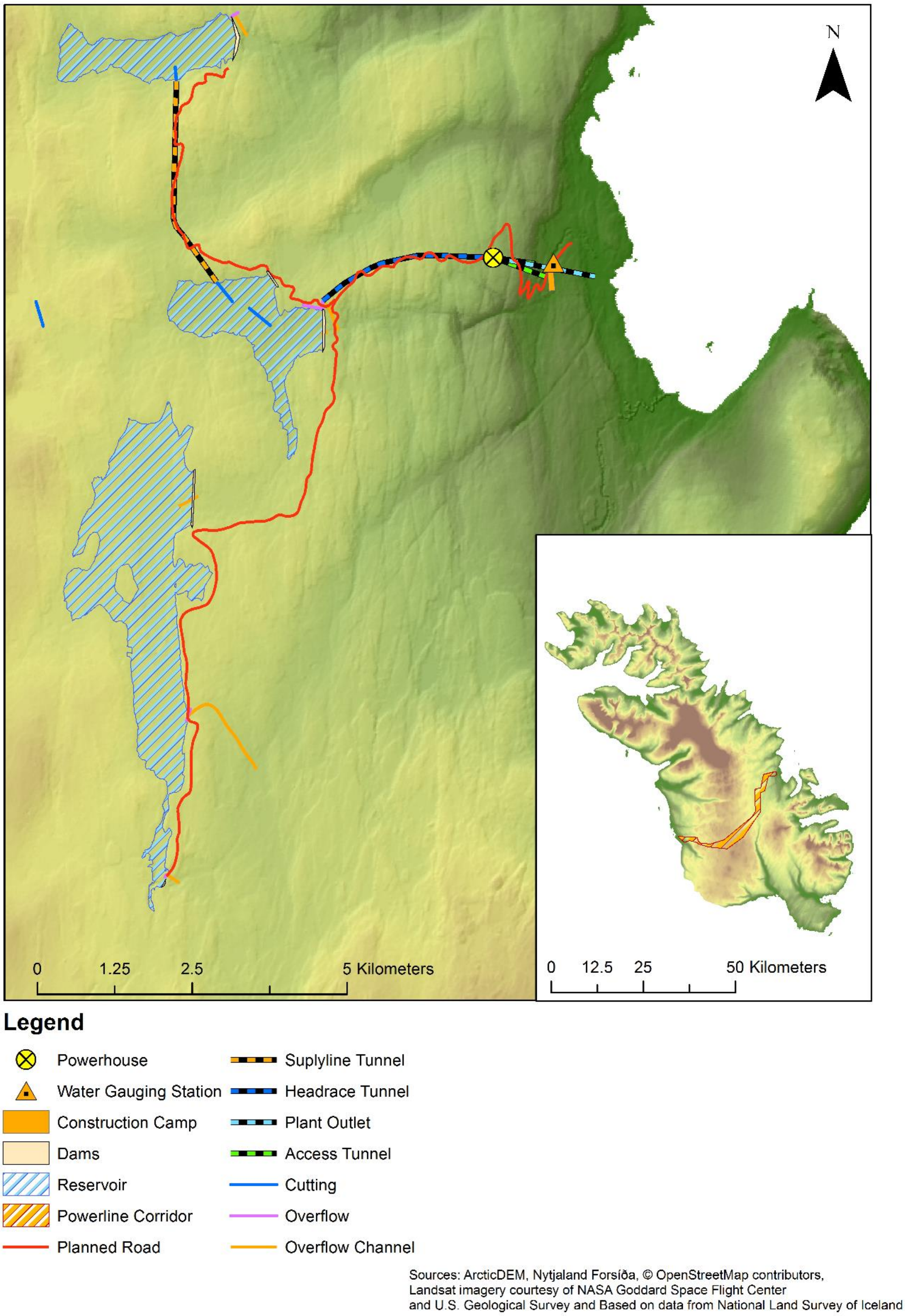

Figure 1.2 The layout of the proposed power plant

2. Defining wilderness and approaches to mapping

2.1 The Wilderness Register and Indicator for Europe report[16] and associated mapping shows that the total area of the top 1% wildest land across the whole of EU/EEA is 56,810km^2 of which 24,063km2 is found in Iceland which accounts, in other words, for just over 42% of the top 1% wildest land in Europe. Although most of the areas highlighted are accounted for in Iceland's numerous icecaps, this is a significant figure and includes significant areas of ice-free land in the interior and remote coastal areas. Figure 2.1 shows the pattern of wilderness quality across Iceland based on the indicator mapping in the EU Wilderness Register report. Iceland was able to return 6,559 ha of designated wilderness areas (Category A areas) and 1,459,301 ha of wild areas (Category A/B areas that are partly meeting the criteria for wilderness, and with the potential to become wilderness category A if specific management measures are taken). These are made up of just one Category A area (Surtsey) and six category A/B areas. The mapping reveals a broader range of wilderness areas which are at present unprotected across the country. According to the EU Wilderness Register, these cover over 3.7million ha in total.

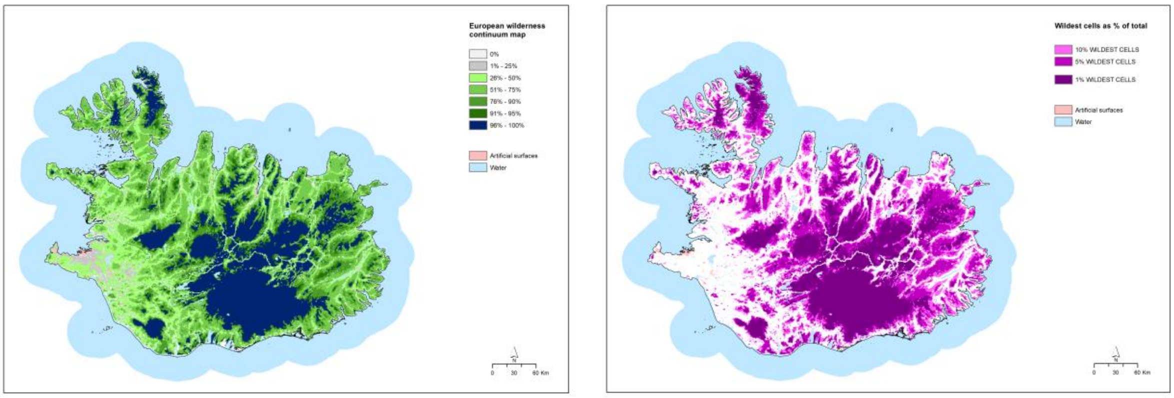

Figure 2.1 Wilderness quality in Iceland (After Kuiters et al., 2013)

2.2 The 2013 Nature Conservation Act No.60/2103[17] which entered in to force in November 2015, introduces the management objectives for wilderness protected areas in Iceland as follows: *"The protection should aim to safeguard the characteristics of the areas e.g. to maintain diverse and unusual landscapes, panoramas and/or conserve complete large ecosystems, and ensure that present and future generations can enjoy therein solitude and nature without disturbance from man-made infrastructures or traffic from motor vehicles"*[18]. This follows closely those objectives as stated in the IUCN standards and guidelines for Category 1b Wilderness Areas which itself defines wilderness areas as: *"Protected areas that are usually large, unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition"* (Dudley, 2013, p. 14). Article 5 of the Nature Conservation Act 2013 provides some basic numeric criteria to help highlight potential wilderness

[16] Wilderness register and indicator for Europe Final report 2013 (draft) Contract N^o: 07.0307/2011/610387/SER/B.3
https://ec.europa.eu/environment/nature/natura2000/wilderness/pdf/Wilderness_register_indicator.pdf
[17] https://www.althingi.is/lagas/nuna/2013060.html
[18] Jóhannsdóttir, Aðalheiður (2016) "Wilderness Protection in Iceland" in Kees Bastmeijer (ed.) Wilderness Protection in Europe. The Role of International, European and National Law pp 370.

areas in Iceland. These are: *" An area of uninhabited land that is usually at least 25 km^2 in size or so that one can enjoy solitude and nature without disturbance from man-made structures or the traffic of motorized vehicles and at least 5 km away from man-made structures and other evidence of technology, such as [power lines,] power stations, reservoirs and main [elevated] road"*[19]. These criteria are just guidelines intended to highlight potential wilderness areas and not regarded as absolute thus giving rise to the need for more robust mapping approaches. Wilderness protection is also mentioned within the new National Planning Strategy (Landsskipulagsstefna) that was adopted by a Parliament Resolution in March 2016[20]. This states that: *"The Planning Agency and the Environment Agency are responsible for regularly updating maps of the extent and development of wilderness in the central highlands. This includes setting criteria for assessing the extent of the wilderness based on planning considerations and having regularly updated maps on the extent of the wilderness accessible to the planning work of local and other parties".* While this currently applies only to the Central Highland Region[21], it will now be expanded to other wilderness areas such as the Drangar Peninsula in future, as per a mandate given by the Minister for the Envionment and Natural Resources to the Planning Agency in 2018[22].

2.3 The connection between physical attributes such as terrain, size, distance and vegetation with how people perceive wildness in the landscape is key to the successful mapping of wilderness. Most wilderness mapping programmes use combinations of perceived and biophysical (ecological) attributes of wilderness to describe the patterns and variations in wilderness quality across a target landscape. While there is no one single and universally accepted method, these mapping programmes tend to focus on measures of naturalness (e.g. how natural the landscape and its ecology is) and remoteness (e.g. how large an area is and how remote places are from human settlement, roads and other infrastructure). Different countries may modify and adjust the measures and attributes used to define wilderness in a manner that best suits their landscape and culture. The work presented here follows closely that developed for Scotland. This has been used and successfully applied at both a local (national park)[23][24] and national scale to support protected area planning and to identify planning boundaries for the protection of wild land areas[25]. While they are different countries, Iceland and Scotland share certain biophysical and geographical similarities in terms of size, openness and low vegetation with limited forest/woodland cover wherein both landscapes are rugged, mountainous, sparsely populated with a remote interior, limited road access and a wild coastline.

2.4 The physical attributes to be used in the identification of wilderness are expanded on in the table 2.1. This table lists both the main (physical) criteria used to describe these attributes, but also gives further interpretation of these regarding how they are likely to influence people's perceptions of wildness in the landscape setting. These are derived and adapted from the SNH Wildness in Scotland's Countryside policy statement (2002) which form the basis for the successful mapping of wild land in Scotland. While the 2002 SNH policy statement provides the basis for subsequent mapping work, it does not provide the exact methodology, rather an indication that the approach adopted might be based on a "simple scoring system"

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[19] As translated in Jóhannsdóttir, Aðalheiður (2016) "Wilderness Protection in Iceland", in Kees Bastmeijer (ed.) Wilderness Protection in Europe. The Role of International, European and National Law pp 367. The original legal text refers to roads as being elevated (uppbyggðir) rather than main roads. The legal text also mentions power lines as an example.

[20] https://www.skipulag.is/en and https://www.landsskipulag.is/english/ and Chapter 1.1 https://www.landsskipulag.is/media/pdf-skjol/Landsskipulagsstefna2015-2026_asamt_greinargerd.pdf

[21] https://www.landsskipulag.is/gildandi-stefna/afmorkun-midhalendisins/

[22] https://www.landsskipulag.is/ferlid/tillaga-i-vinnslu and https://www.landsskipulag.is/media/landsskipulagsstefna-vidbaetur/Landsskipulagsstefna-vidb_brefradherra.pdf

[23] "Wildness study in the Cairngorms National Park" Report prepared for the Cairngorms National Park Authority and SNH, September 2008. https://wildlandresearch.org/wp-content/uploads/sites/39/2018/10/Cairngorm2008.pdf

[24] "Wildness study in Loch Lomond and The Trossachs National Park" Report prepared for the Loch Lomond and The Trossachs National Park Authority and SNH, January 2011. http://www.lochlomond-trossachs.org/park-authority/publications/wildness-study/

[25] National Planning Framework 3: The third National Planning Framework, setting out a long-term vision for development and investment across Scotland over the next 20 to 30 years. Scottish Government 2014. https://www.gov.scot/publications/national-planning-framework-3/

such as has been used successfully in the development of the Australian National Wilderness Inventory[26] and the Human Footprint/Last of the Wild[27]. As such SNH supported two feasibility studies based around mapping wildness in the Scottish National Parks and, in recognising the difficulties surrounding varied perceptions of wildness and the interpretation of physical attributes, also supported two public perception surveys, one in 2007 (reporting in 2008)[28] and one in 2011 (reporting in 2012)[29].

2.5 The Scottish national wildness map has been developed by SNH based on an up-scaling of the National Parks' methodology. This has inevitably involved some modifications. These are outlined briefly below and the differences in respect to the original National Park mapping highlighted. The SNH approach has been to map wildness in three phases:

- Phase 1: An equally weighted multi-criteria GIS mapping of those physical attributes of wildness as defined in the 2002 SNH policy document based on practical interpretations of how these attributes affect people's perceptions of wildness to map spatial variations and patterns in wildness on a relative scale from least wild to most wild. This essentially mirrors the methodology and techniques developed for mapping wildness in the two National Parks by WRi with some minor modifications to the data used and resolution to allow up-scaling across the whole of the country. These mainly concern the use of coarser resolution models and the omission of selected datasets which would have been difficult to source and/or validate at the national scale.
- Phase 2: A statistical classification and grouping areas from the resulting Phase 1 map based on Jenks Natural Breaks Optimisation to define areas with high levels of wildness according to all four attributes and application of differing size thresholds north and south of the Highland Boundary Fault. This differs from the National Parks' mapping only in that a different statistical method is used to arrive at the classification of the wildness areas. In the National Park mapping, classifications for the Phase 1 wildness quality map was performed using fuzzy classification techniques[30].
- Phase 3: A simplification of the GIS-derived mapping in Phase 1 and 2 using lines drawn at 1:50,000 scale to align the wilderness area boundaries with recognisable features on the ground such as rivers, lochs, ridges, etc. and take into account local features and recent development consents. This phase is similar to that used by the two Scottish National Park authorities whereby the defined boundaries of wild areas are informed by the Phase 1 and 2 mapping and the additional expert knowledge of Park staff.

2.6 The final map of wilderness areas was published in June 2014 along with the final SPP2 and NPF3 documents. A total of 42 wilderness areas are identified covering just under 20% of the land area of Scotland. All the maps and details of the mapping process and underpinning policy documents can be found on the SNH web pages[31].

2.7 Phase 1 and 2 of the Scottish national wildness mapping approach are adapted here to fit Icelandic data sources and environmental conditions. This is best suited to mapping patterns and variations in wilderness quality in the Drangar Peninsula based on similarities with northwest Scotland and previous experience with applying these approaches elsewhere. Data collection, processing and model development is described in detail in sections 3 and 4 of this report. Results from the mapping of wilderness quality in the Drangar Peninsula are presented in section 5 and the implications discussed in section 6.

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[26] National Wilderness Inventory's *Handbook of Procedures, Content and Usage*, Second Edition, May 1995
[27] Sanderson, E. W., Jaiteh, M., Levy, M. A., Redford, K. H., Wannebo, A. V., & Woolmer, G. (2002). The Human Footprint and the Last of the Wild. *BioScience*, *52*(10), 891-904.
[28] SNH Commissioned Report No.291 Public Perceptions of Wild Places and Landscapes in Scotland (ROAME No. F06NC03) James Fenton Scottish Natural Heritage.
[29] Public Perception Survey of Wildness in Scotland. Report for Loch Lomond & The Trossachs National Park Authority, Cairngorms National Park Authority & Scottish Natural Heritage in Association With Research Now July 2012.
[30] Comber, A., Carver, S., Fritz, S., McMorran, R., Washtell, J., & Fisher, P. (2010). Evaluating alternative mappings of wildness using fuzzy MCE and Dempster-Shafer in support of decision making. Computers, Environment and Urban Systems, 34(2), 142–152.
[31] SNH Mapping Scotland's wildness and wild land http://www.snh.gov.uk/protecting-scotlands-nature/looking-after-landscapes/landscape-policy-and-guidance/wild-land/mapping/

Table 2.1 Physical attributes in the identification of wild land (After SNH, 2002)

Attributes	Main criteria	Further detail
Perceived naturalness	Vegetation cover primarily composed of functioning, natural habitats. Catchment systems largely unmodified, and other geomorphological processes unaffected by land management.	Habitat may often not be in best condition or at optimum ecological status. But there will normally be potential for recovery, and the vegetation cover should be composed of natural components. Some small plantations may be tolerated especially at the edge of an area, if they are the only detracting feature and of limited effect on wildness.
Lack of constructions or other artefacts	No contemporary or recent, built or engineering works within the area. Little impact from out with the area on wild qualities from built development, power lines, or masts or other intensive land uses (say forestry), or from noise or light pollution. Limited effects on the wild qualities of the area from older artefacts.	Older features (fences, bridges, stalking tracks, or small buildings may be present, if not intrusive overall. Archaeological features (normally a light imprint on the land) will contribute to visitors' appreciation of the continuity of human use of these areas. Some intrusive features (say vehicular tracks which partly penetrate into an area) may be tolerated, where their effects are limited, and where excluding such land would reject an area of high intrinsic quality.
Little evidence of contemporary land uses	Extensive range-grazing and field sports (as economic uses of the land) will often be present, as well as public recreation. Land uses of an intensive nature should not be present.	The cumulative effects of the economic uses of the land should not be intrusive. Evidence of muirburn or over-grazing, habitat management, footpath deterioration and erosion, or the effects of the use of off-road vehicles may be visible. But the effects of any one of these activities, or their cumulative expression should not be of a scale or intensity so as to significantly devalue visitors' perceptual experience.
Rugged or otherwise Challenging terrain	Striking topographic features, or land having extensive rough terrain or extensive bog lands, difficult to traverse. Natural settings for recreational activities requiring hard physical exercise or providing challenge.	Different kinds of terrain can offer an inspiring or challenging experience for people but, in the main, it is those landscapes which are of arresting character (by virtue of the scale and form of the terrain) which are most valued for their wildness.
Remoteness and inaccessibility	Distance from settlements or modern communications. Limited accessibility, either by scale of the area, difficulty in passage, or the lack of easy access, say by vehicular tracks, bridges, or by boat.	Distance is not an absolute guide on its own, but most of the wild land resource will lie in the remaining remote areas, as defined by distance from private and public roads and other artefacts.
Extent of area	An area of land sufficient to engender a sense of remoteness; to provide those who visit them with physical challenge; and to allow for separation from more intensive human activities.	Smaller areas of land of high intrinsic merit or inaccessibility can hold the qualities which underpin a sense of wildness, say an inaccessible rocky gorge, and the same applies to some small uninhabited islands, or stretches of isolated coast.

3. Developing a wildness model

3.1 Maps of the four attributes of wildness – perceived naturalness of land cover, remoteness from mechanised access, absence of modern human artefacts, and ruggedness - can be combined to produce a series of wildness maps for the Drangar Peninsula using the MCE and fuzzy methods developed and used in previous studies[32] [33] [34] [35]. MCE methods allow the combination of predefined and standardised attribute layers (criteria) describing the relative merits of a solution or location using a set of user-defined weights to describe the relative importance or priorities assigned to each input layer. This process is illustrated as a flow chart in Figure 3.1.

3.2 The model illustrated in Figure 3.1 needs to be populated by attribute maps derived from raw data and a set of weights reflecting the relative importance of the attributes in defining the overall wildness map. The attribute maps are prepared from the interpretation of raw spatial data such that they represent the components of wildness derived from SNH policy and applied here to the Drangar Peninsula with adaptations to suit Icelandic data and landscape conditions. These are described in detail in section 4. Attribute weights can be defined either numerically (e.g. Carver et al., 2002) or using fuzzy methods (e.g. Fritz et al., 2000). The weights allocated to each of the attribute maps can be defined in consultation with the partners and local stakeholders using appropriate perception surveys. The exact detail of the power plant proposal has yet to be decided and Verkís, the designer/consultant, and Vesturverk, the proponent, have refused to release further spatial data on the engineering designs. As a result, several different wildness maps are produced as part of this study using MCE and fuzzy methods to reflect the likely different conditions and scenarios associated with the power plant proposal in order to take different scenarios into account. For example, while the exact route of the power line connecting the proposal power plant to the Iceland power grid is not yet fully defined, there is the option of using an underground power line or routing it overhead on pylons. Both scenarios are therefore modelled. A wildness map that combines each of the four attribute maps using equal weights is produced and used as a benchmark. These wildness maps indicate the perceived wildness using a continuous scale rather than discrete areas. The current pattern in the variation of wilderness quality across the Drangar Peninsula is shown in Figure 3.2.

3.3 Care needs to be taken during this process to ensure that the input attribute maps do not exhibit a high degree of spatial correlation such that one particular theme does not dominate the results. For example, it is conceivable that the remoteness and ruggedness might be closely correlated in the core mountain areas away from the main valley routes. Statistical checks are performed to make sure attribute maps are not correlated and to flag up any possible problem areas where spatial correlations are found to exist (see section 4.5).

3.4 All map layers need to be standardised (normalised) onto a common relative scale to enable cross comparison. For example, remoteness and perceived naturalness are measured using time (minutes) and nominal naturalness class, and so cannot be directly compared. In addition, the 'polarity' of individual map layers needs to be maintained such that higher values in the standardised maps are deemed to be 'better' (i.e. indicative of greater wildness). Standardisation of the attribute maps is achieved here using a linear re-scaling

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[32] Carver, SJ. "Integrating MCE with GIS-modelling urban system." International Journal of Information System 5 (1991): 321-339.
[33] Fritz, Steffen, Steve Carver, and Linda See. "New GIS approaches to wild land mapping in Europe." In *In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 2: Wilderness within the context of larger systems; 1999 May 23–27; Missoula, MT. Proceedings RMRS-P-15-VOL-2. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 120-127*, vol. 15. 2000. https://www.fs.fed.us/rm/pubs/rmrs_p015_2/rmrs_p015_2_120_127.pdf
[34] Carver, Steve, A. J. Evans, and Steffen Fritz. "Wilderness attribute mapping in the United Kingdom." International Journal of Wilderness 8, no. 1 (2002): 24-29. http://eprints.whiterose.ac.uk/934/1/evansaj7.pdf
[35] Carver, Steve, Alexis Comber, Rob McMorran, and Steve Nutter. "A GIS model for mapping spatial patterns and distribution of wild land in Scotland." Landscape and Urban Planning 104, no. 3-4 (2012): 395-409. https://lra.le.ac.uk/bitstream/2381/27733/2/7_carver_et_al_LUP.pdf

of the input values onto a 0-255 scale on an equal interval basis and lower values are 'worse' (i.e. indicative of lower wildness). The weights applied to the map layers are defined on an equal weighted basis for the purposes of this report. These are then applied within a simple Weighted Linear Combination4 MCE model within the GIS. Alternative wildness maps are created to demonstrate the influence of different weighting schemes on the results. These alternative weighting schemes and resulting wildness maps are described in section 5.

3.5 Weighted Linear Combination is simply based on the sum of the weighted standardised map layers as follows:

$$S_{ij} = \sum_{ij}^{i=n} \left(W_{ij} X_{ij} \right)$$

where S = suitability of the choice alternative (site or grid cell), W = criterion weights, X = standardised criterion score, i = i^{th} choice alternative, j = j^{th} criteria.

3.6 The equal weightings option weights all of the components of wildness equally so that there is no implied difference in importance attached to any of the four wilderness attributes. There are several reasons for doing this. Firstly, under the assumption of equal salience, where all four components are deemed to be equally as important as each other, it provides an objective unbiased approach. Secondly, the data from any future perception survey would need to be interpreted in order to be used as these are likely show cognition bias where unfamiliar terms are less well supported than familiar ones by survey respondents. The equal weighting option for the overall wildness map is therefore in this case a more reliable approach.

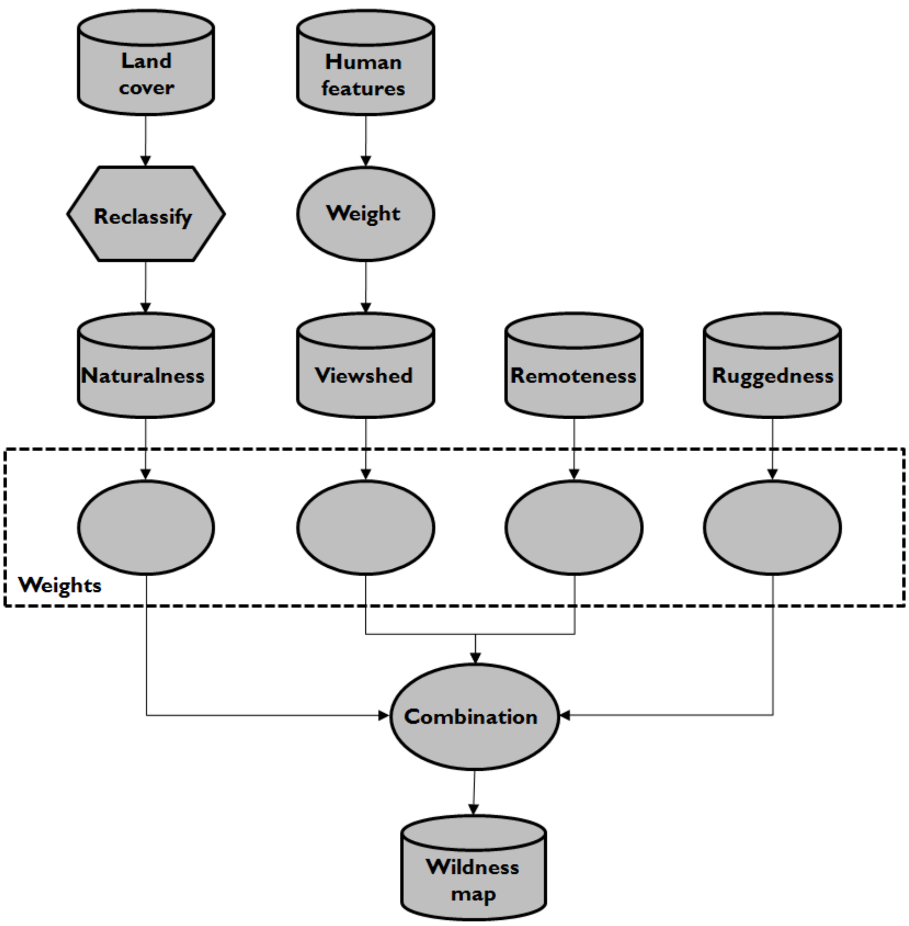

Figure 3.1 Flow chart showing how the data are parameterised by weights and combined to generate a wildness map

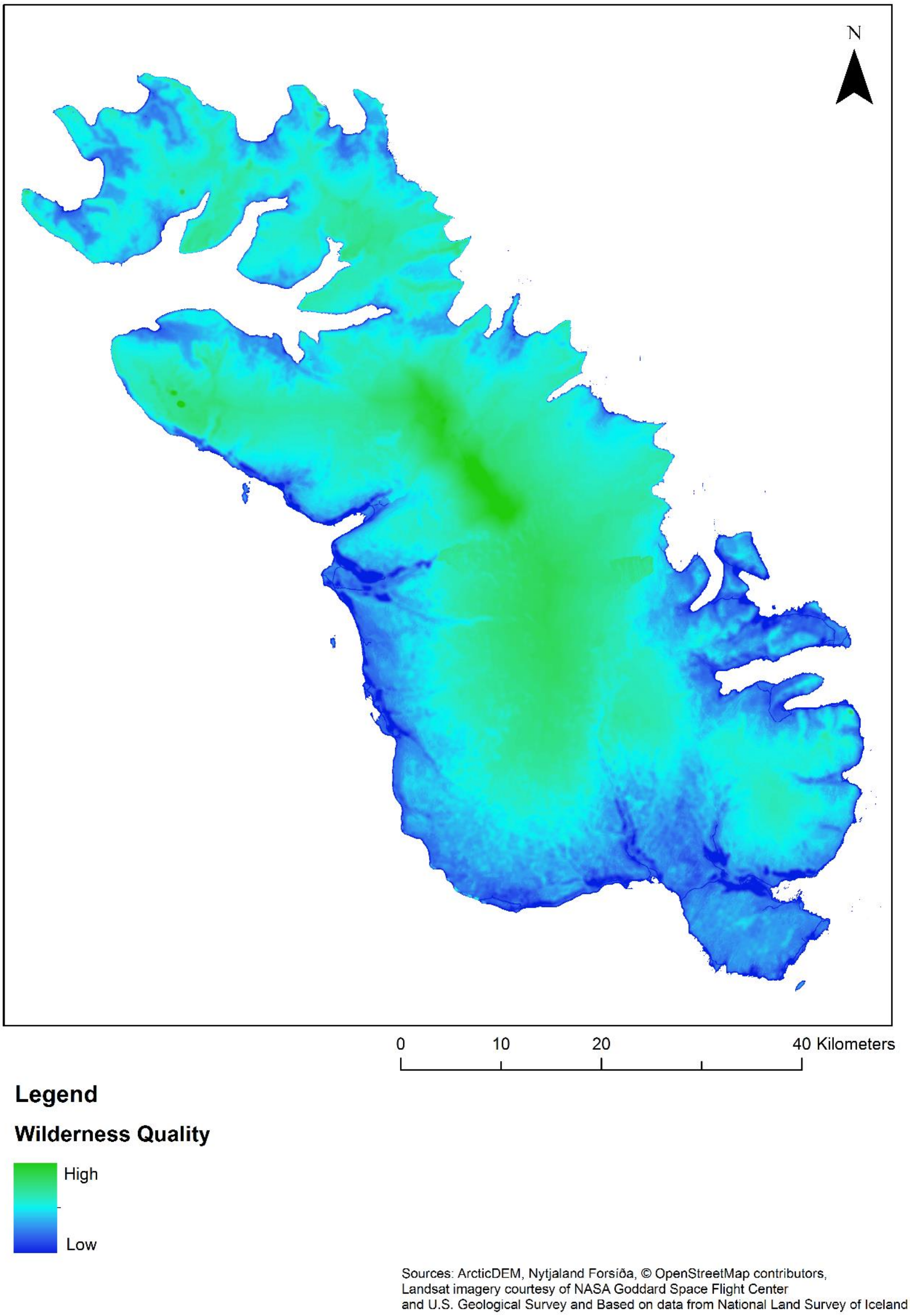

Figure 3.2 Current patterns of wildness in the Drangar Peninsula

4. Attribute maps

4.1 The four attributes of wildness as defined by SNH (2002)[36] are modified for Icelandic wilderness and mapped using a combination of readily available datasets and the latest GIS-based techniques. These attribute maps are produced for the proposed Hvalá power plant and the Drangar Peninsula area. The whole of the Drangar Peninsula is mapped to ensure that there are no edge effects arising from visible human features and points of access immediately outside Hvalá power plant area. These are described in turn, together with the data used, the method of mapping and associated caveats and assumptions.

Perceived naturalness of land cover

4.2 Perceived naturalness of land cover is described here as the extent to which land management, or lack of it, creates a pattern of vegetation and land cover which appears natural to the casual observer. Perceptions of wilderness are in part related to evidence of land management activities such as fencing, improved pasture and stocking rates, as well as presence of natural or near-natural vegetation patterns. Here the Nytjaland /Landnýting 2016 datasets[37] are brought together to best describe perceived naturalness in the Drangar Peninsula.

Data sources

4.3 Aspects of land management are identifiable from national land cover datasets like Nytjaland. These datasets are available from the Kortavefsjá Landbúnaðarháskóla Íslands[38]. The distribution, presence and absence of features related to wilderness can often be inferred from their classes and relative positions.

4.4 Previous work by Carver (2005)[39] and Carver et al. (2008)[40] has based naturalness of land cover on a reclassification of the LCM2015[41], and the earlier products, into a smaller number of naturalness classes. The land cover classes from the Nytjaland were reviewed with local experts (e.g. mountain guides) for ground truthing and then were applied to equivalent naturalness classes. The naturalness classes used here are shown in table 4.1.

Method

4.5 The Nytjaland land cover map, re-projected at a nominal resolution of 20m to match other data in the overall model, is reclassified into 5 naturalness classes based on similar classifications used by SNH as shown in Table 4.1. To account for the influence that the pattern of land cover in the area immediately adjacent to the target location has upon perceived naturalness of a certain grid cell the mean naturalness class is calculated for each location within a 250m radius neighbourhood. This value is then assigned to the target cell to represent the overall naturalness score for that location. Edge effects are avoided by calculating perceived naturalness for the whole Drangar Peninsula area**.** The resulting attribute map is shown in Figure 4.1.

[36] SNH Policy Statement WILDNESS IN SCOTLAND'S COUNTRYSIDE Policy Statement No. 02/03 https://www.nature.scot/sites/default/files/2019-10/Wildness%20in%20Scotland%27s%20Countryside%20-%20Policy%20Statement.pdf

[37] http://www.nytjaland.is/landbunadur/wgrala.nsf/key2/nytjaland.html

[38] http://lbhi.maps.arcgis.com/apps/webappviewer/index.html?id=227b358de2ec4738b9d51c8e86457c0d

[39] Carver, S. (2005) Opportunity Mapping for New Wildwoods: a report submitted to the North Pennines AONB Partnership by the University of Leeds. University of Leeds.

[40] Wildness study in the Cairngorms National Park. Report prepared for the Cairngorms National Park Authority and SNH, September 2008. https://wildlandresearch.org/wp-content/uploads/sites/39/2018/10/Cairngorm2008.pdf

[41] Centre for Ecology and Hydrology Land Cover Map 2015 https://www.ceh.ac.uk/services/land-cover-map-2015

Caveats and assumptions

4.6 The Nytjaland index data is known to suffer from some misclassification errors at a local scale on a cell-by-cell basis. However, the dataset is considered here to be the best available basis for developing indicators of naturalness for landscape scale studies in Iceland. The reclassification of the Nytjaland into 5 naturalness classes from natural/semi-natural to improved and built on land is based on the subjective reading of the class descriptions given in the dataset documentation. There is likely to be differing levels of naturalness within Nytjaland land cover classes due to differing levels of management (e.g. improved pastures) or topological relationships with other land classes (e.g. bare rock and barely vegetated) that are not fully accounted for within the data descriptions.

Absence of modern artefacts

4.7 Absence of modern human artefacts is considered here to refer to the lack of obvious artificial forms or structures within the visible landscape, including roads, vehicle tracks, pylons, dams, buildings and other built structures. The choice of which human features to include here is driven largely by what is understood to act as a wilderness detractor based on SNH wild land policy (SNH, 2002), relevant sections of the perception survey and what data is available. Previous work on the effects of human artefacts on perceptions of wilderness carried out at national to global scales has tended to focus on simple distance measures[42] [43] [44]. More recent work has used measures of visibility of human artefacts in 3D landscapes described using digital terrain models[45] [46].This is feasible at the landscape scale utilising viewshed algorithms and land cover datasets to calculate the area from which a given artefact can be seen. Work by Carver (2007)[47] for the Nidderdale AONB has utilised cumulative and distance weighted viewshed algorithms to give a more accurate impression of the spatial pattern of the impacts of visible human artefacts on peoples' perceptions of wilderness in guiding decisions about suitable areas for regeneration of native woodland. A similar approach to that used for the SNH work is adopted here using artefacts are deemed to have an impact on wilderness, together with more a digital surface model (DSM) derived from ArcticDEM and a novel and rapid viewshed assessment method developed for the earlier Cairngorm wildness mapping project (2008).

Data sources

4.8 Visibility analysis and viewshed calculations rely on the ability to calculate line-of-sight from one point on a terrain surface to another. It has been shown that the accuracy of viewsheds produced in GIS is strongly dependent on the accuracy of the terrain model used and the inclusion of intervening features (buildings, woodland, etc.) or terrain clutter in the analysis (Fisher, 1993). The terrain data used here is the ArcticDEM 2m resolution digital surface model (DSM) and derived digital terrain model (DTM). This data is derived from DigitalGlobe Satellite Constellation imagery and is accurate to with -0.01 m ± 0.07 m[48].

4.9 Modern human artefacts are extracted from the OSM buildings dataset[49]. These are divided into several discrete height classes using ground truth based on expert local knowledge classified into heights of 2, 4, 5, 7 or 10m.

[42]Lesslie, R. (1993) The National Wilderness Inventory: wilderness identification, assessment and monitoring in Australia. International wilderness allocation, management and research. Proceedings of the 5th World Wilderness Congress. 31-36.
[43] Carver, S. (1996) Mapping the wilderness continuum using raster GIS. in S.Morain and S.Lopez-Baros (eds) Raster imagery in Geographic Information Systems. OnWord Press, New Mexico, 283-288.
[44] Sanderson, E. W., Jaiteh, M., Levy, M. A., Redford, K. H., Wannebo, A. V. and Woolmer, G. (2002) The human footprint and the last of the wild. Bioscience. 52(10): 891–904.
[45] Fritz, S., Carver, S. and See, L. (2000) New approaches to wild land mapping in Europe. Proceedings of 15-VOL-2 (2000) Missoula, Montana.
[46] Carver, S. and Wrightham, M. (2003). Assessment of historic trends in the extent of wild land in Scotland: a pilot study. Scottish Natural Heritage Commissioned Report No. 012 (ROAME No. FO2NC11A).
[47] Carver, S. (2007) Regeneration of native woodland in the Nidderdale AONB. University of Leeds.
[48] https://www.pgc.umn.edu/data/arcticdem/
[49] https://www.openstreetmap.org/relation/299133

Method

4.10 The use of visibility analyses in GIS that incorporate both a DSM and feature data showing the location and pattern of modern human artefacts allows the creation of cumulative viewsheds that can be weighted according to artefact type and distance. These can be combined and used to describe the attribute layer showing the relative effects associated with the presence and absence of human artefacts. These are applied in the cumulative viewshed methodology. Bishop's (2002)[50] work on the determination of thresholds of visual impact, and the SNH report on "Visual Assessment of Windfarms: Best Practice" (SNH, 2002)[51], were used to help define the limits of viewsheds and the distance decay function used.

4.11 Viewshed analyses such as these are extremely costly in terms of computer processing time. Detailed analyses can take weeks, months or even years to process depending on the number of human artefacts included in the database. It is usual to reduce processing times by generalising the artefact database by aggregating the number of human features in a cell of a given size. Work by Carver (2005 and 2007) used cell sizes of 500x500m and 250x250m, respectively. Recent work by Washtell (2007)[52] has shown that it is possible to both dramatically decrease the processing times required for GIS-based viewshed analyses and improve their overall accuracy, through judicious use of a voxel-based landscape model and a highly optimised ray-casting algorithm.

4.12 While studies exist comparing the advantages of various optimised viewshed algorithms in their own right (Kaučič and Zalik, 2002)[53] as of yet few of these seem to have percolated through into proprietary GIS packages. It is not clear whether the relative lack of sophistication of viewshed analyses sought within the Environmental Sciences (usually restricted to calculating the visibility of a handful of point features), owes itself to limitations in the pervading software, or whether the reverse is true. However, researchers in the domain have for some time been pushing the capabilities of the available tools - for example, by refining workflows for producing cumulative viewsheds (Wheatley, 1995)[54].

4.13 The algorithm used herein, which is similar to those used in real-time rendering applications and in some computer games, was designed to perform hundreds of traditional point viewshed operations per second. By incorporating this into a custom-built software tool which has been designed to work directly with GIS data (see Figure 4.2), it is possible to estimate the visibility between every pair of cells in a high-resolution landscape model utilising only moderate computing resources. In this way, features of interest are no longer limited to a finite collection of points, but any set of features which can be described by a GIS data layer. This approach (called a 'viewshed transform') can be regarded as a maturation of traditional cumulative viewshed techniques. It was chosen for this project owing to the complexity of the surface and feature layers involved and the importance of applying methods that can realistically model the human perception of visual isolation in complex terrain. Figure 4.2 shows the voxel viewshed transform software interface with both the DSM and feature layers loaded (Figure 4.2a) and with an example inverse square distance weighted viewshed (Figure 4.2b).

4.14 The approach adopted here utilises the Arctic DEM and feature data extracted from the OSM data to:

- calculate a viewshed for every single human artefact;
- incorporate estimates of the proportional area of each artefact that is visible; and
- run separate viewshed calculations for each of the different categories of features listed above and combine these to create the absence of human artefacts attribute map.

[50] Bishop, I. (2002) Determination of thresholds of visual impact: the case of wind turbines. Environment and Planning B. 29(5) 7070-718.
[51] https://pdfs.semanticscholar.org/47b7/7e7fd1fb08fb00e05cdfb2bdd9379ce6e635.pdf
[52] Washtell, J. (2007) Developing a voxel-based viewshed transform for rapid and real time assessment of landscape visibility. Unpublished course Paper. MSc in Multi-disciplinary Informatics, University of Leeds.
[53] Kaučič, B. and Zalik, B. (2002) Comparison of viewshed algorithms on regular spaced points. In Proceedings of the 18th Spring Conference on Computer Graphics (Budmerice, Slovakia, April 24 - 27, 2002). SCCG '02. ACM, New York, NY, 177-183. DOI=http://doi.acm.org/10.1145/584458.584487
[54] Wheatley, D (1995), "Cumulative Viewshed Analysis: a GIS-based method for investigating intervisibility, and its archaeological application", in G.Lock and Z.Stancic (eds.) Archaeology and GIS: A European Perspective. pp 171-185, London: Taylor & Francis.

4.15 An inverse square distance function is used in calculating the significance of visible cells. This function gives the relative area in the viewer's field of view that a cell or feature occupies; its relationship to perceived visual intrusion is borne out by the studies previously mentioned. This function is very sensitive to small changes in relative distance and in order that the results of these visibility calculations can be appreciated visually, a log scale is applied such that in the extreme case where a feature fills the observer's field of view, the maximum value is output, with each successive value thereafter representing an order of magnitude less visual intrusion. As even very small levels of visual intrusion are visible on such a scale, it also serves very well to highlight areas which are in total shadow from all visual features owing to the shape of the local landscape. Such areas of low or zero visual intrusion from modern human artefacts currently comprise a significant portion of the core areas of the Drangar Peninsula many of which occupy the interior and valleys which are shielded by their topography. While occurring less frequently in the proximity of modified areas (such as coastal roads, farms and cottages), pockets entirely bereft of visual intrusion can be found everywhere, owing to the high relief and general ruggedness of the terrain.

4.16 Example outputs from the voxel viewshed transform showing the visibility of each separate feature class are given in Figures 4.3 and 4.5. The completed absence of modern human artefacts attribute map created from the combination of these output layers is shown in Figure 4.6. In all viewshed maps, high values equal low visibility of the features and low values represent high visibility. Areas where no feature is visible are also highlighted on the maps.

Caveats and assumptions

4.17 For this work certain compromises and customisations are necessary in order to make the task manageable. These include:

- The cell resolution in this instance was limited to 20m for all features
- A re-sampling[55] was done to generate the buildings feature data in order to guarantee that smaller and larger features in the area were weighted differently by height and size so that the viewsheds produced may be viewed as a realistic representation of the visual impact of the artefacts present;
- The landscape was split into several overlapping tiles, such that they could be worked on in parallel by a cluster of desktop computers; and
- The maximum viewshed distance is 15km for all features (Bishop, 2002).

Rugged and physically challenging nature of the terrain

4.18 The nature of the terrain within the Drangar Peninsula is varied and requires careful analysis to determine variations in its morphology (i.e. ruggedness) and challenging nature. Here, rugged and physically challenging terrain is taken to refer to the physical characteristics of the landscape including effects of steep and rough terrain that is frequently found across the peninsula. A digital terrain model is used to derive indices of terrain complexity that take slope (gradient), aspect and relative relief into account to create an attribute map describing the rugged and physically challenging nature of the terrain in the Drangar Peninsula.

Data sources

4.19 The ArcticDEM is used here to represent the terrain surface of the Drangar Peninsula for these analyses as described in 4.8, resampled at 20m resolution[56].

[55] Re-sampling of feature layers in GIS is normally carried out on a "majority class" basis wherein the value of a grid cell takes on the value of the largest feature by area that it contains. Using this rule, a 5x5m building in a 20x20m grid cell that was otherwise not classified as an artefact, say heather moor, would not be recorded on re-sampling. The "pessimistic" re-sampling used here operates on a presence/absence basis such that any grid cell containing a human artefact will be classified as such even though the actual area or footprint of the artefact may not cover most of the grid cell.

[56] The ArcticDEM resource was created from both the tiles and the 2014 - 2016 summer strip files which were obtained from the 2m index shapefiles for tiles and strips acquired from: https://www.pgc.umn.edu/data/arcticdem/. Files from each index were selected by location with selected files overlapping with the Drangajökull Peninsula shapefile as the criteria. The information for the selected files were exported to tables and the download links were then moved into a .csv file. This file was inputted into a custom script to automatically download all files in batch from links. The Tiles were examined within ArcGIS for

Method

4.20 Ruggedness is calculated from the ArcticDEM 20m resampled DEM as a simple index defined as the standard deviation (SD) of terrain curvature within a 250m radius of the target location. This is calculated. This generates values representing the amount of convex and/or concave curvature of the surface in both plan form and profile. Areas where curvature changes frequently are identified because they are deemed to represent rapidly changing terrain and hence ruggedness. This is achieved by applying a standard deviation function to the curvature surface within a 250m radius filter as shown in Figures 4.6 and 4.7.

Caveats and assumptions

4.21 It is understood that there are many ways of looking at and measuring ruggedness or roughness of a terrain surface. Other methods considered included fractal complexity[57], combinations of slope and aspect and statistical indices derived from these. As with the perceived naturalness map, a radius of 250m is used to estimate ruggedness within a fixed neighbourhood around the target location. This is used to spatially limit the ruggedness index to the immediate vicinity of the observer.

Remoteness

"Distance, 10 miles; total climb, 6,300 feet; time, six and a half hours (including short halts). This tallies exactly with a simple formula, that may be found useful in estimating what time men in fair condition should allow for easy expeditions, namely, an hour for every three miles on the map, with an additional hour for every 2,000 feet of ascent." Naismith (1892)[58]

4.22 Given the varied and challenging nature of the terrain found within the Drangar Peninsula it is essential to include terrain as a principal variable governing remoteness across the peninsula. Remoteness is mapped in the Drangar Peninsula based on a GIS implementation of Naismith's Rule using detailed terrain and land cover information to estimate the time required to walk from the nearest point of mechanised access be that a road or track or boat landing point. Maps showing remoteness from public roads and hill tracks are included in the SNH policy document 'Wildness in Scotland's Countryside' (SNH, 2002). These are based on linear distance from the nearest public road or hill track taking barrier features such as lochs and reservoirs into account. Work by Carver and Fritz (1999) has developed anisotropic measures of remoteness based on a GIS implementation of Naismith's Rule incorporating Langmuir's corrections[59]. This model assumes a person can walk at a speed of 5km/hr over flat terrain and adds a time penalty of 30mins for every 300m of ascent and 10mins for every 300m of descent for slopes greater than 12 degrees. When descending slopes between 5 and 12 degrees a time bonus of 10mins is subtracted for every 300 metres of descent. Slopes between 0 and 5 degrees are assumed to be flat. This has been subsequently applied in modelling the historic trends in wild lands in the central Highlands (Carver and Wrightham, 2003) and wild land quality in the Scottish national parks (Carver et al., 2012)[60].

4.23 This anisotropic[61] approach to modelling remoteness is based on the relative time taken to walk into a roadless area from the nearest point of mechanised access taking the effects of distance, relative slope,

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any key areas of missing data and where available the best strip file was co-registered using python script from https://github.com/dshean/demcoreg. The outputted strip files and tiles were then mosaicked into a new 2m Raster and clipped to the Drangajökull Peninsula. The DEM was then converted to 20m using the "resample" tool any remaining missing data being taken from the 10 National Land Survey DEM acquired from https://www.arcgis.com/home/item.html?id=5bb01c378d2e4d0381c49e38bd96d4d9.Verk

[57] Fractal complexity refers to the degree to which an object can be divided into separate objects each of which is similar to the original. For example, a tree can be split into a series of branches each of which may resemble the original tree. These branches can then be divided themselves into twigs, each of which again may resemble the original tree and its branches.

[58] Naismith, W. W. (1892) Scottish Mountaineering Club Journal. II: 136

[59] Langmuir, Eric. (1984) Mountaincraft and leadership: a handbook for mountaineers and hillwalking leaders in the British Isles. Edinburgh: Scottish Sports Council, 1984.

[60] Carver, Steve, Alexis Comber, Rob McMorran, and Steve Nutter. "A GIS model for mapping spatial patterns and distribution of wild land in Scotland." Landscape and Urban Planning 104, no. 3-4 (2012): 395-409.

[61] Anisotropic models do not assume equal ease of travel/movement in all direction, rather movement is either aided or restricted by other factors such as steepness of slope and the presence of impassable barriers such as

ground cover, and barrier features[62], such as open water, tidal crossings and very steep ground, into account. This assumes remoteness to be directly proportional to the time taken to walk from A to B across varied terrain and is therefore analogous to the concept of the long walk in which is a long-established principle in Scottish mountaineering and could equally be applied to the terrain of the Drangar Peninsula with some modifications for boat access, river crossings and the Drangajökull icecap. The implementation of this model of remoteness requires a detailed terrain model and ancillary data layers that are used to modify walking speeds according to ground cover (e.g. Naismith's approximation of 5 kilometres per hour on the map can be reduced to 4 kilometres per hour or less when walking across open heath or tundra), and include barrier features as null values which force a detour to find a safe and suitable crossing point.

Data sources

4.24 Calculating remoteness based on Naismith's Rule requires a range of data including a detailed terrain model, land cover data and information on the location of rivers, open water, roads, tracks and other access features. These are all sourced from datasets described in the previous sections on naturalness, human artefacts and ruggedness. The ArcticDEM data is used for the terrain model, the Nytjaland forsíða for the land cover data and OSM for the road, track, open water and river data. Foot bridges, tidal crossing and at access points, which are important access features, were digitised from Ferðamálasamtök Vestfjarða paper map and Landsat-8 Satellite imagery via head-up digitising[63] from raster maps using ground source data and use of a NDWI.

Method

4.25 Remoteness is calculated here using a GIS implementation of Naismith's Rule incorporating Langmuir's Correction based on the PATHDISTANCE function in ArcGIS. This estimates walking speeds based on relative horizontal and vertical moving angles across the terrain surface together with appropriate cost or weight factors incurred by crossing different land cover types and the effects of barrier features such as lakes, large rivers and very steep ground (cliffs). Remoteness is calculated considering access over land only. However, given the prevalence of large expanses of open water within and surrounding the peninsula, remoteness models incorporating access utilising boat services were also incorporated. These models cover access by motor boats and the passenger ferry services operating around the Drangar Peninsula. The outputs from the land and water-based remoteness models were combined to produce a total remoteness map. The theory and practical application of this model is described by Carver and Fritz (1999). The walking model is applied using the following conditions:

Source grid: This is taken to be those **roads** that provide vehicular access via private car and those locations along the coastline where the use of a boat is a common way to gain access to some of the more remote locations north of the coastal road network.

Cost surface: This is assumed to be *5km/*h for all land cover types except heathland which is 3km/hr and wetland which is 2km/hr. Fords across rivers were deemed to take 20mins to which equates to approximately *0.06km/h* as the pixel size was 20m. The roads and tracks data associated with the proposed power plant have been digitised and are used to amend the cost surface assuming a speed of 15km/hr where it is possible to use a mountain bike to gain more rapid access to the core areas if road access was blocked to the public in private motor vehicles.

Barriers to movement: These are taken to include rivers that appear as polylines in the OSM data, slopes that were identified (using information supplied by local experts and guides) as unpassable. These sections of river are assumed to be crossable where there is a bridge or where these rivers are crossed by a path and so can be assumed to be passible at these locations with the same time delay as fjord rivers above.

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lochs such that the cost of movement is not-directly proportional to horizontal distance. Isotropic models are much less realistic because they do assume equal ease of movement in all directions and therefore oversimplify the concept of remoteness in this context.

[62] NoData or null values in a raster grid contain no data and so are disregarded in most calculations unless the model explicitly references these. NoData values are useful in building access models in that they can be used to describe the locations of barrier features that cannot be crossed.

[63] Digitising directly onto a map on the computer screen using the mouse cursor.

4.26 The inputs to the remoteness modelling for the current conditions existing within the Drangar Peninsula are shown in Figure 4.8. The current remoteness from mechanised access as modelled using these methods and data is shown in Figure 4.9.

Caveats and assumptions

4.26 Naismith's Rule and the model used to implement it here assumes a fit and healthy individual, and does not make any allowance for load carried, weather conditions (such as poor visibility and strong head winds) and navigational skills. The model does, however, take barrier features and conditions underfoot into account as described above. Lakes and reservoirs are considered impassable on foot and are included as barrier features by coding these as NoData (null values) in the model inputs. This forces the model to seek a solution that involves walking around the barrier. The model also uses a cost or friction surface that controls the walking speed according to the land cover or conditions underfoot. A speed of 4km/hr (1.389m/s) is assumed for most land cover types, while speeds of 3km/hr (0.833m/s) and 2km/hr (0.555m/s) are assumed for the heathland and wetland examples, respectively[64]. The angle at which the terrain is crossed (i.e. the horizontal and vertical relative moving angles) is used to determine the relative slope and height lost/gained[65]. These values are input into the model using a simple look up table as shown in Table 4.2. The road network, both within and outside the boundary of the Drangar Peninsula, together with commonly used boat landing points along the coast, is used as the access points from which to calculate remoteness of off-road areas. In considering the effects of large rivers deemed to be barrier features, these are assumed crossable only at those points where roads, tracks or footpaths cross and only where there is a bridge.

Table 4.1 Naturalness classifications applied to land cover features

Naturalness class	Land cover class
0	NoData
2	Cultivated Land/Shrubland
3	Grassland/Unknown (Lowland Vegetated)
4	Rich Heathland/Poor Heathland
5	Mossland/Damp Wetland/Wetland/Poorly Vegetated/Barren/Lakes/Glacier/Unknown

Table 4.2 Speed applied to land cover classes

Id	Class	Speed (km/h)
0	NoData	NoData
1	Grassland	4
2	Rich Heathland	4
3	Cultivated Heathland	4
4	Poor Heathland	3
5	Scrubland	3
6	Moss land	2
7	Damp Wetland	2
8	Wetland	2
9	shrub land (Forestry)	3
10	Poorly vegetated	3
11	Barren	3

[64] Lower walking speeds are included here based on discussion about the maximum likely speeds attainable across these two land cover types.

[65] Vertical and horizontal factors determine the difficulty of moving from one cell to another while accounting for the vertical or horizontal elements that may affect the movement, these include slope and aspect as they determine the relative angle of the slope in the direction it is crossed and hence the height gained or lost

12	Lakes	NoData
13	Glacier	1
14	Unknown	3

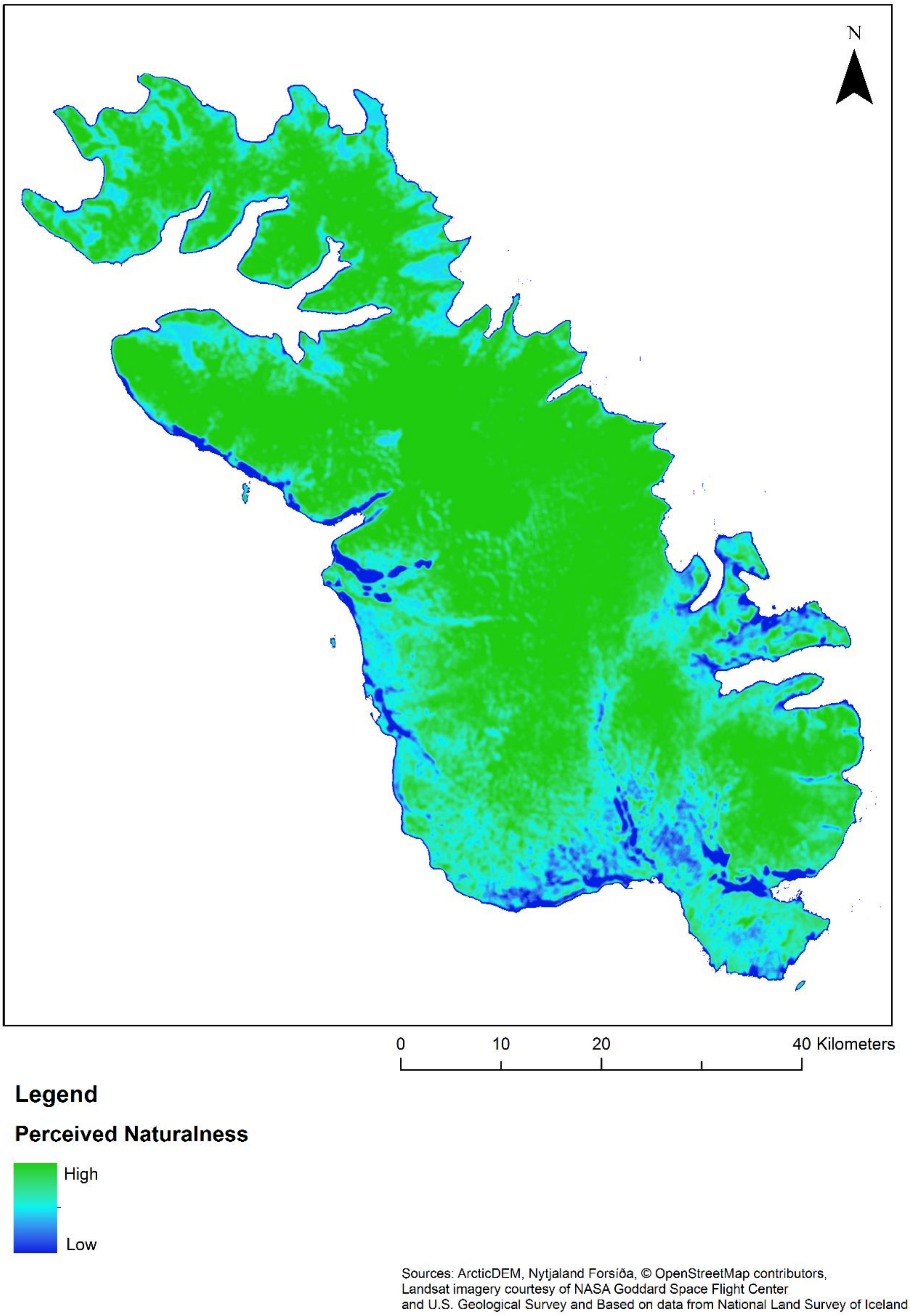
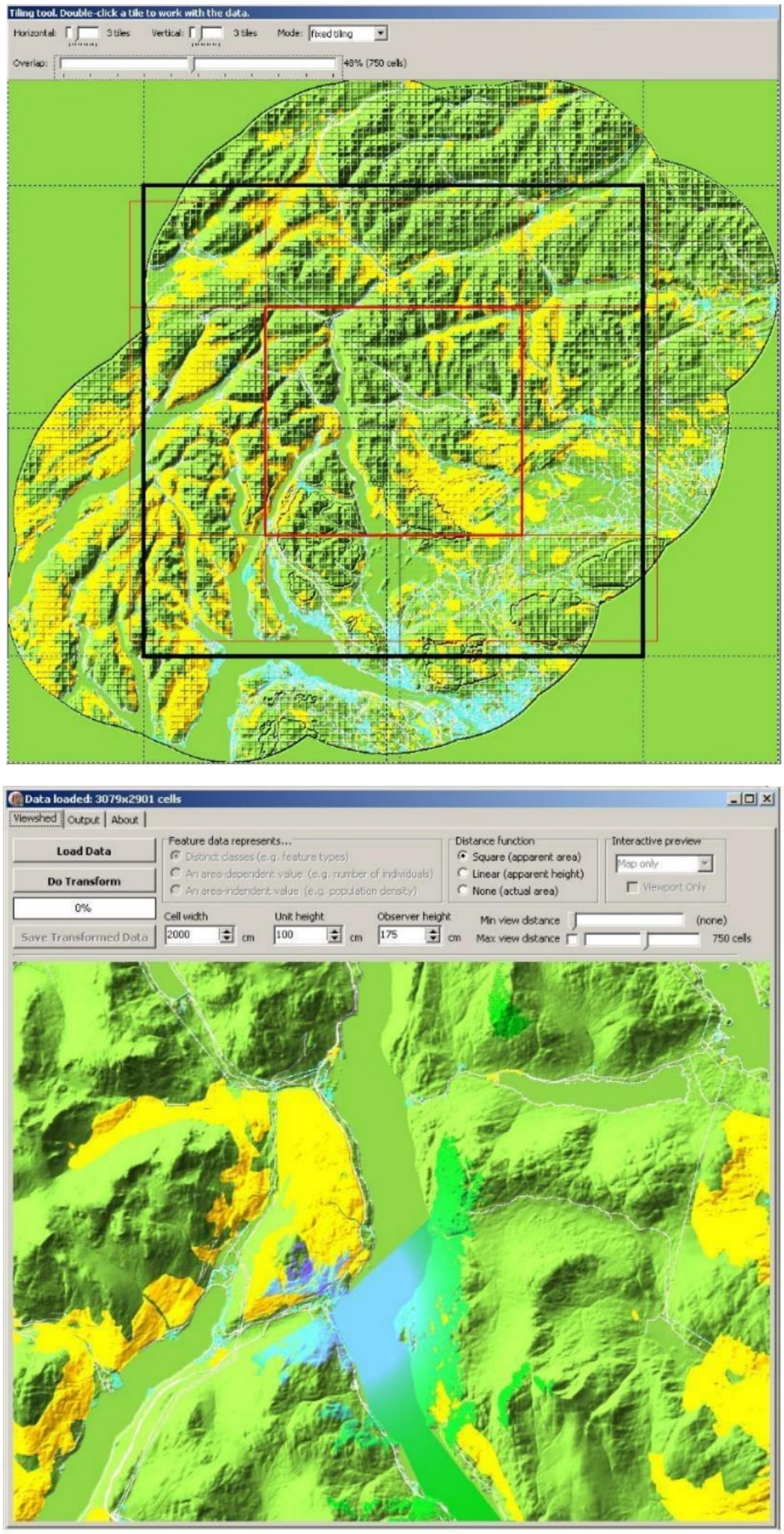


Figure 4.1 Perceived naturalness of land cover



(a)

(b)

Figure 4.2 The Viewshed tool interface demonstrating (a) the tiling tool (b) sample DSM and feature tiles loaded into the model

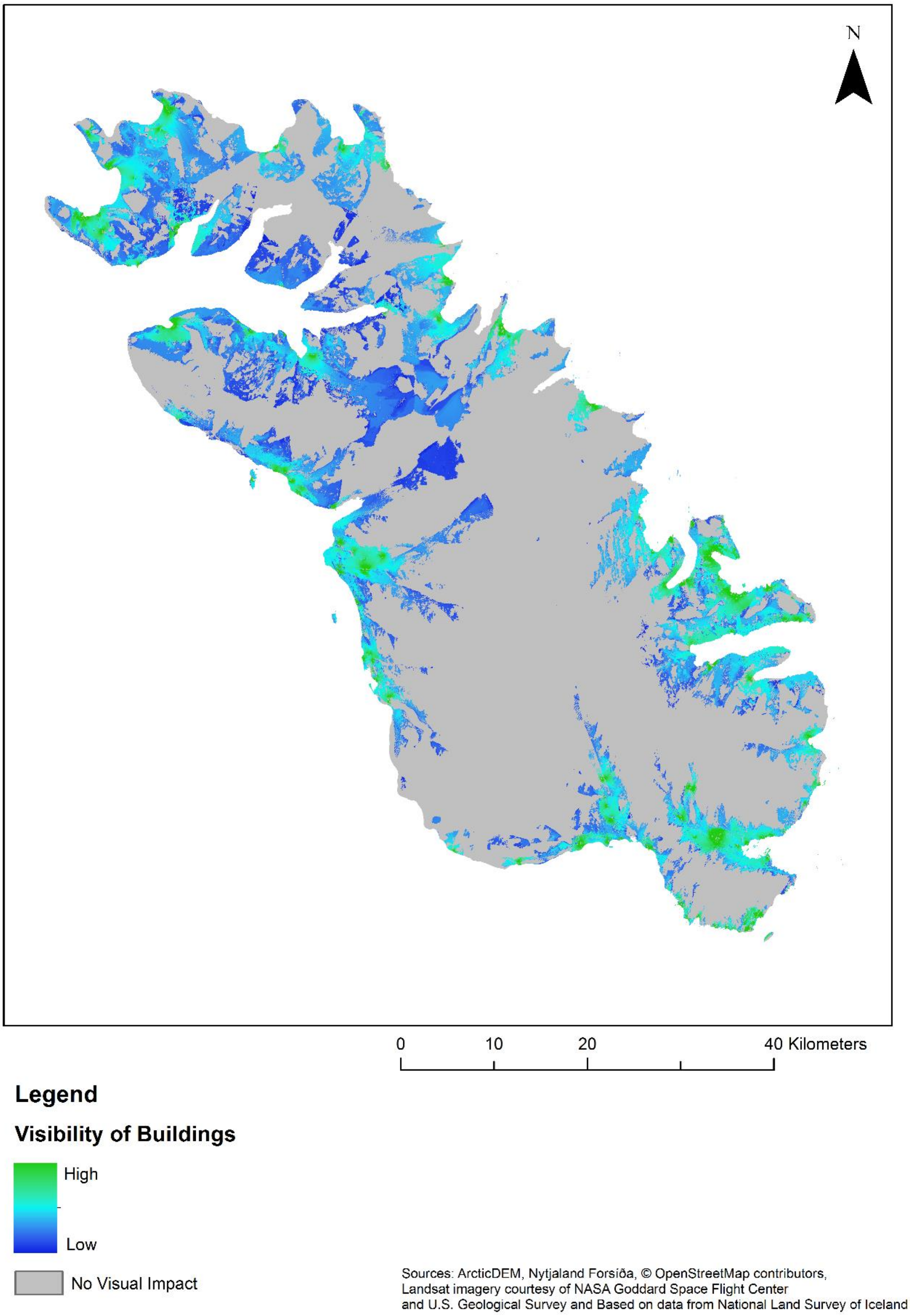


Figure 4.3 Visibility of existing buildings

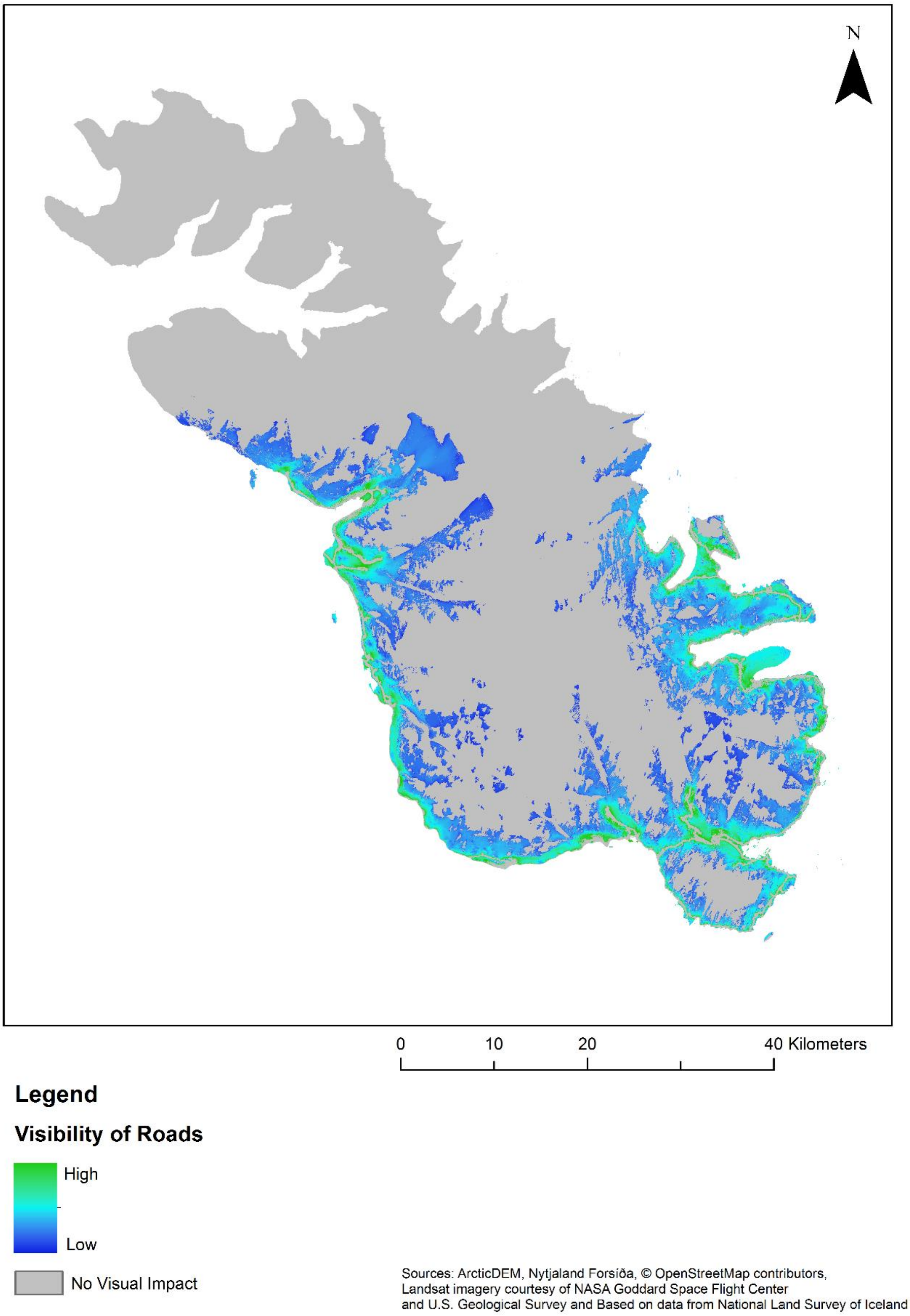


Figure 4.4 Visibility of existing roads

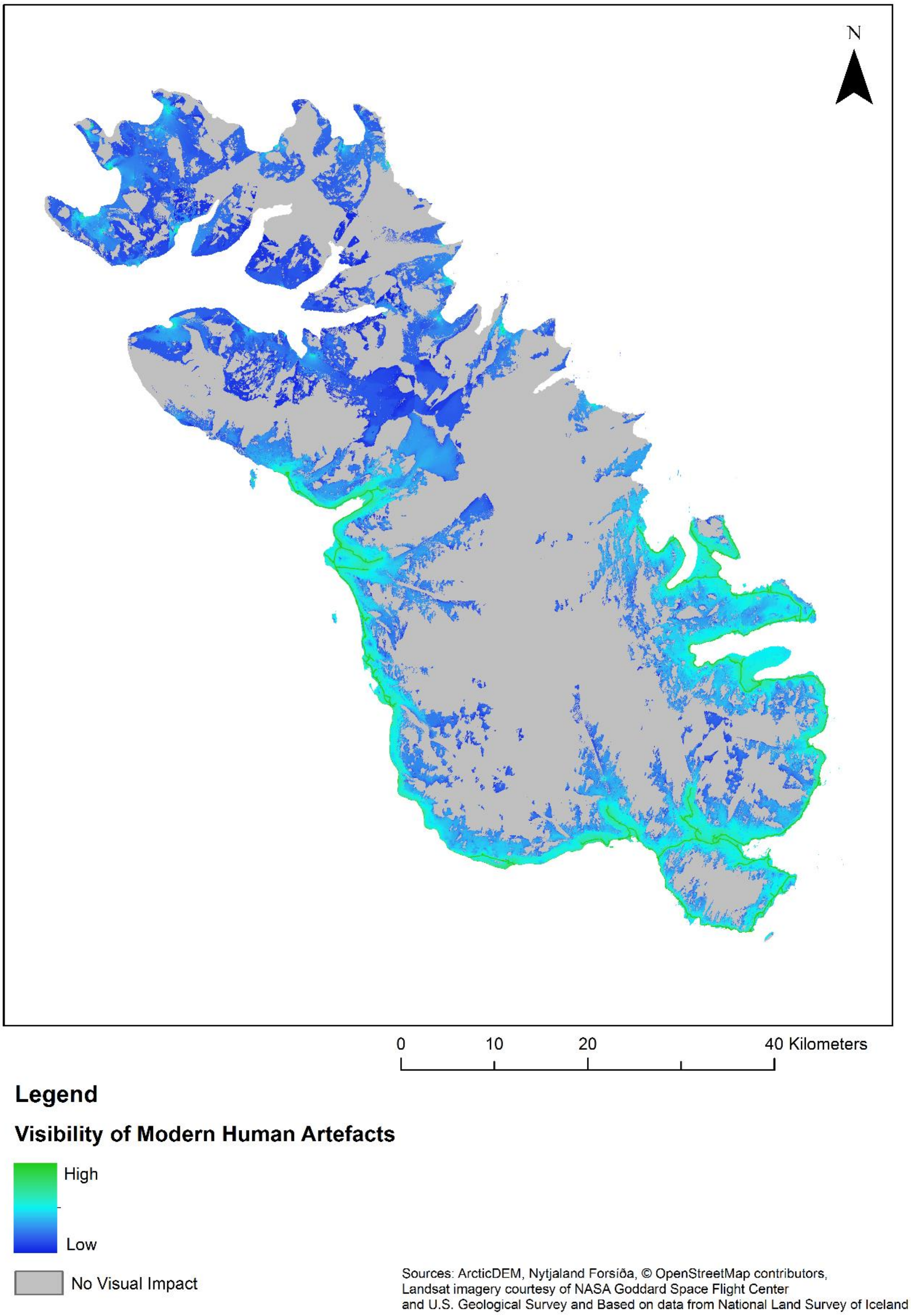


Figure 4.5 Visibility of existing pre-work modern human artefacts

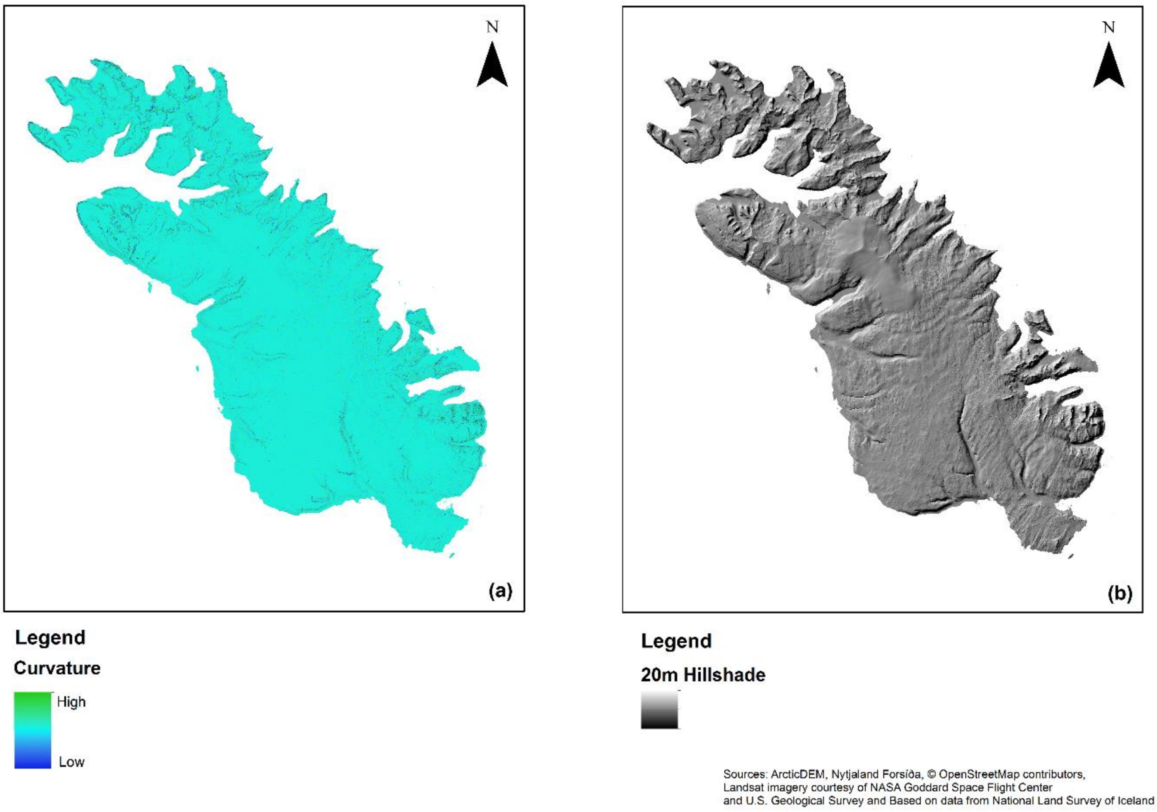


Figure 4.6 Variation in curvature (a) and hillshade representing terrain surface (b)

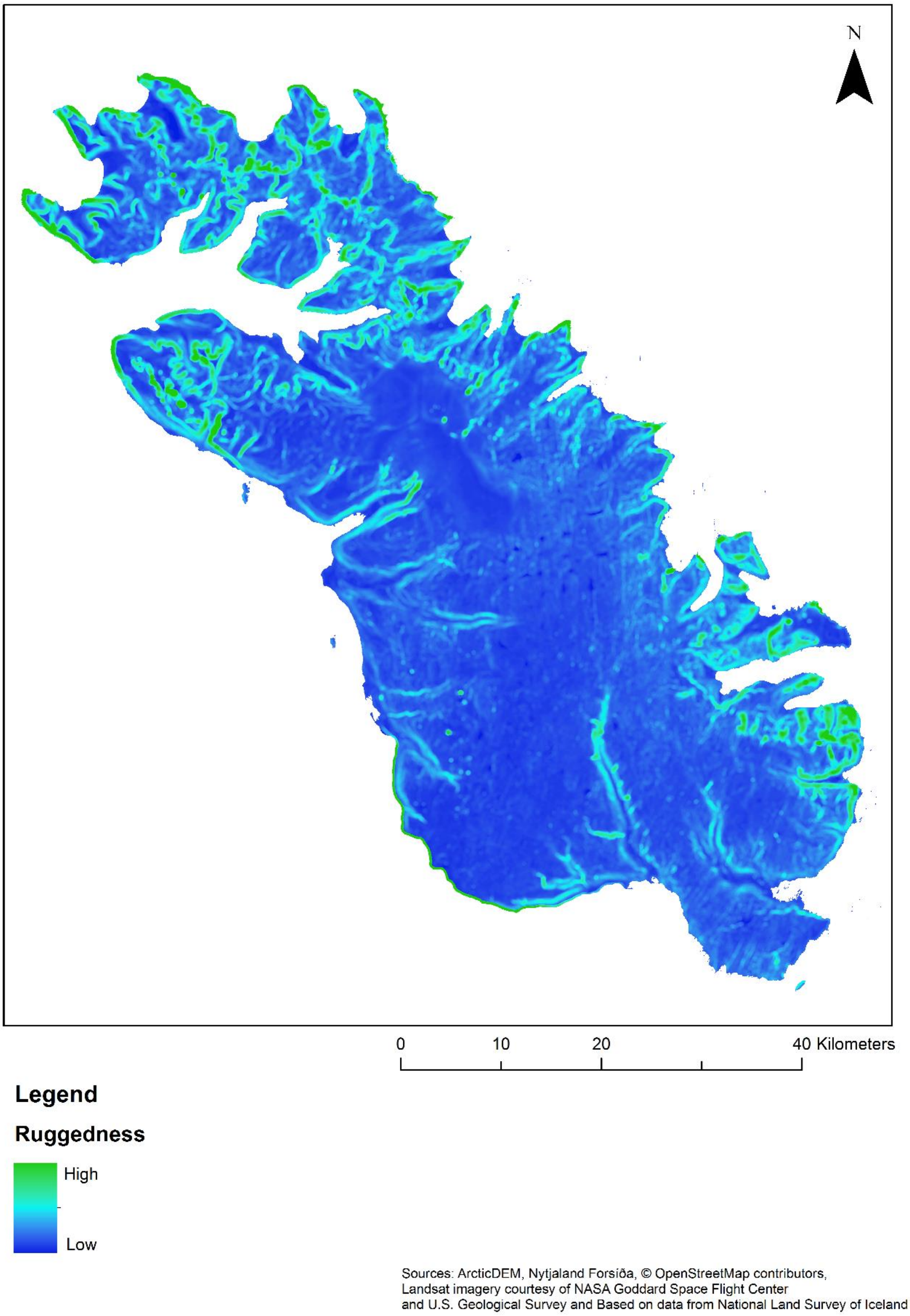


Figure 4.7 Rugged and challenging nature of the terrain

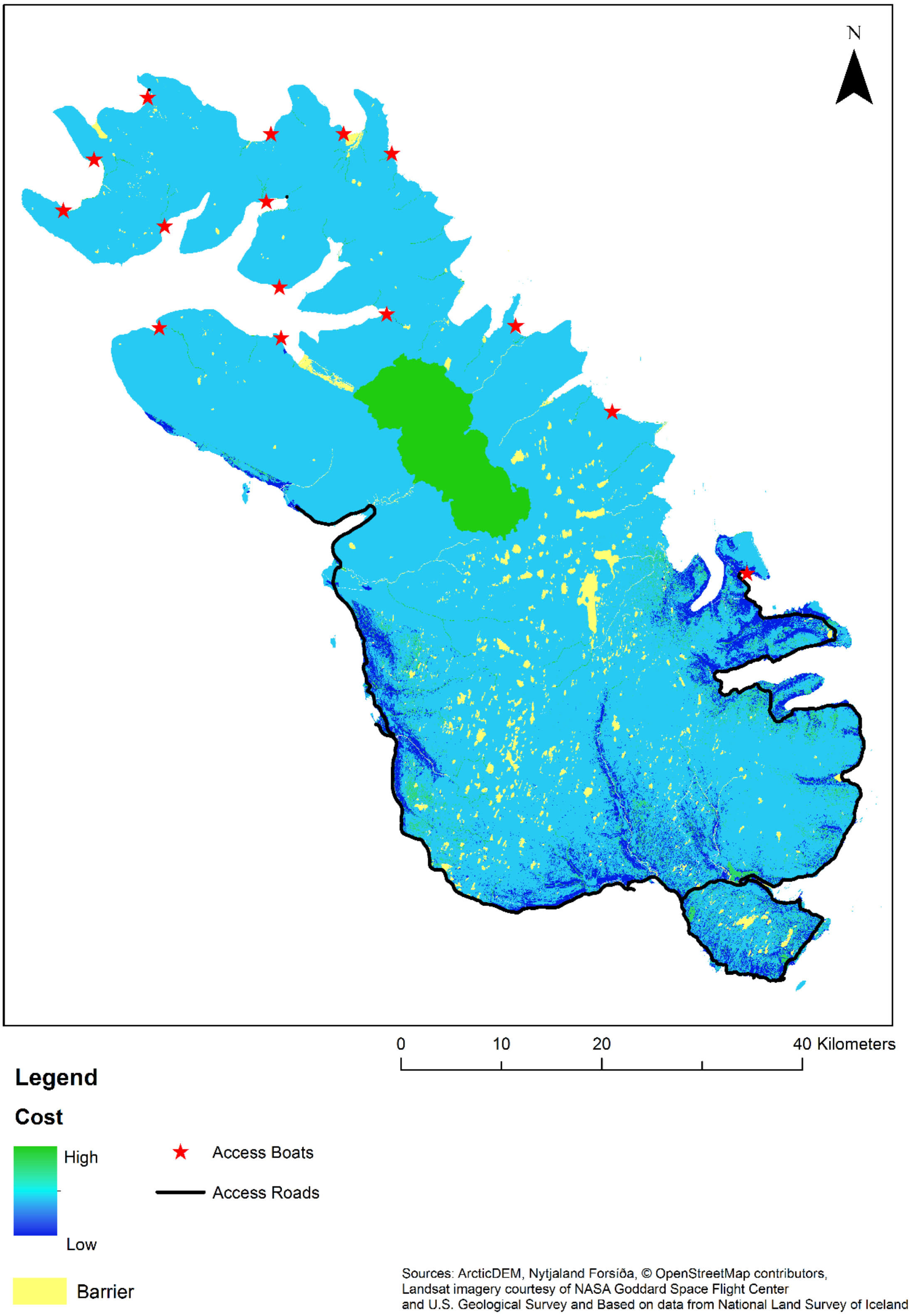


Figure 4.8 Inputs to the remoteness model under current conditions showing mechanised access (source), cost surface and barriers to movement.

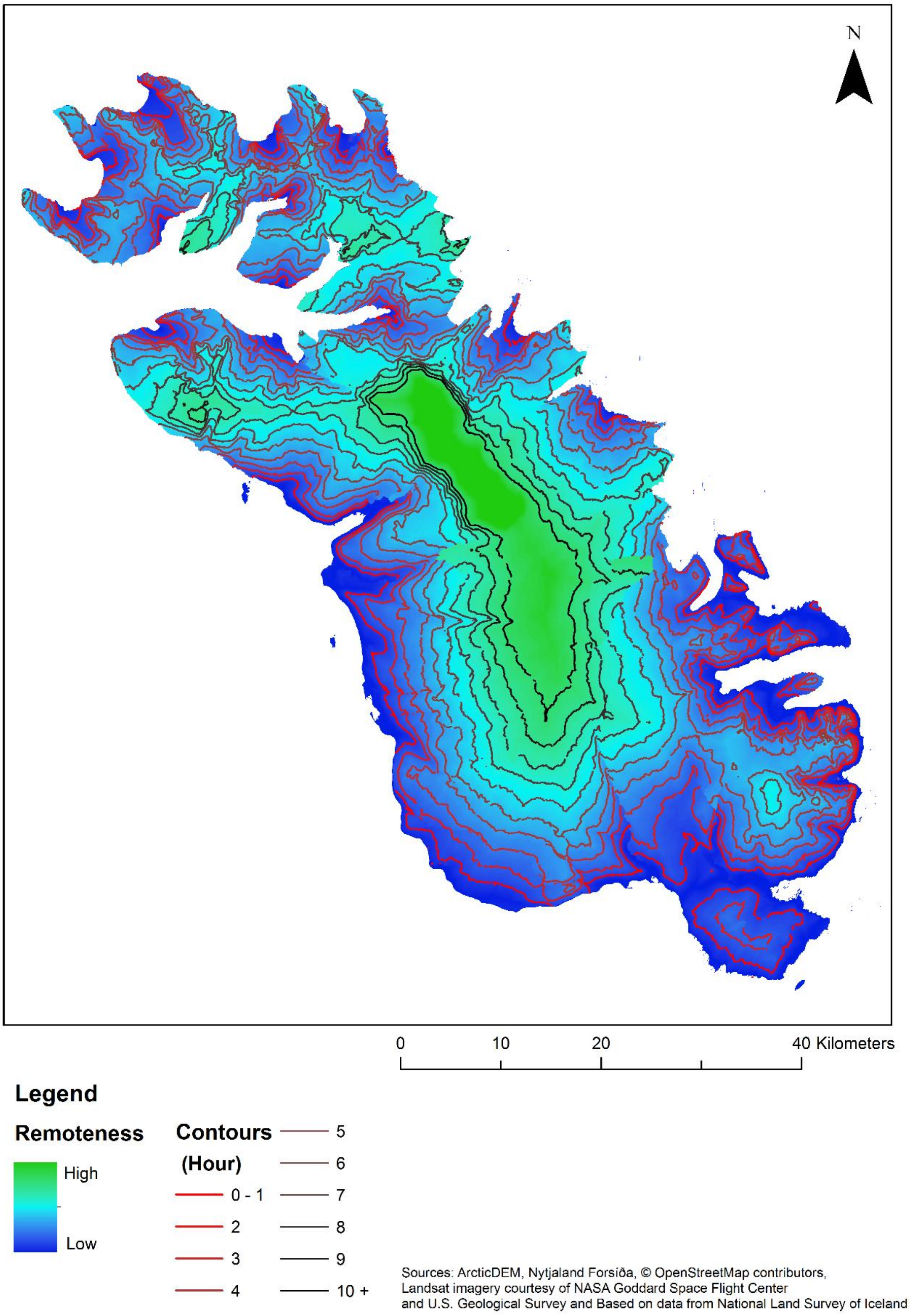


Figure 4.9 Current remoteness from mechanised access

5. Results: impacts on the patterns of wilderness in the Drangar Peninsula

5.1 The spatial variation in wilderness quality across the Drangar Peninsula under current conditions is shown in Figure 3.2. This is based on applying the model described in Section 3 to each of the four attributes of wilderness described in Section 4. This provides a rigorous and robust spatial baseline for wilderness quality against which the predicted impacts of the proposed Hvalá power plant can be measured through repeat mapping. This requires that the four wilderness attributes described and illustrated in Section 4 are recalculated with the planned infrastructure of the power plant development in place.

5.2 To do this, each of the input layers used in calculating the perceived naturalness of land cover, absence of modern human artefacts, ruggedness and remoteness from mechanised access are amended and updated to include the site features shown in Figure 1.2. The impact from the construction of the proposed power plant on each of these four attributes can be determined by subtracting the post-construction attribute maps from the current pre-construction maps.

5.3 Because of variations in the planned power plant construction as regards the connecting power line and the public use of power plant access roads, two options are provided for both post-construction absence of modern human artefacts and post-construction remoteness from mechanised access. These post-construction attribute maps and the impacts on wilderness quality resulting from the planned construction are shown in Figures 5.1-5.12.

5.4 There are two options for connecting the proposed power plant to the Icelandic power grid. These are via overhead power lines, or via an underground cable. Both options will involve the construction of an access track for construction and maintenance, though the underground cable will have a slightly reduced visual impact due to the lack of pylons[66]. Nonetheless, both options will involve a degree of visual impact and these are shown in Figures 5.3 and 5.4, with the resulting impact on this attribute from these two options shown in Figures 5.5 and 5.6.

5.5 There are also two options as regards the public use of the proposed access roads. These are that the public will be allowed to use these with motorised vehicles, or that public use will be restricted to walking and mountain bikes. Both options will involve reductions to the overall remoteness of the Drangar Peninsula but at different levels depending on the speed of travel along these new access roads; a fast speed assuming use of motorised vehicles or a slow, but nonetheless relatively rapid, speed assuming restriction of public use to walking or mountain bike. Both options are modelled here, and the post-construction remoteness results are shown in Figures 5.9 and 5.10, with the resulting impact on this attribute from these two options shown in Figures 5.11 and 5.12[67].

5.6 Predicted changes to the current spatial pattern of wilderness quality across the Drangar Peninsula for all combinations of these options in power line construction and public use of access roads are shown in Figures 5.13-5.16. The associated impacts in terms of changes to the overall spatial pattern of wilderness quality in the Drangar Peninsula are shown in Figures 5.17-5.20.

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[66] It is noted that at this time the actual route of the proposed connecting power line and associated access/maintenance track are not fully known and has yet to be accurately mapped. The route of the power line and track used here is based on the map provided in the 2016 Environmental Impact Statement Hvalárvirkjun í Ófeigsfirði Figure 5.2 http://www.skipulag.is/media/attachments/Umhverfismat/1215/13029003-4-SK-0126-Hvalarvirkjun-MS_Hluti1%20(1)%20(1).pdf. This shows an approximate corridor along which the power line could be routed. This is used here to define a centre line to simulate the likely impact on the power line and track.

[67] These maps assume that the fastest means available will be used to gain access to these areas.

5.7 The wilderness quality maps can be classified into core, buffer and edge zones based on the application of the Phase 2 mapping methods used in the mapping of Scottish Wild Land Areas[68]. Here, SNH applied a classification of their Phase 1 wilderness quality index based on dividing the spread of wilderness quality values using the Jenks natural breaks method[69] with 8 classes, from which the top two classes (8&7) are taken to define the core areas, the next two classes (6&5) are taken to define the buffer zone, and the remain 4 classes (4-1) are taken to define the edge or non-wilderness areas. This approach is adapted and applied here, and the results shown in Figures 5.21-5.25. This allows the calculation of both absolute areas and percentage changes to the existing core wilderness and buffer zones that would result from the construction of the proposed Hvalá power plant.

[68] SNH's Mapping of Scotland's Wildness and Wild Land: Non–technical Description of the Methodology (June 2014) https://www.nature.scot/snhs-mapping-scotlands-wildness-and-wild-land-non-technical-descirption-methodology

[69] The Jenks natural breaks method seeks to minimize each the deviation within each class from the average deviation from the class mean, while maximizing each class's deviation from the means of the other groups.

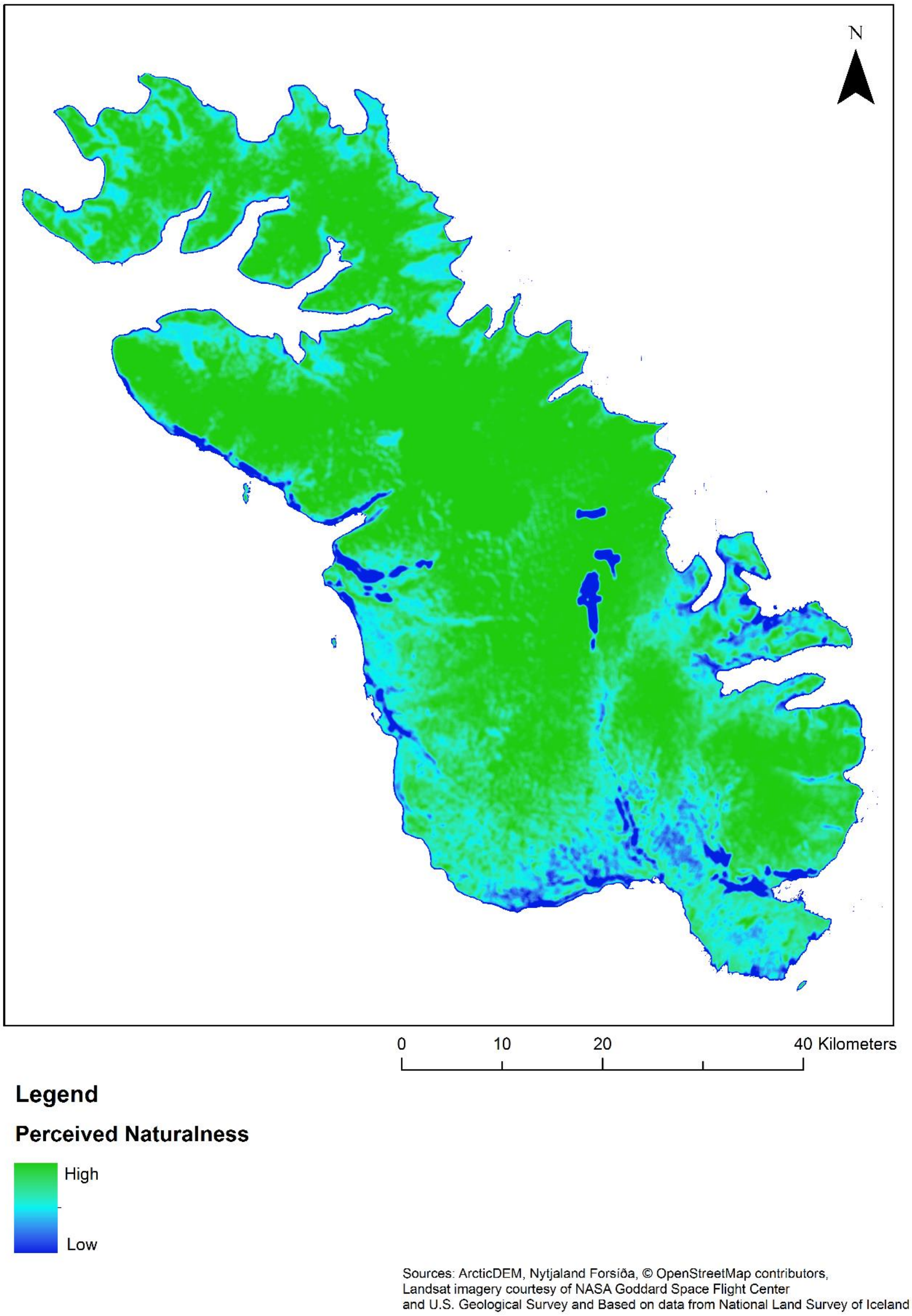

Figure 5.1 Perceived naturalness post-construction

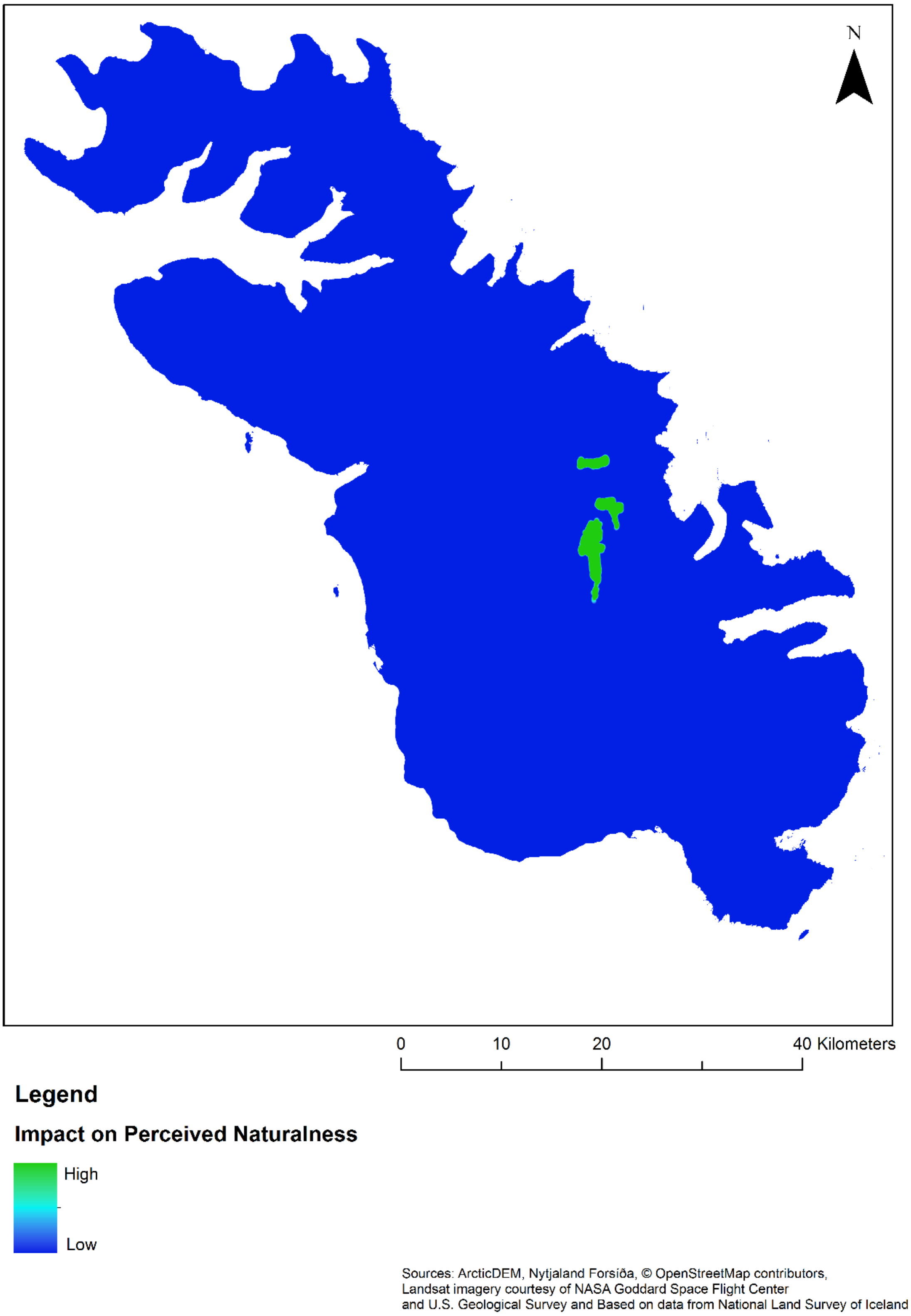

Figure 5.2 Impact of power plant construction on perceived naturalness

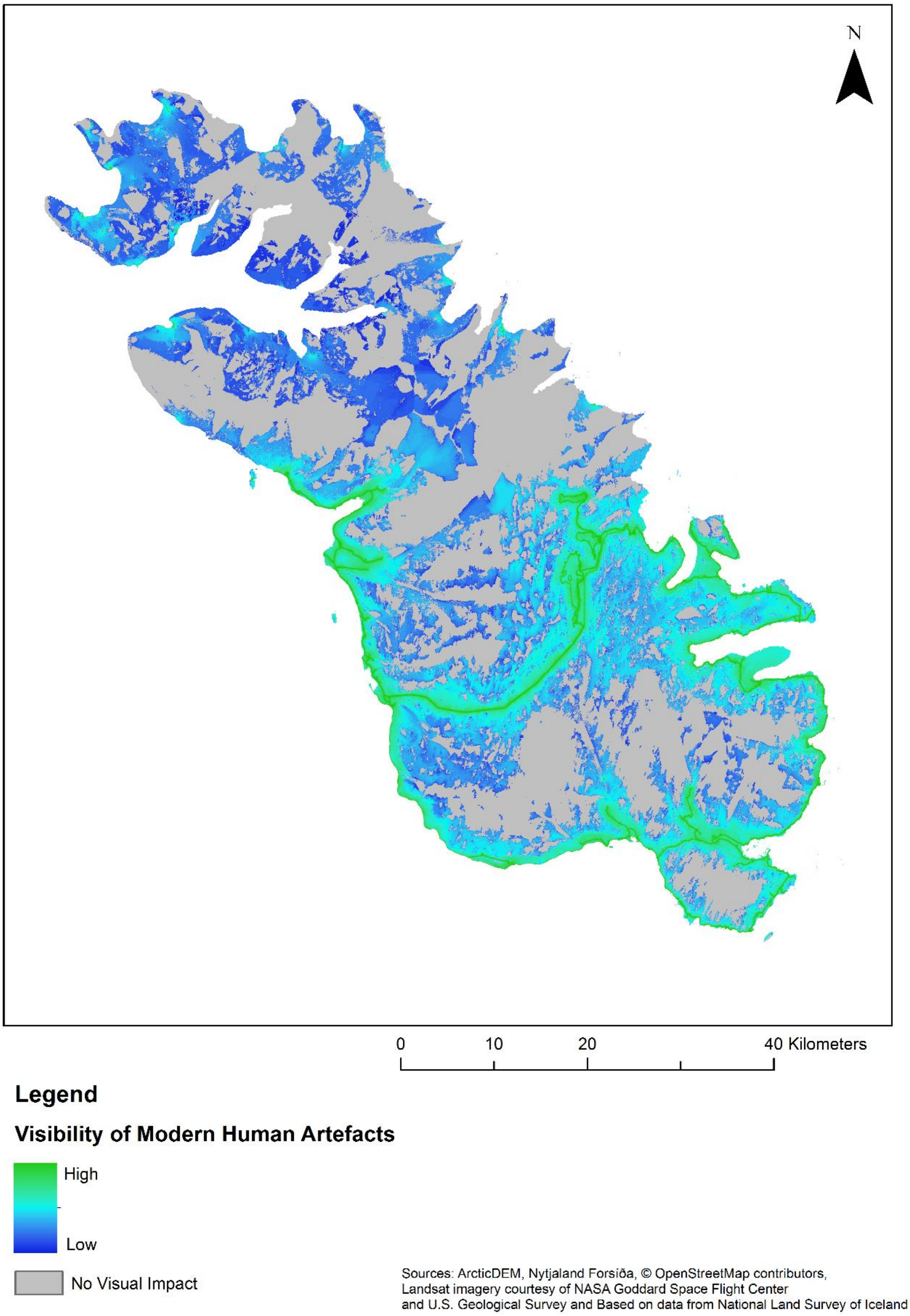

Figure 5.3 Absence of modern human artefacts post-construction: overhead power line option

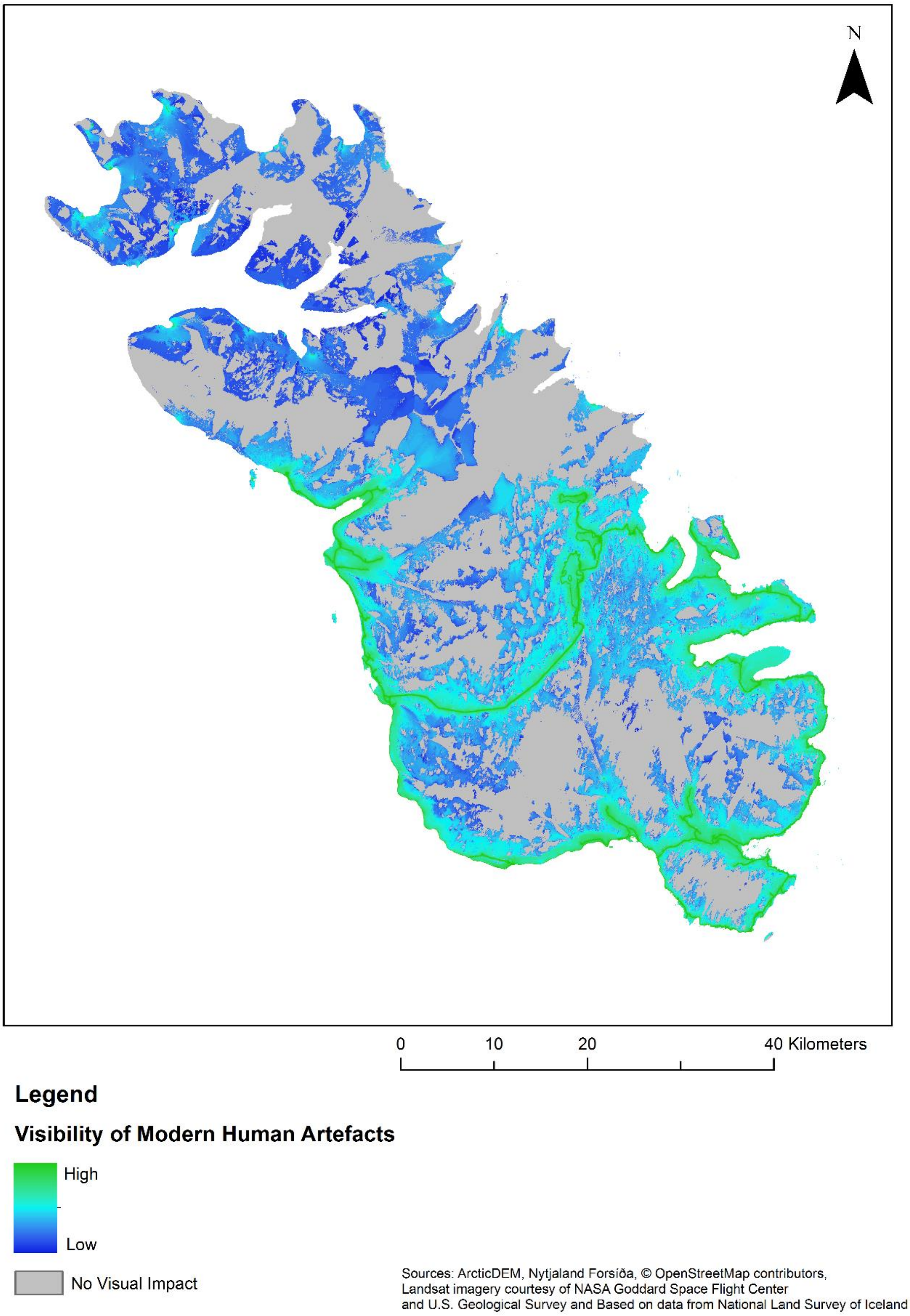

Figure 5.4 Absence of modern human artefacts post-construction: underground power line option

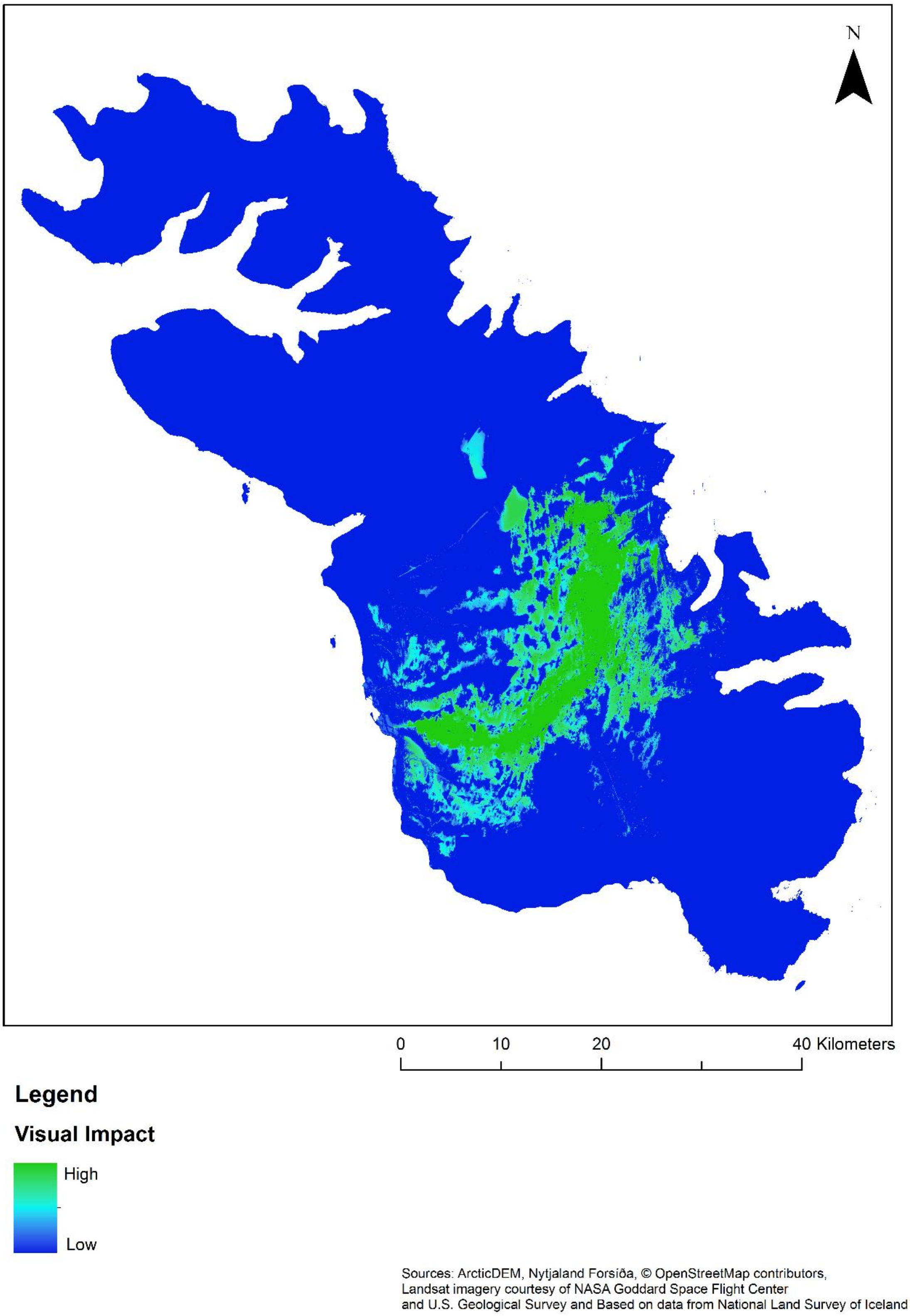

Figure 5.5 Impact of power plant construction on absence of modern human artefacts: overhead power line option

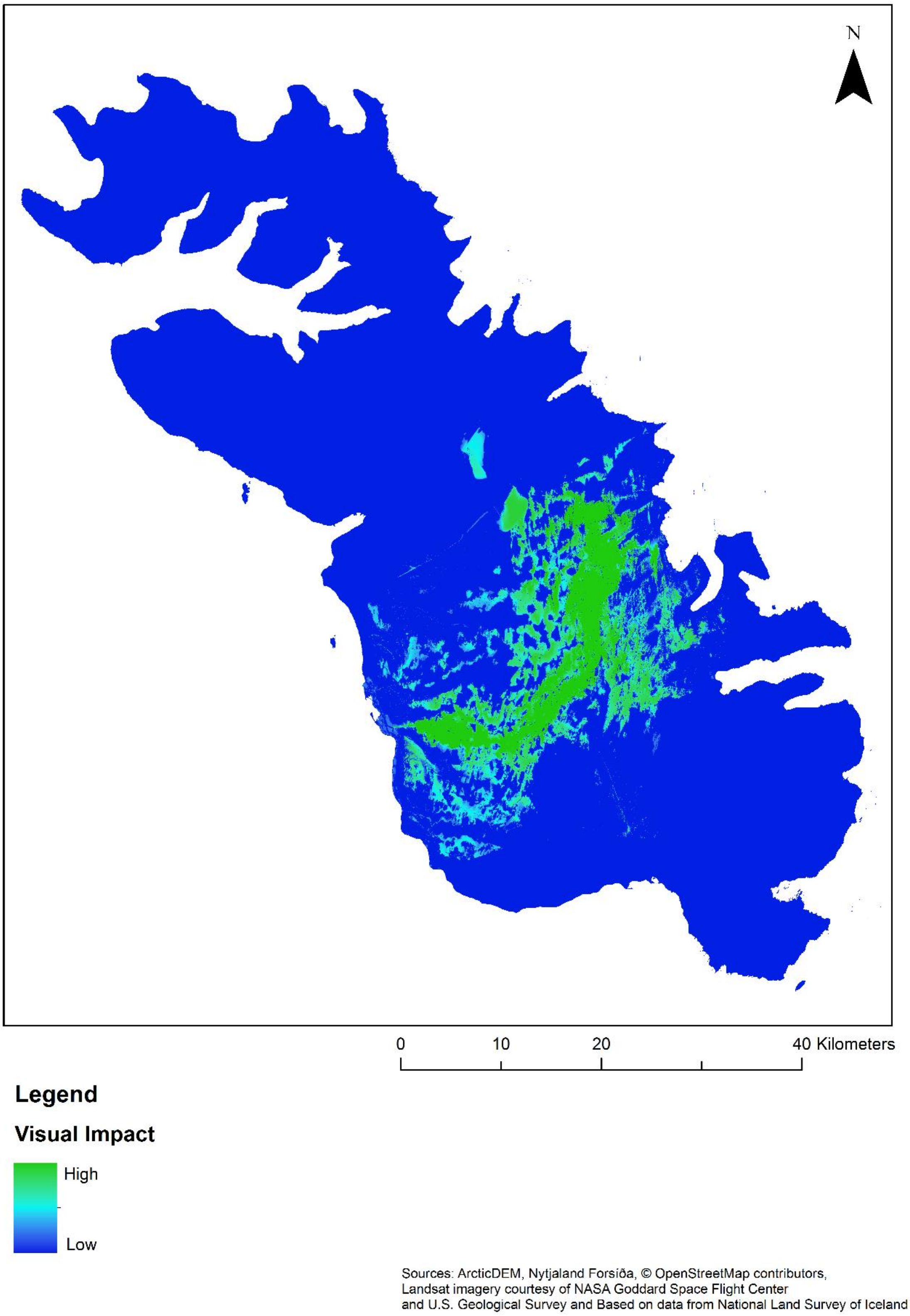

Figure 5.6 Impact of power plant construction on absence of modern human artefacts: underground power line option

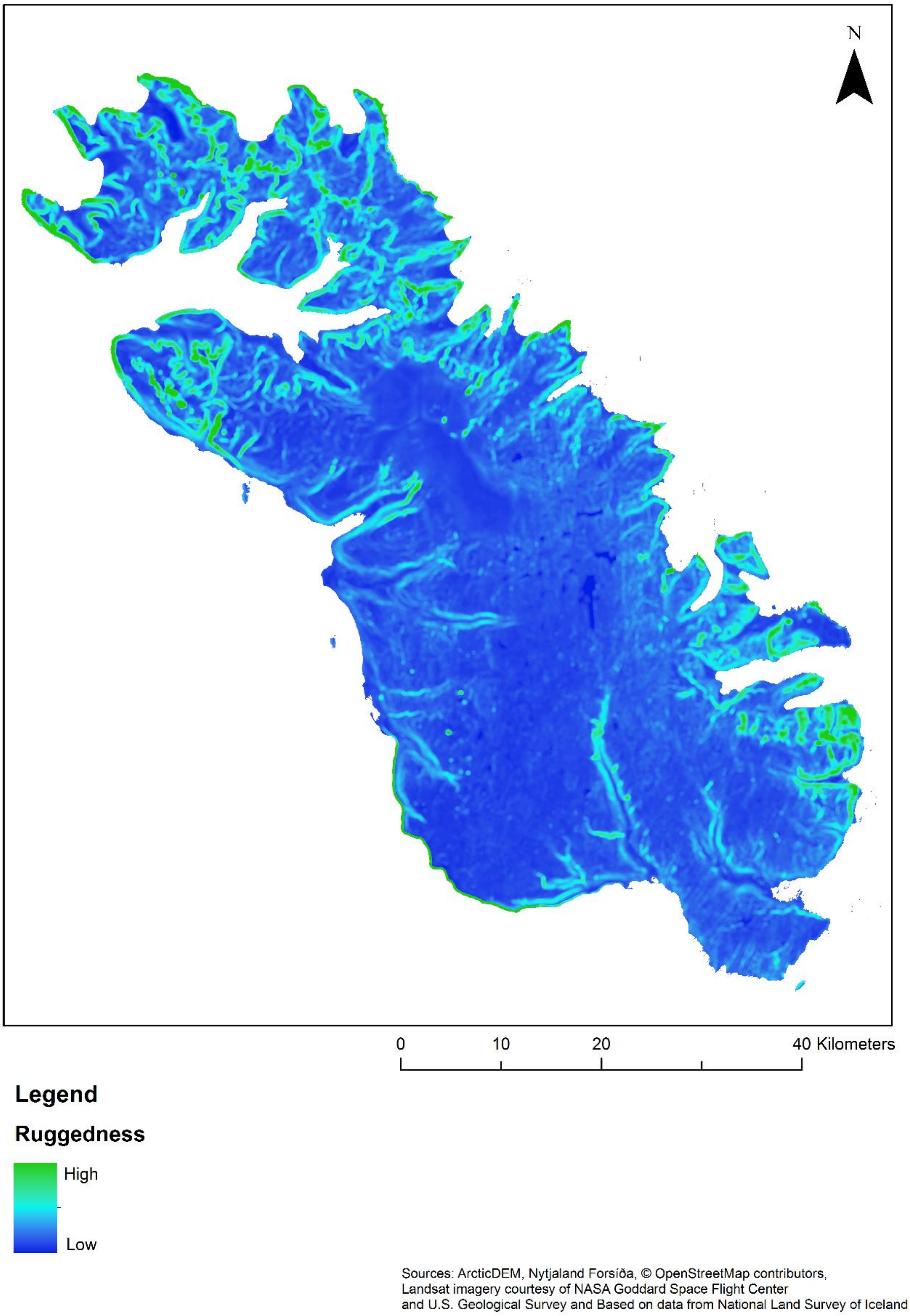

Figure 5.7 Ruggedness post-construction

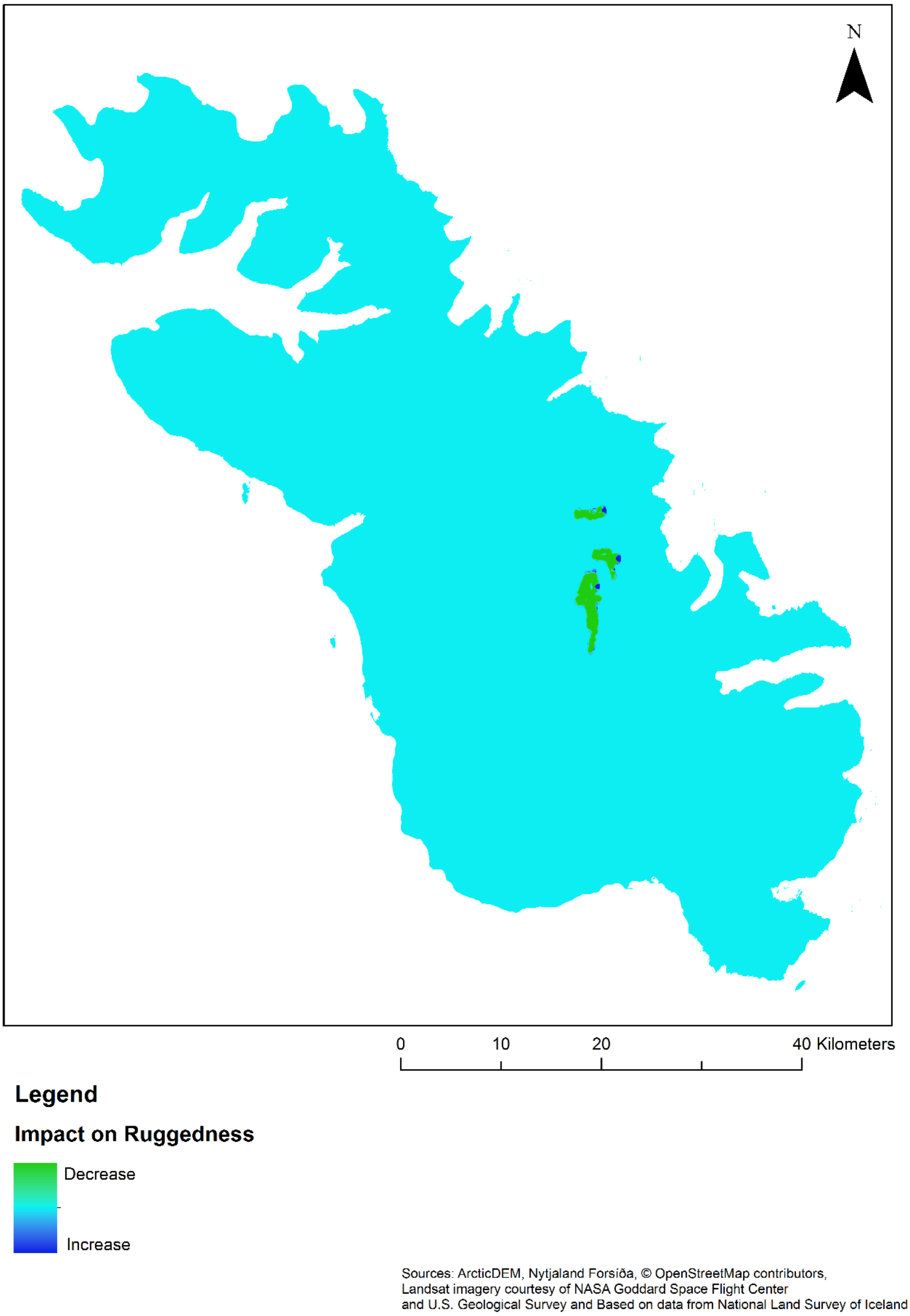

Figure 5.8 Impact of power plant construction on ruggedness

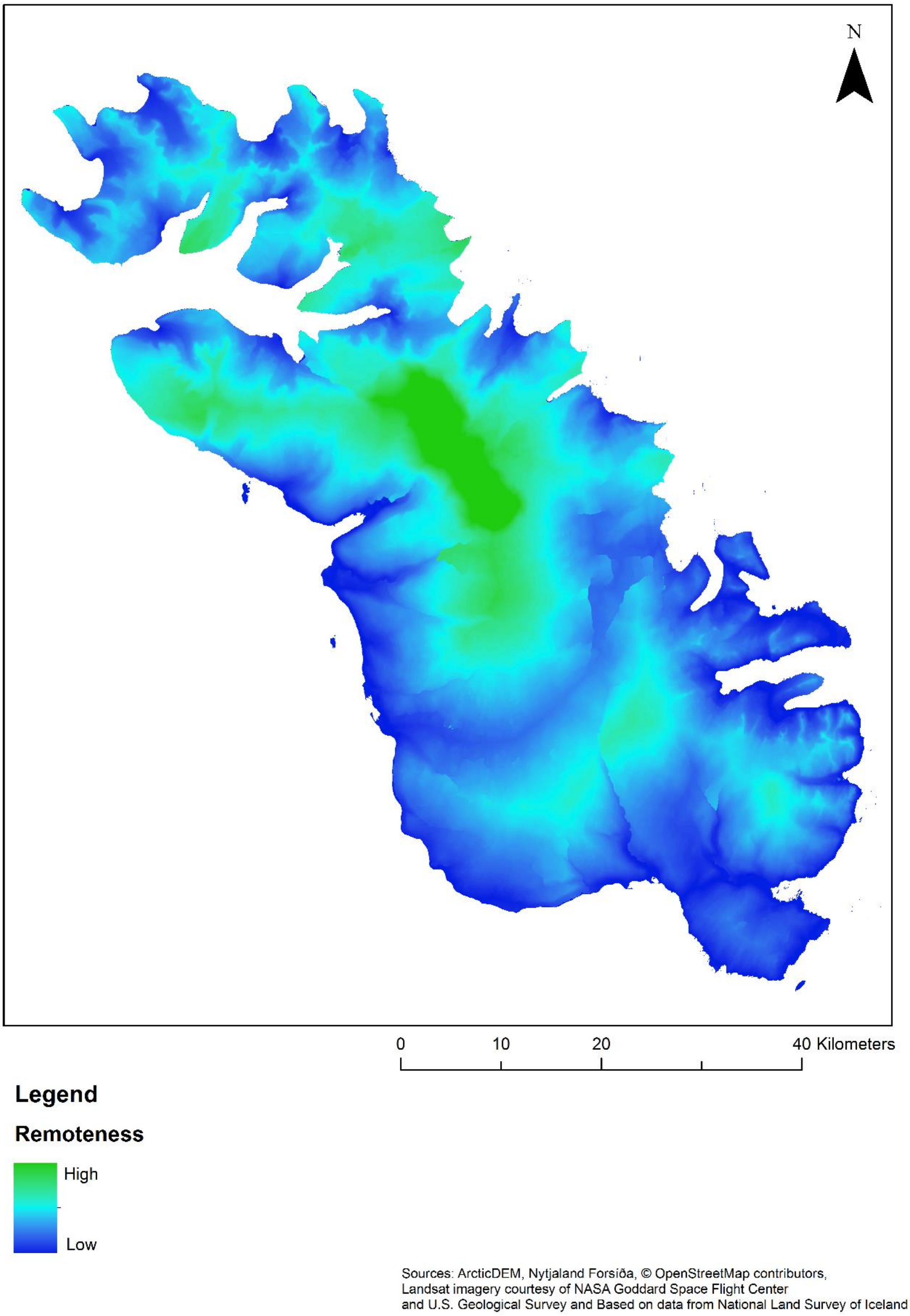

Figure 5.9 Remoteness post-construction: fast access times

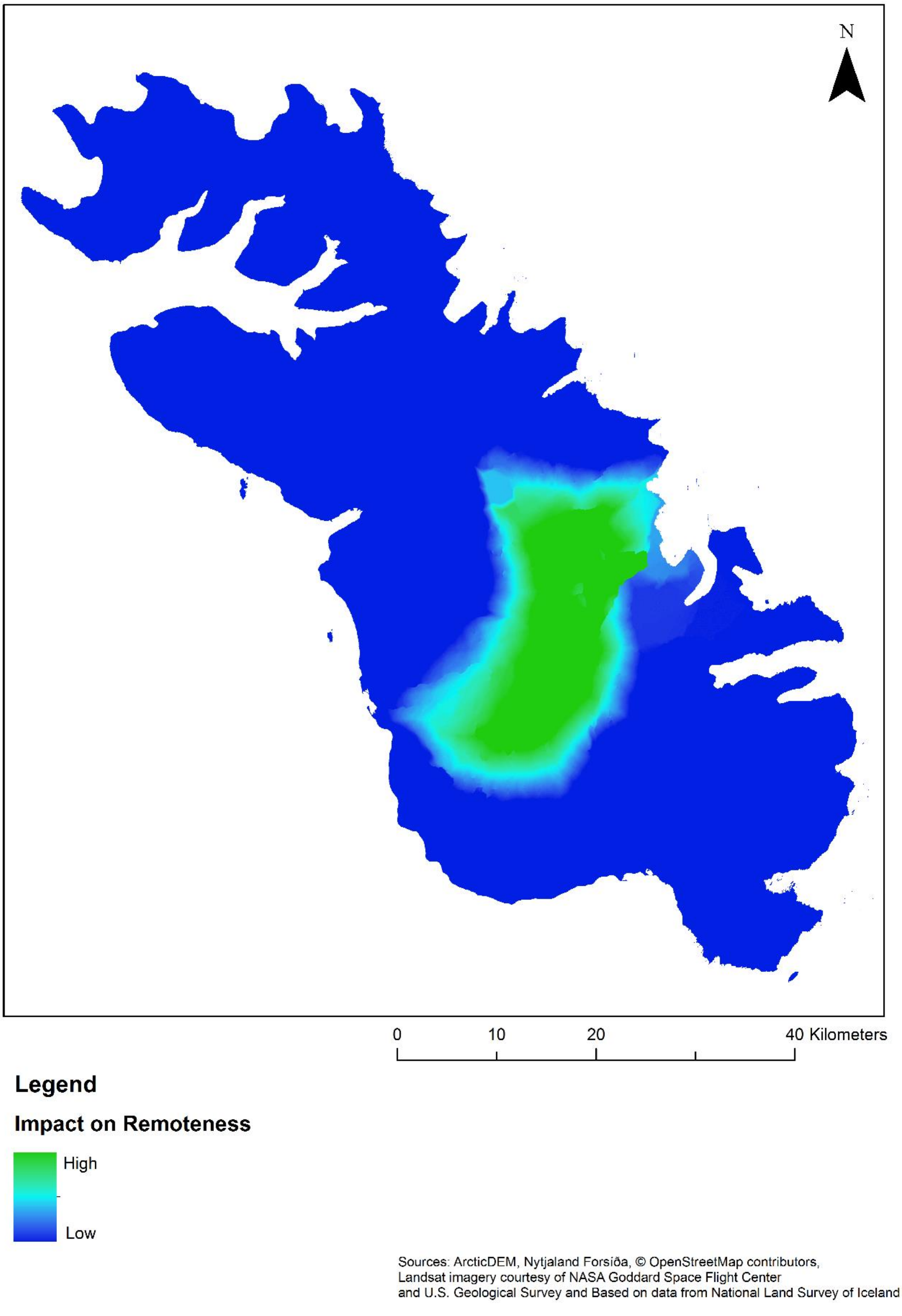

Figure 5.10 Remoteness post-construction: slow access times

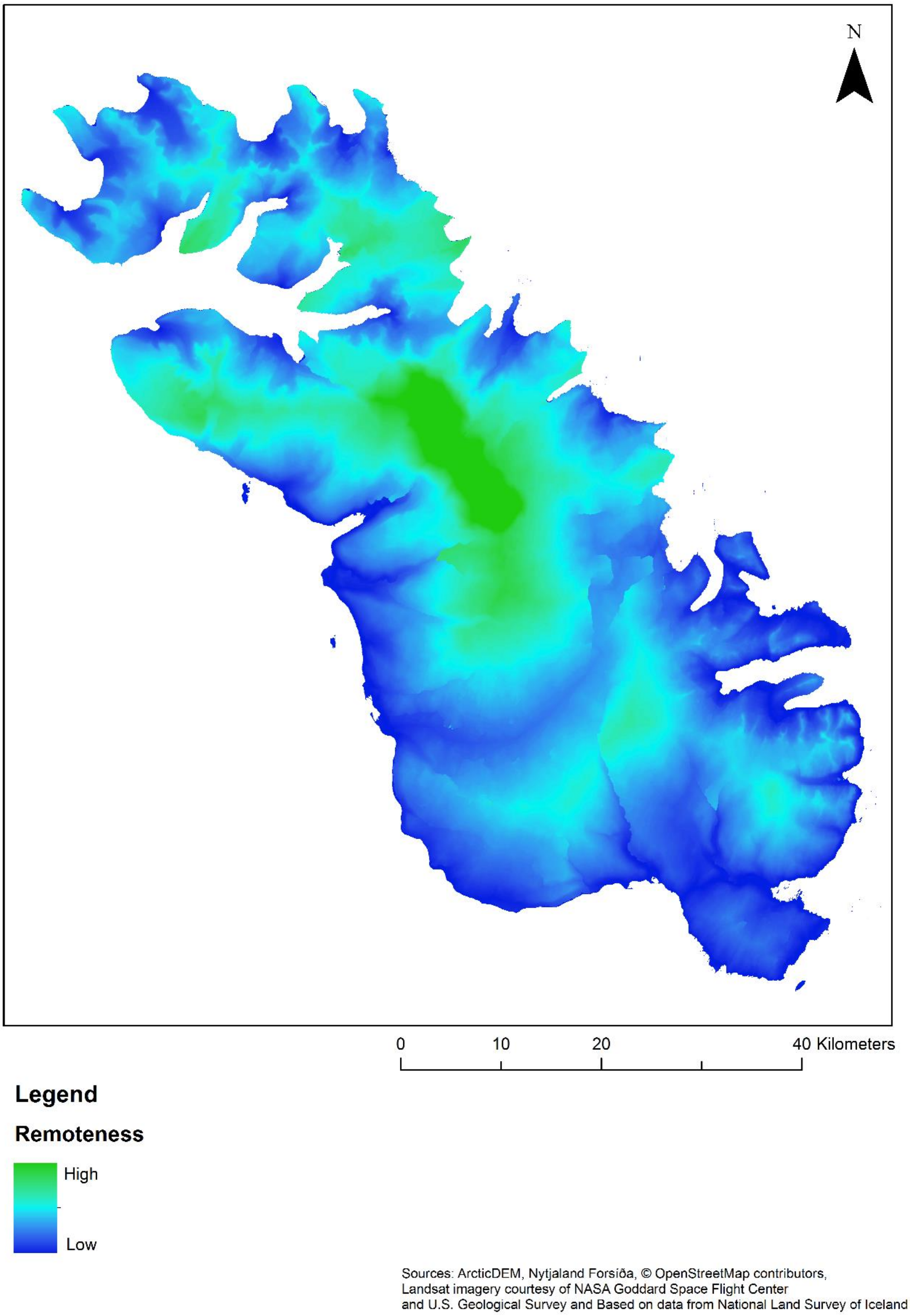

Figure 5.11 Impact of power plant construction on remoteness: fast access times

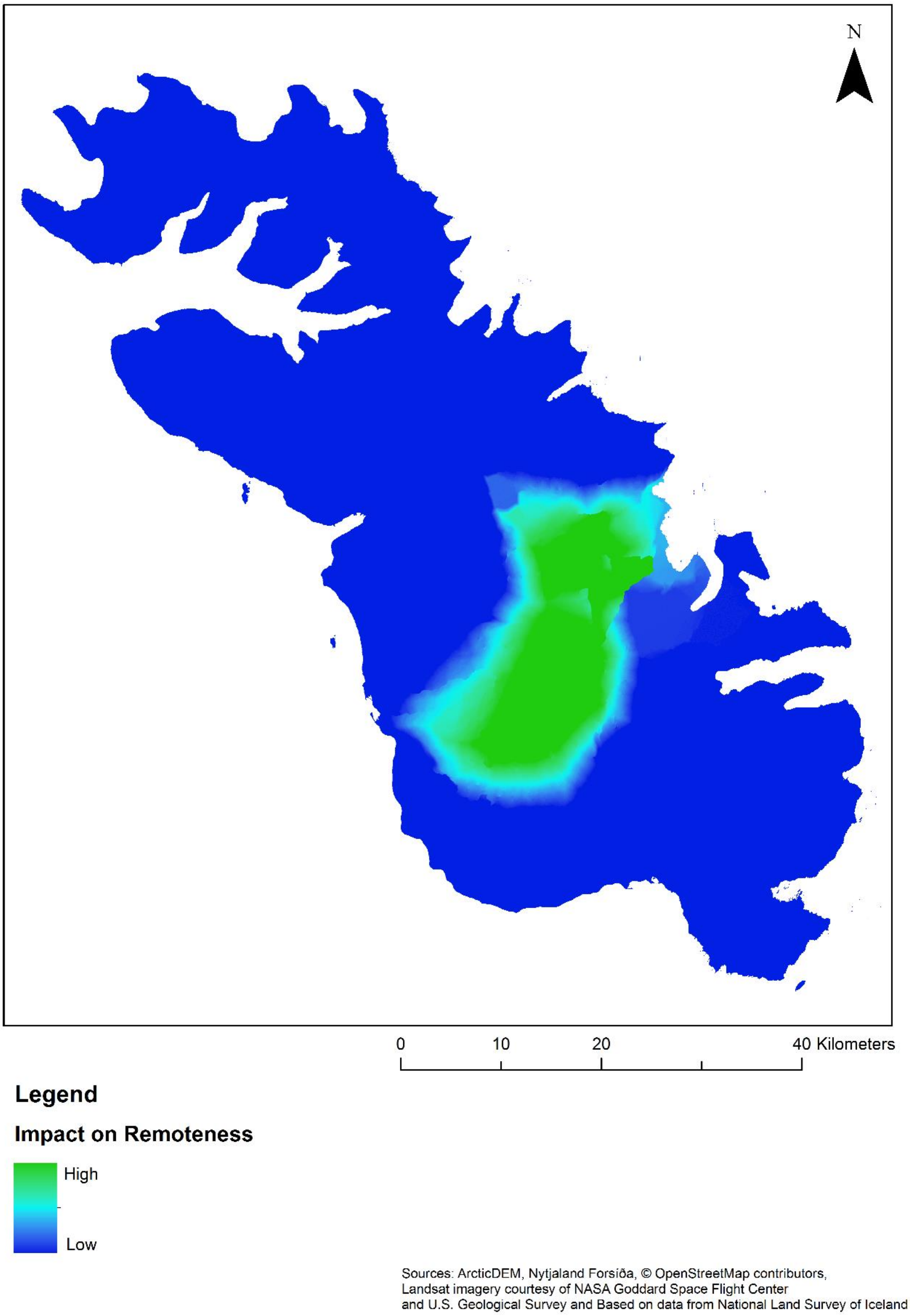

Figure 5.12 Impact of power plant construction on remoteness: slow access times

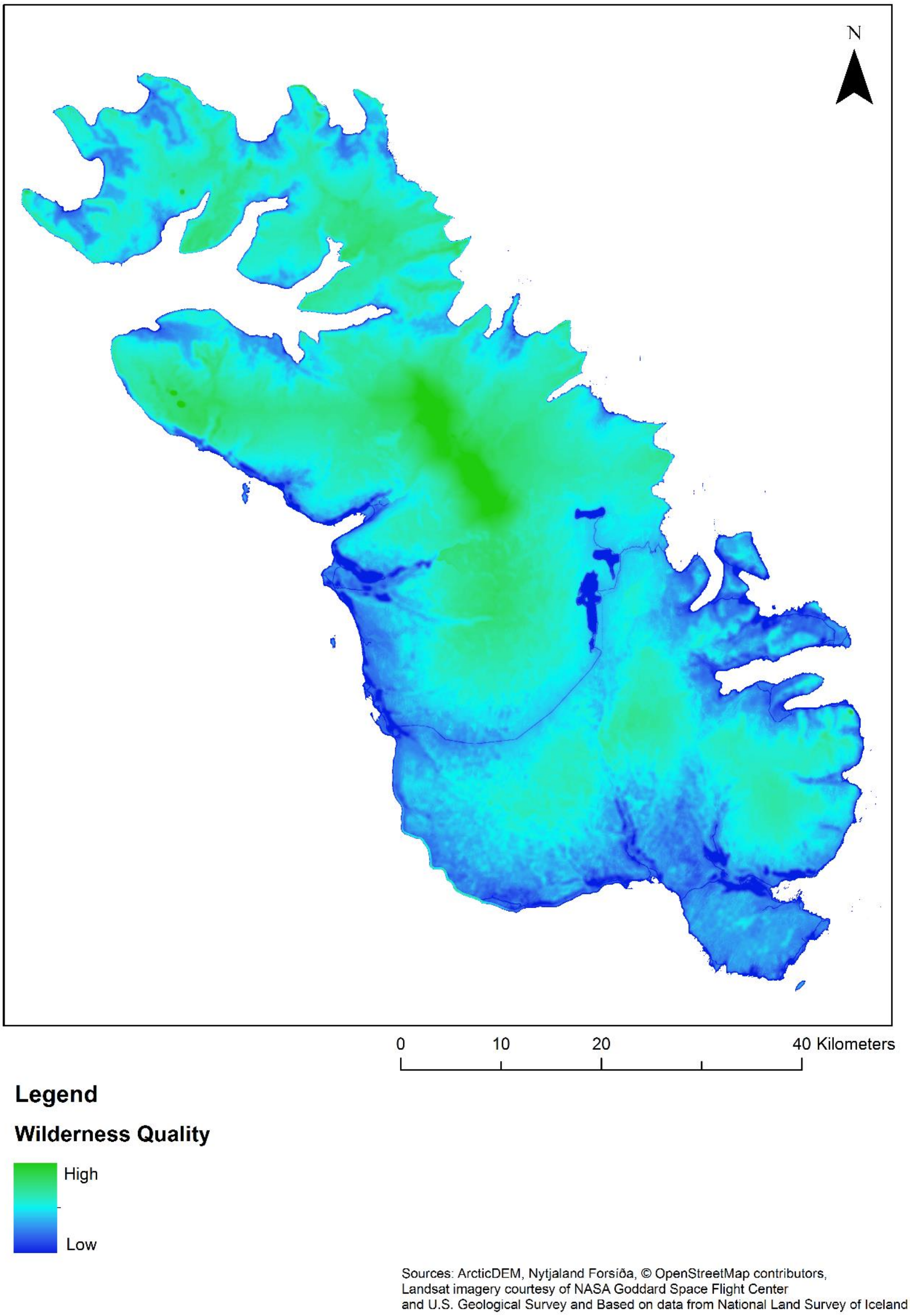

Figure 5.13 Wilderness quality post-construction: fast overhead power line option

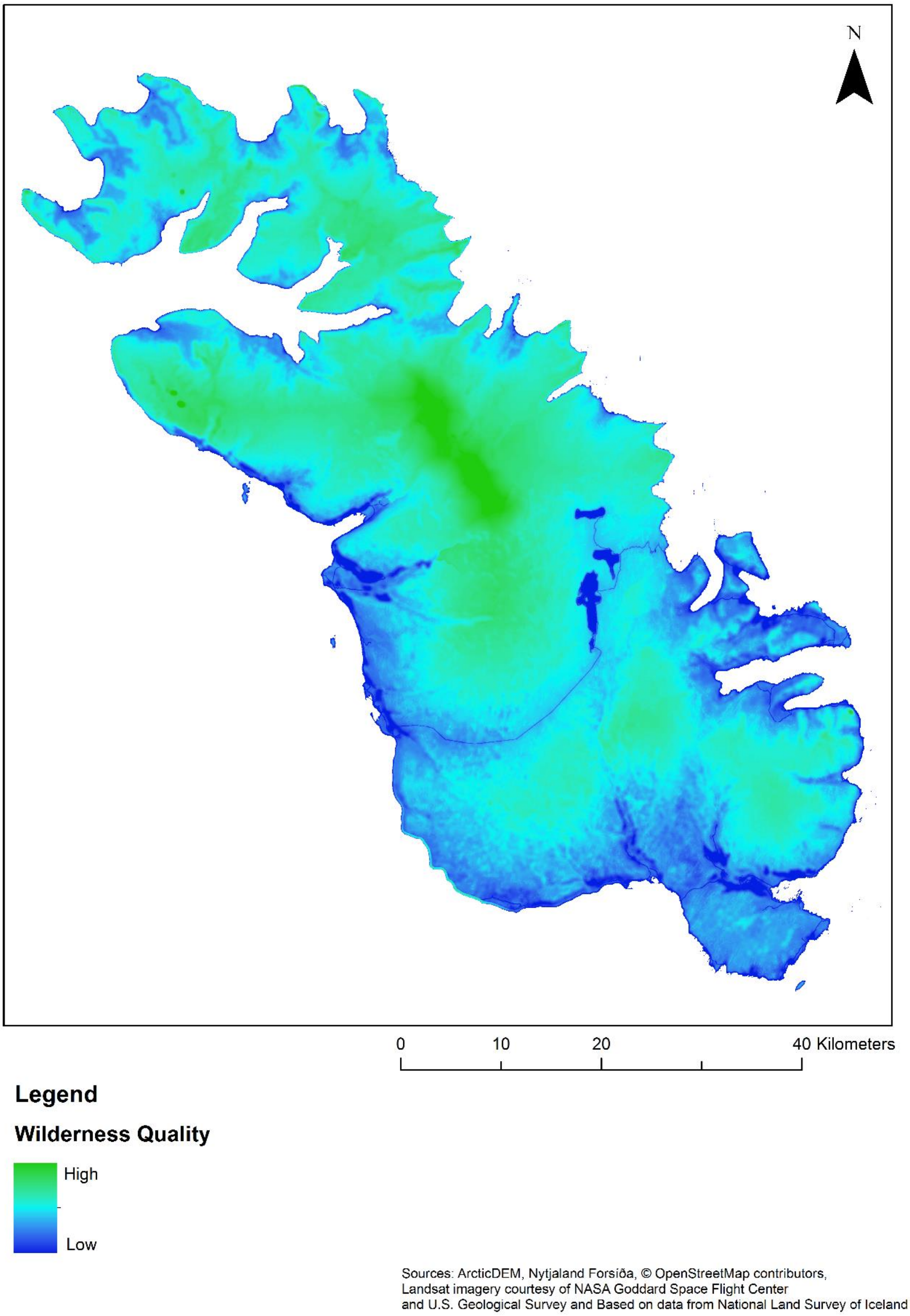

Figure 5.14 Wilderness quality post-construction: fast underground power line option

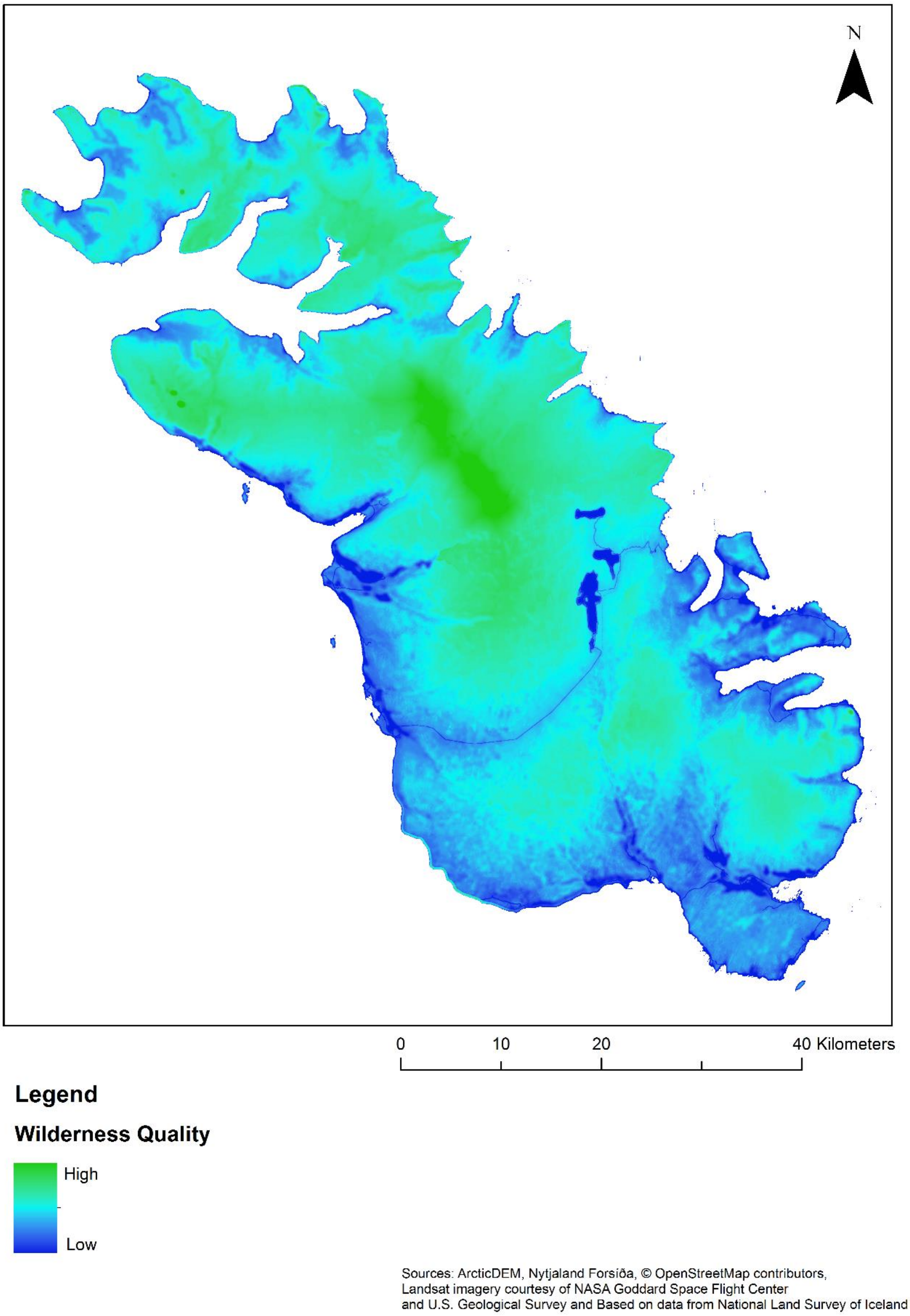

Figure 5.15 Wilderness quality post-construction: slow overhead power line option

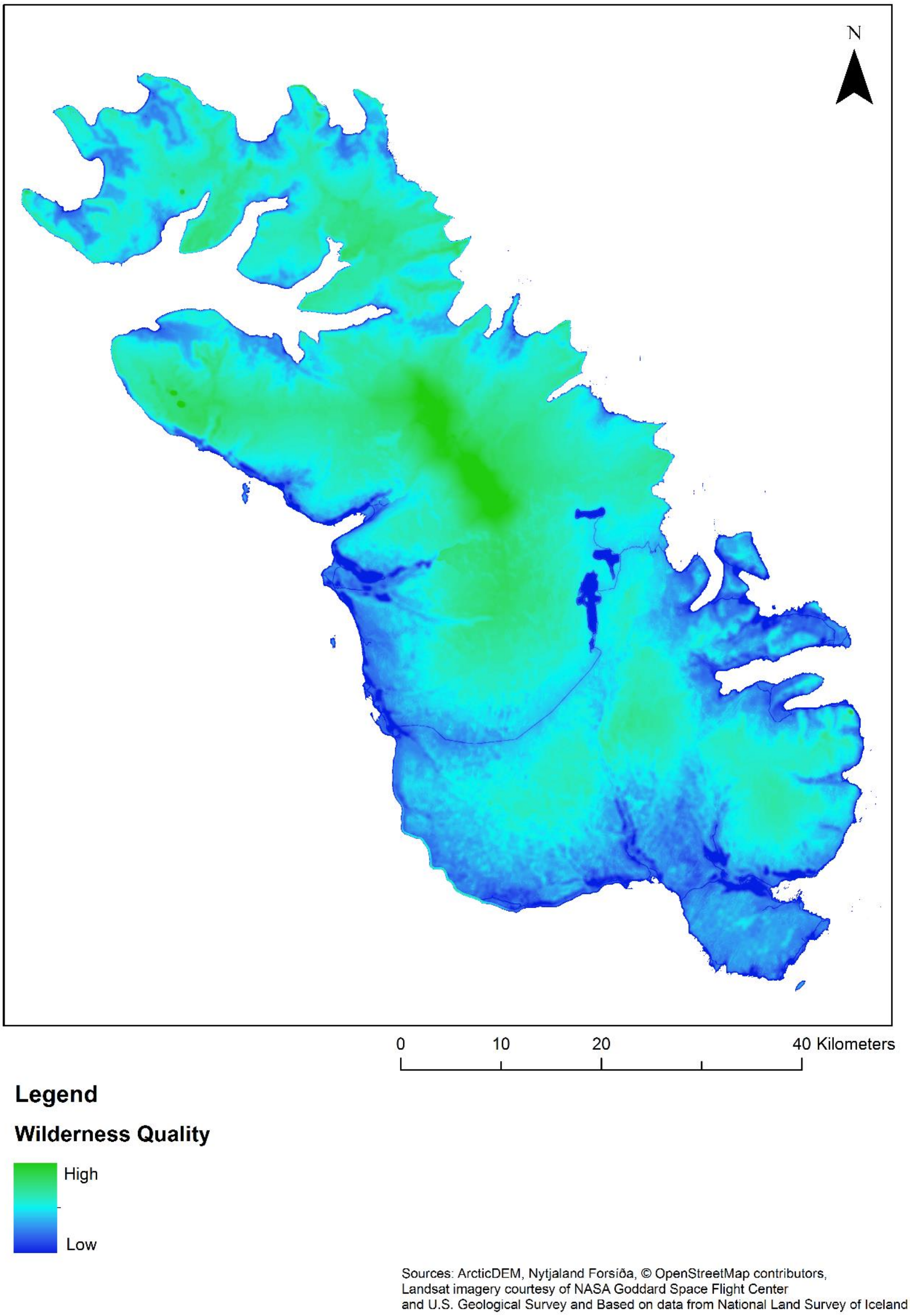

Figure 5.16 Wilderness quality post-construction: slow underground power line option

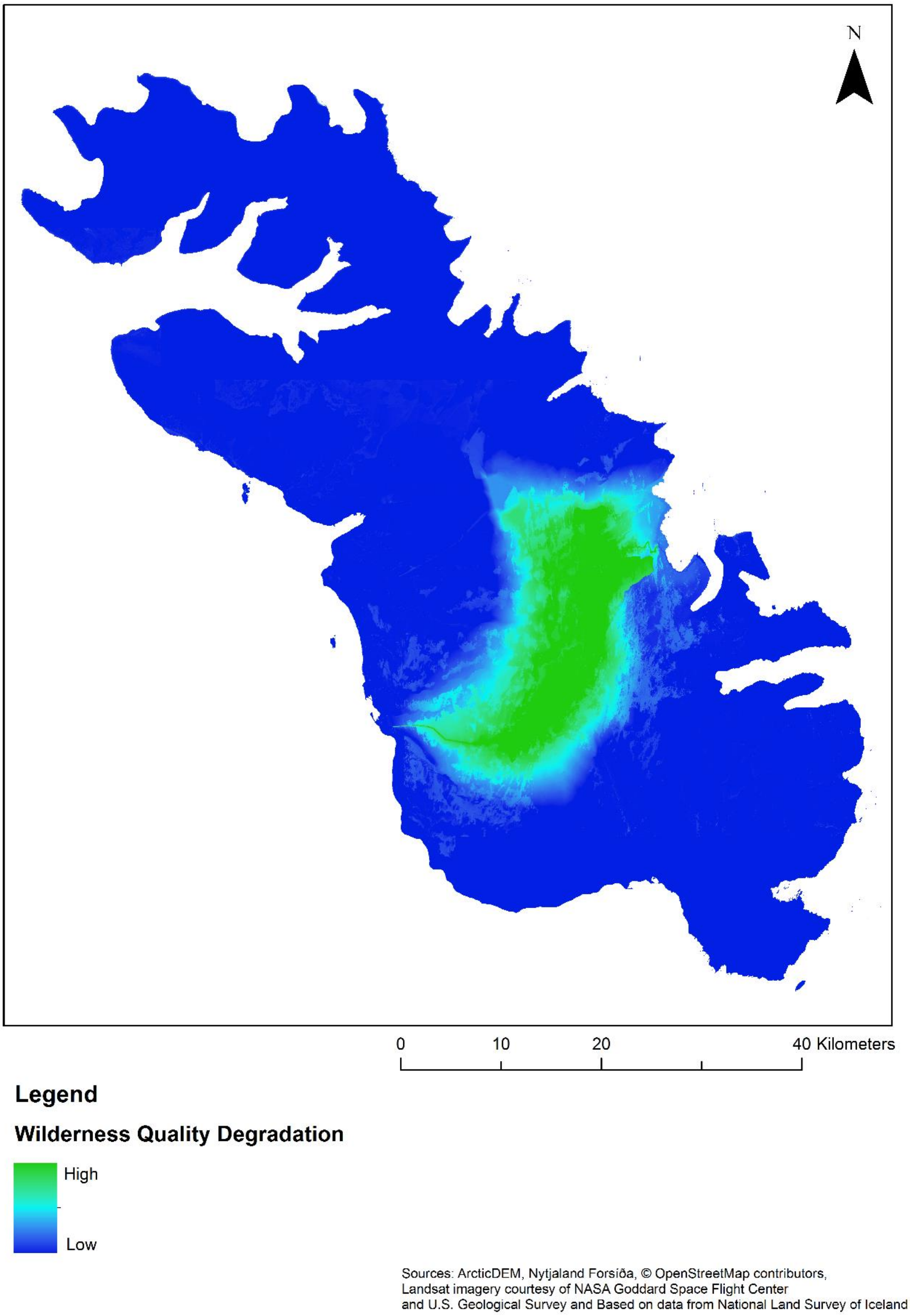

Figure 5.17 Impact of power plant construction on wilderness quality: fast overhead power line option

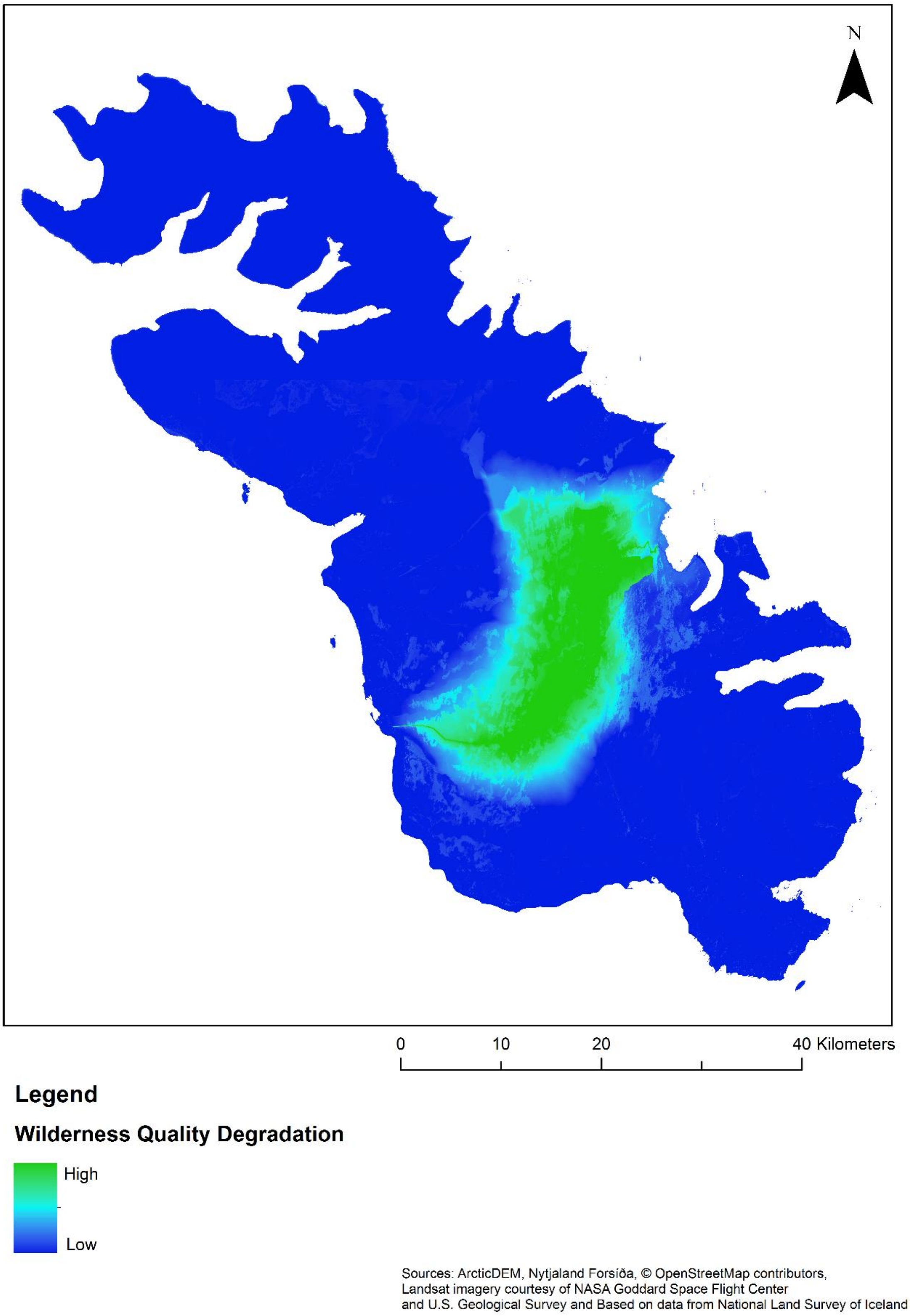

Figure 5.18 Impact of power plant construction on wilderness quality: fast underground power line option

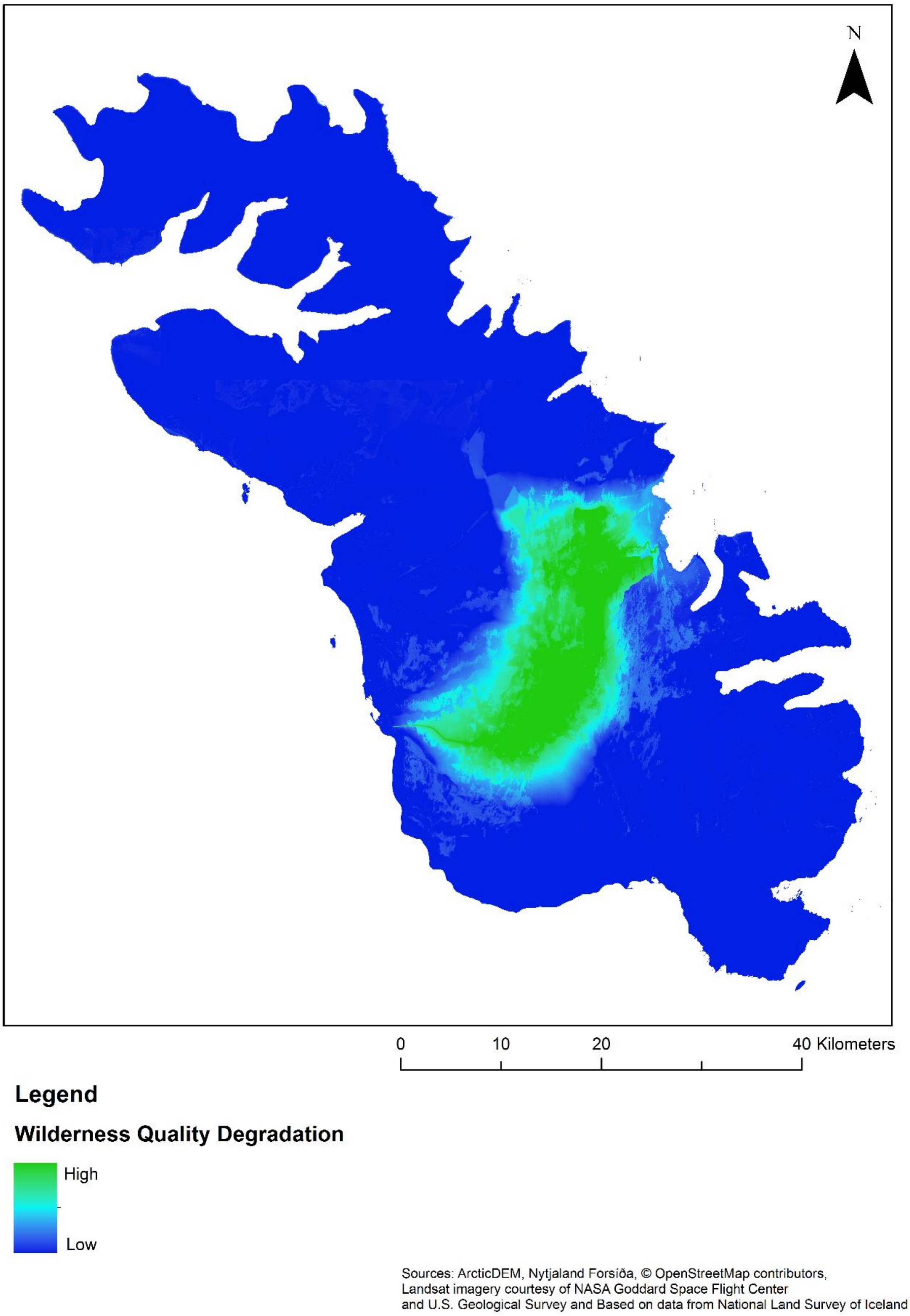

Figure 5.19 Impact of power plant construction on wilderness quality: slow overhead power line option

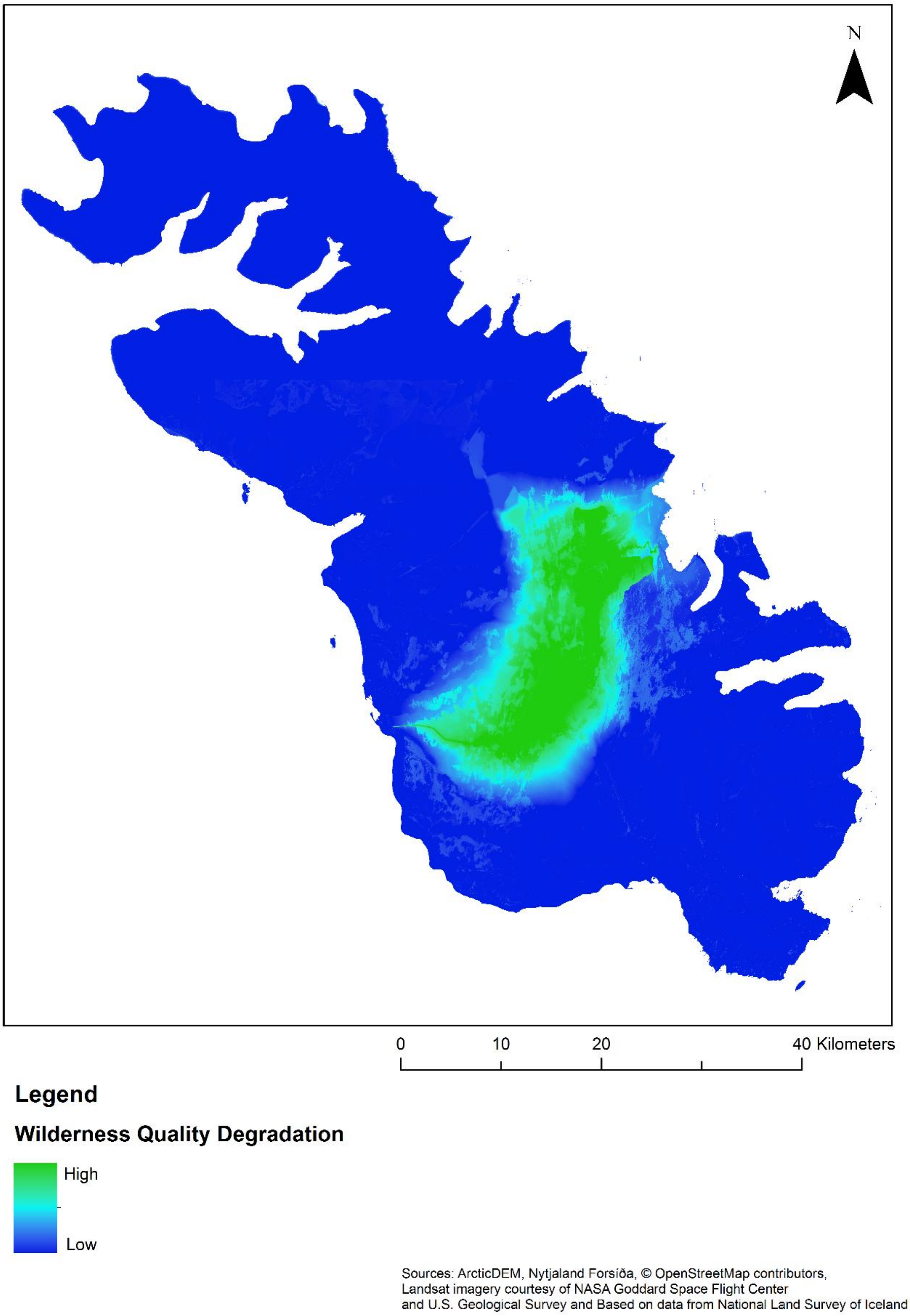

Figure 5.20 Impact of power plant construction on wilderness quality: slow underground power line option

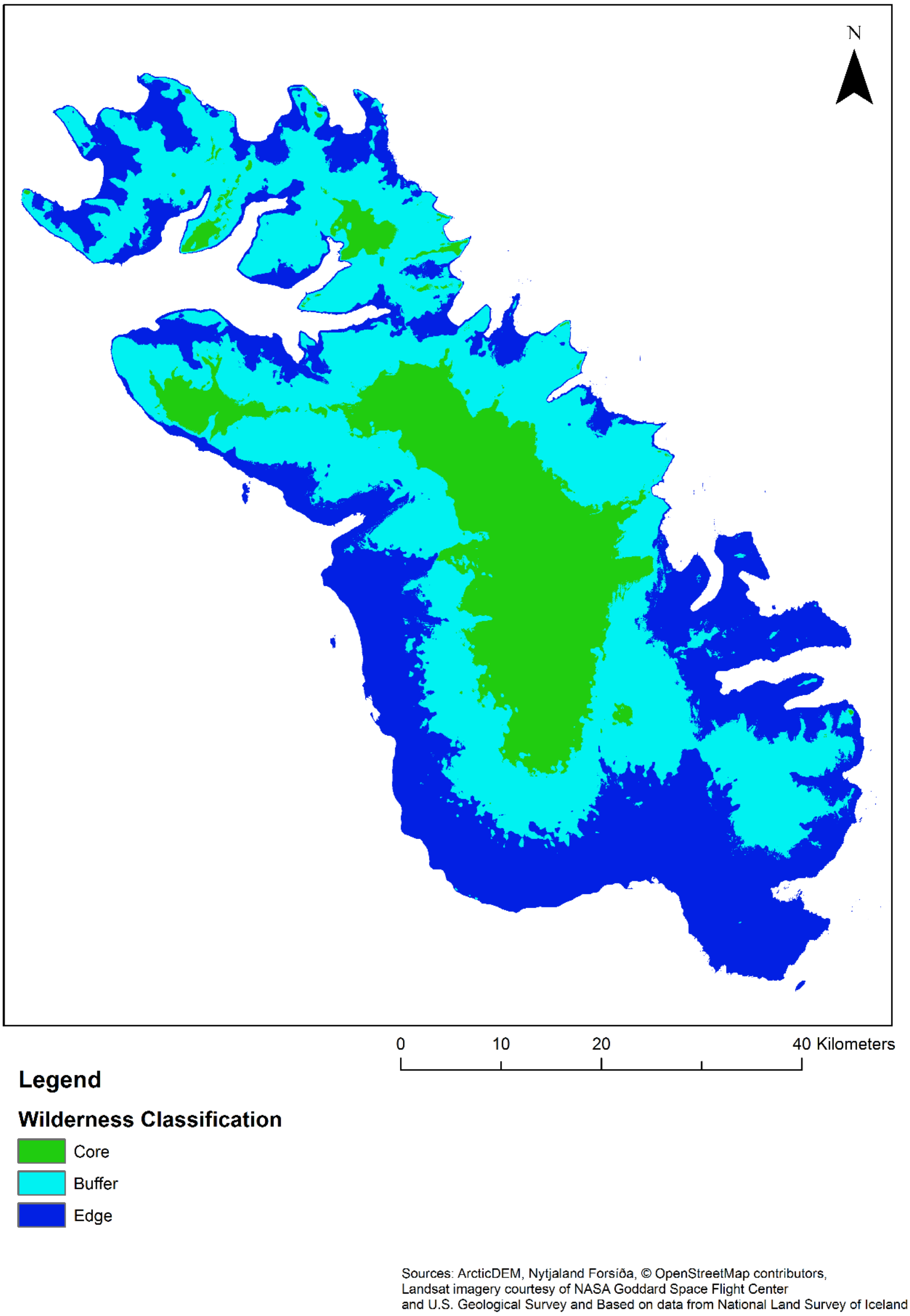

Figure 5.21 Current core wilderness areas

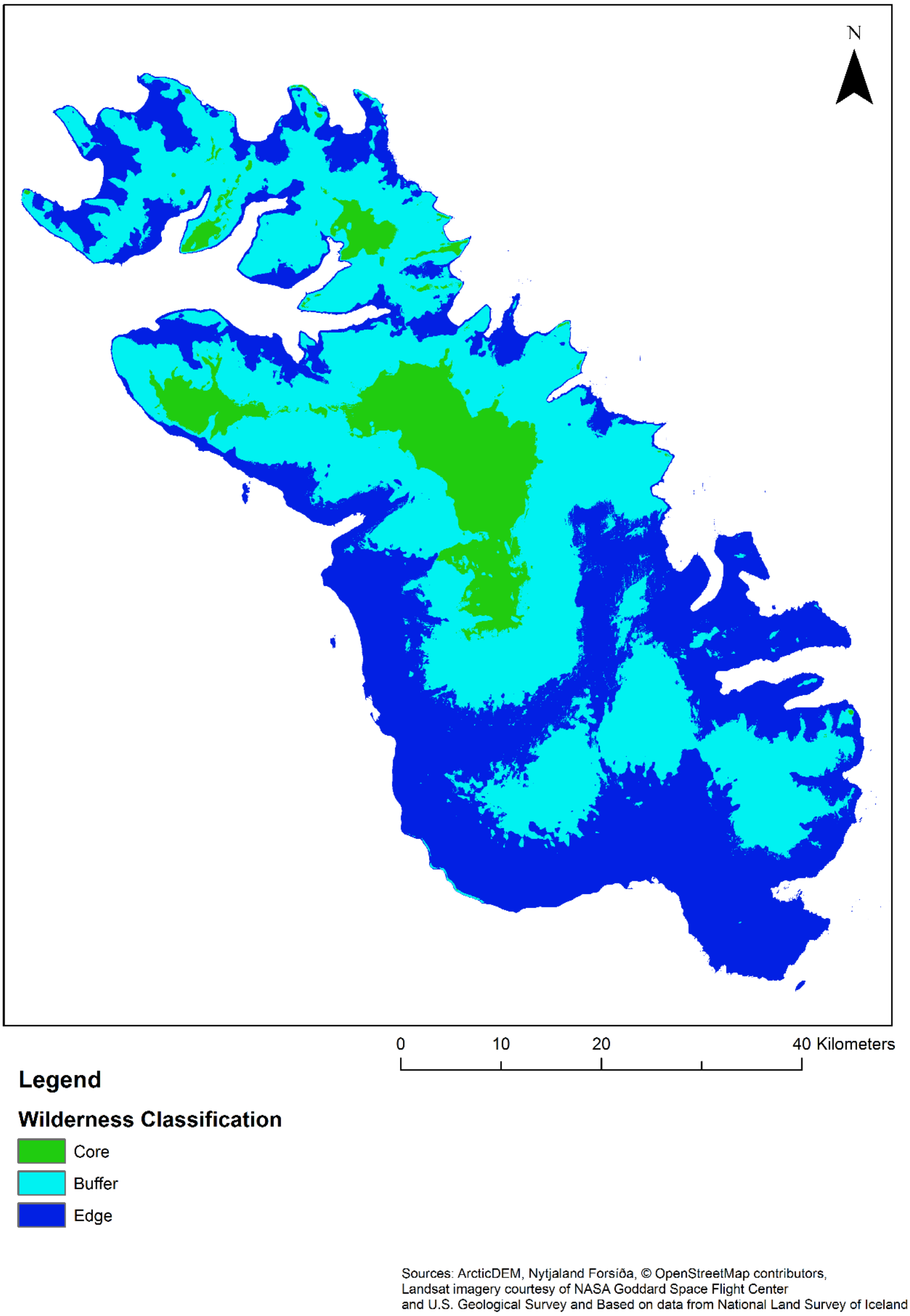

Figure 5.22 Core wilderness areas post-construction: fast overhead power line option

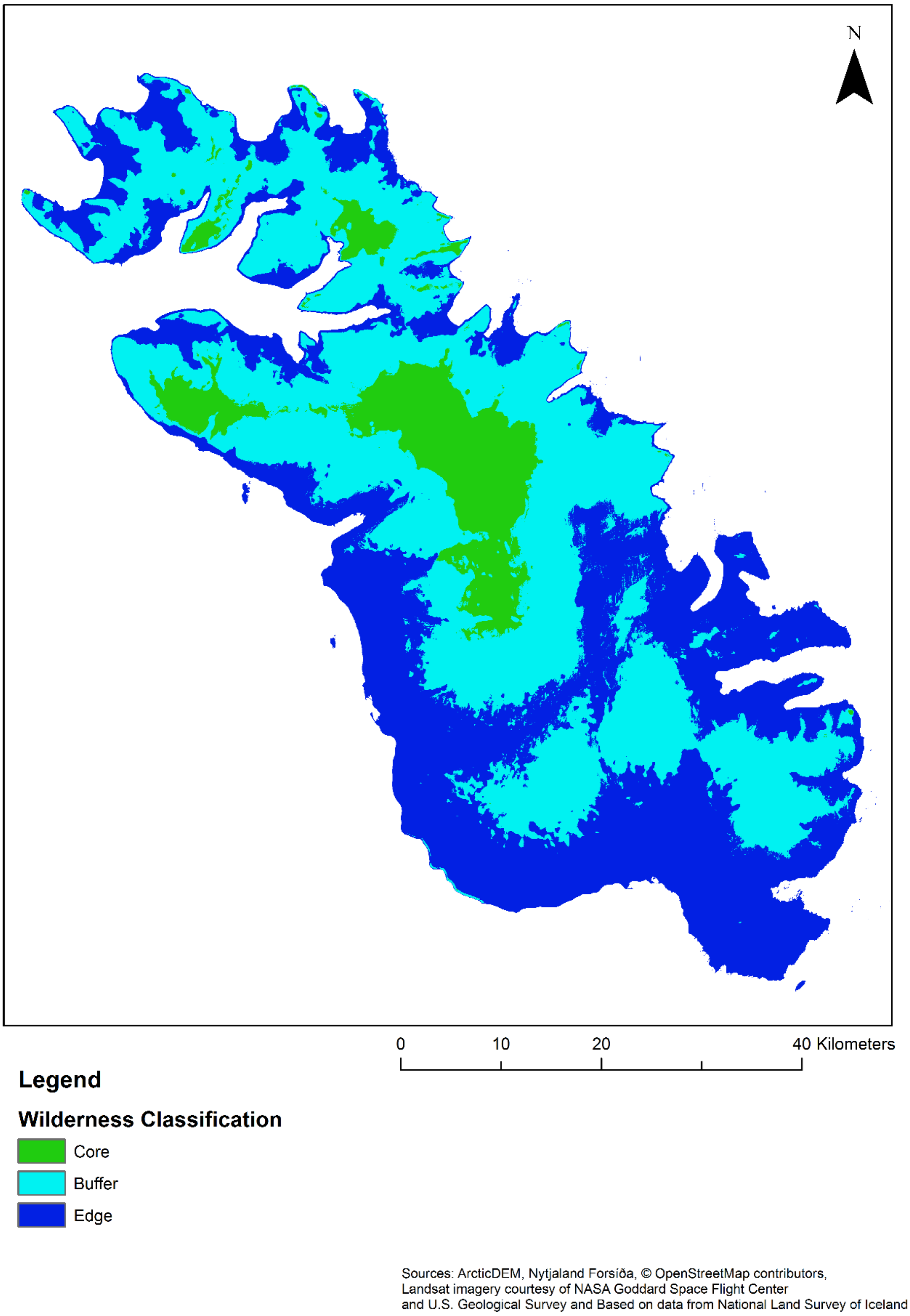

Figure 5.23 Core wilderness areas post-construction: fast underground power line option

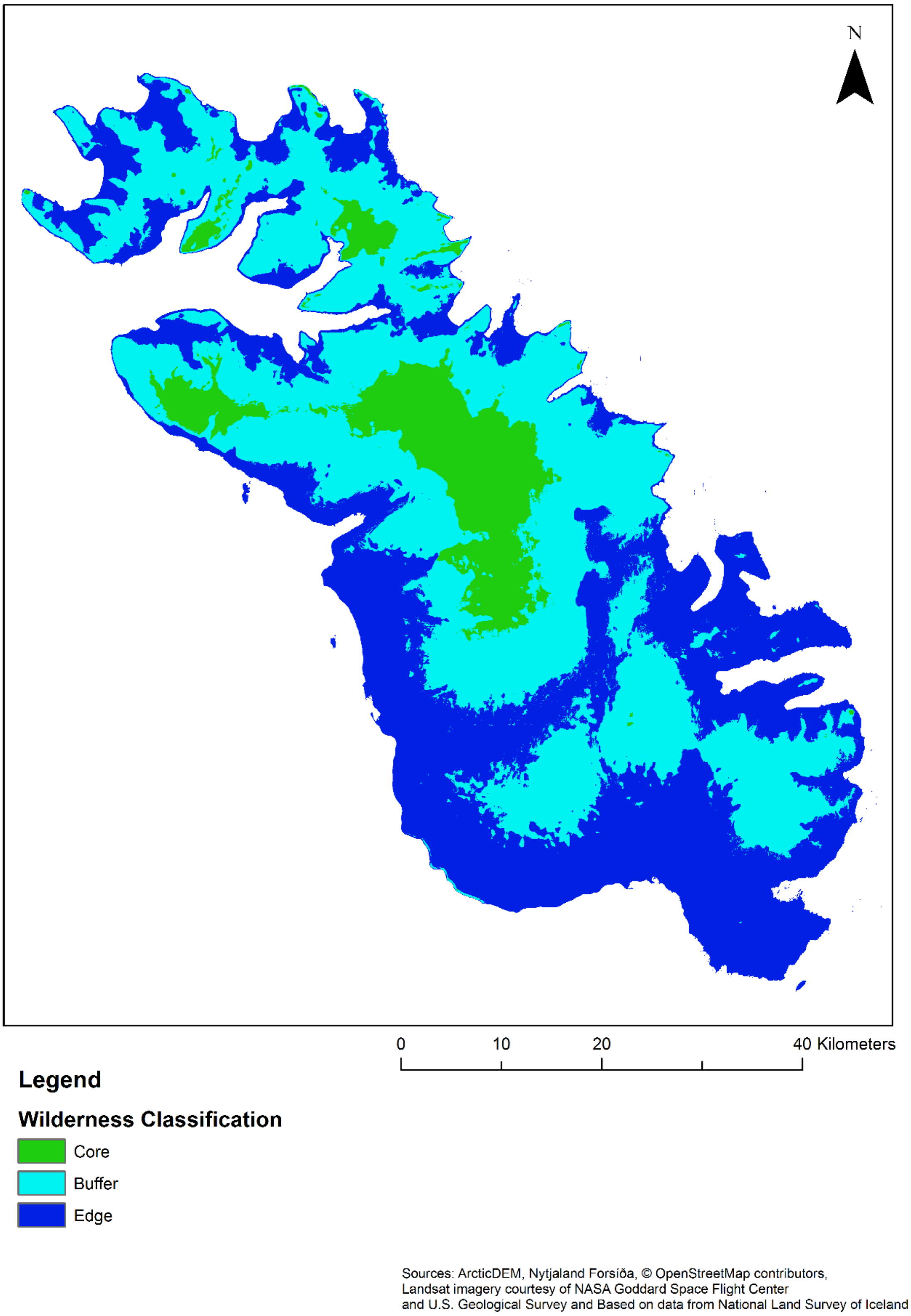

Figure 5.24 Core wilderness areas post-construction: slow overhead power line option

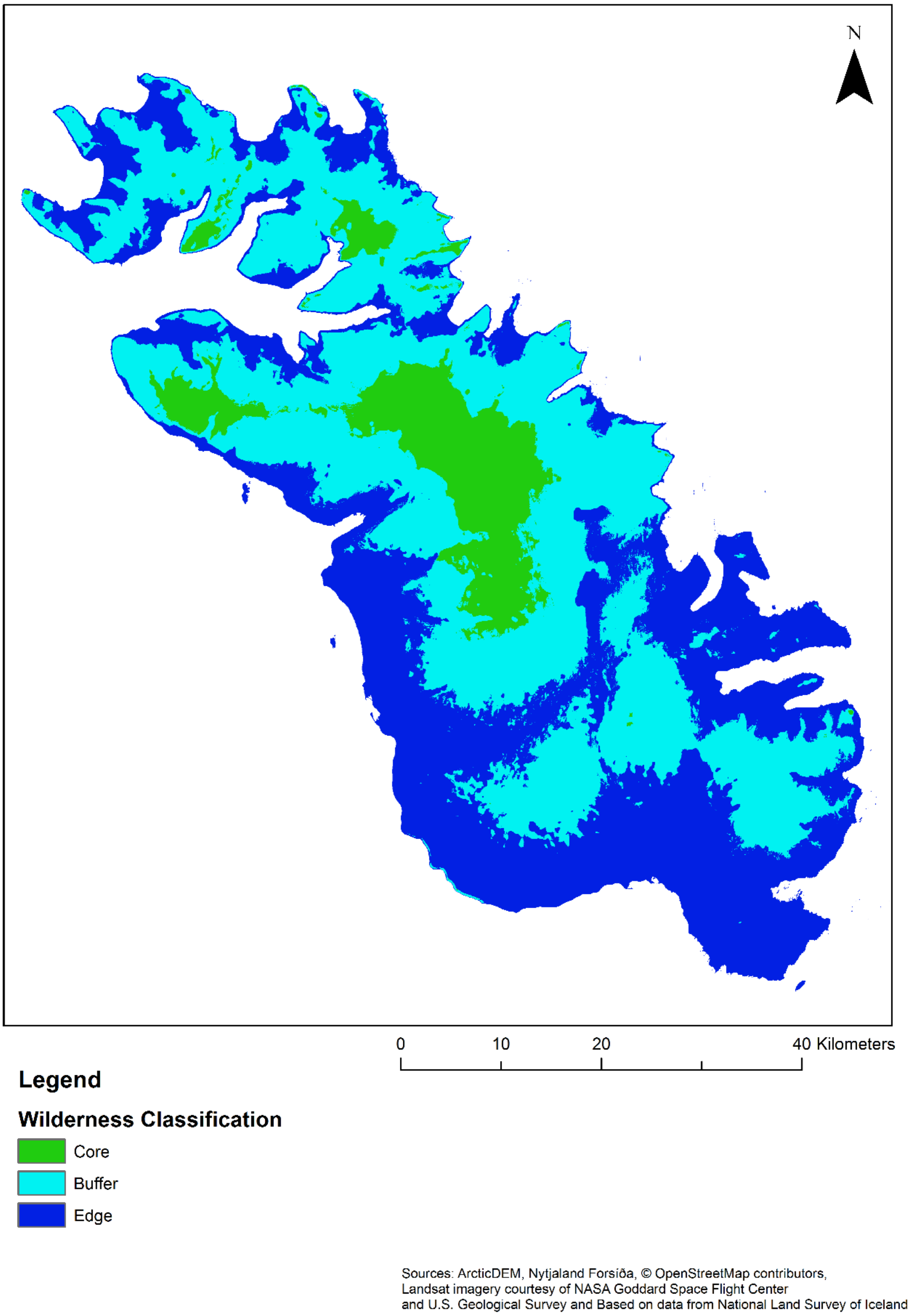

Figure 5.25 Core wilderness areas post-construction: slow underground power line option

6. Potential impact on wilderness from power plant construction

6.1 The proposed Hvalá power plant lies just to the south of the Drangajökull icecap in a remote and wild area of the Drangar Peninsula. It should be obvious - even without further analysis and consideration - that a development of the scale proposed would have a significant adverse impact on the qualities of this area of wilderness, with the likely outcome that if the development goes ahead the area of wilderness in the vicinity would be considerably reduced. In addition, the development would place a large hydro power plant into an area that is currently without this kind of development. The construction of the power plant would involve upgrades to existing access roads to allow for heavy construction vehicles and material transport, the construction of further access roads, building dams, overflows, tunnels and other infrastructure, the raising of lake levels on the Eyvindarfjarðarvatn, Hvalávatn and Nyrðra/Syðra Vatnalautavatn lakes and reduced flows in the Rjúkandi, Hvalá and Eyvindarfjarðará rivers, the construction of a work camp, and the construction of either an overhead or underground power line to connect to the existing grid network together with much disruption to delicate ecosystems, impacts on local waterfalls from reduced river flows and destruction of the unique geology including fossil remains. The purpose of this section of the report, having outlined the mapping process and the data used, is to demonstrate the level of impact of the proposed development on wilderness and the surrounding landscape.

6.2 The proposed development at Hvalá would impact significantly on at least three out of the four wilderness attributes used to map the spatial distribution and patterns of wilderness quality across the Drangar Peninsula. These are perceived naturalness of the land cover, absence of modern human artefacts, and remoteness from mechanised access. Rugged and challenging nature of the landscape would remain largely unaffected except in localised areas where existing lakes are expanded.

6.3 Perceived naturalness of the land cover would be impacted by the extent of the ground works and changes to lake extents required to develop a power plant of this scale. Upgrading of access roads, building new roads, digging of quarries/borrow pits, construction of dams and other engineering works, new power lines, compounds and associated buildings would all leading to large scale ground disturbance in the vicinity of the site and associated ecological/geological impacts. Naturalness values of affected cells would be reduced from high to low in all the areas thus affected. While the spatial pattern of disturbance will be limited to the site itself, the new artificial lakes/reservoirs created and the access roads, this level of disturbance would lead to significant localised reduction in the mapped perceived naturalness of land cover attribute. The maps in Figures 4.1 and 5.1 illustrate the perceived naturalness of the proposed development site before and after development, while Figure 5.2 highlights the degree of change in the perceived naturalness of land cover attribute should the development be consented. The main feature that stands out here are the newly created hydro reservoirs and while these may look natural in themselves, they are not natural and the draw-down line around the new shoreline will have a noticeable impact when these are not at full capacity.

6.4 Absence of modern human artefacts would be the most heavily impacted of the attribute layers. The presence of the power plant and associated access roads and infrastructure within the area would have a significant impact on the visual integrity of the landscape in terms of wilderness quality. The ZTV for the proposed development is extensive and the power plant and connecting power line and roads would be visible from inside much of the southern part of the Drangar Peninsula, most notably the southern portion of the Drangajökull and key mountain summits in the area including Urðartindur, Krossnesfjall, Seljanesfjall and Glissa. A full list of mountain summits potentially impacted is given in Table 6.1 and a map given in Figure 6.1. Figures 4.3-4.5 together with Figures 5.3-5.4 show the absence of modern human artefacts before and after development, respectively. Figures 5.5 and 5.6 highlights the degree of change in the absence of modern human artefacts layer should the proposed development be consented. The differences between these two maps arise from the options for either an overhead or underground power line. What is clear, however, is that regardless of which option is ultimately chosen, the visual impact from the proposed power plant is extensive and stretches across a wide swathe of the southern/central areas of the Drangar Peninsula.

6.5 The rugged and challenging nature of the terrain attribute would largely be unaffected by the development with the exception of changes around the expanded lakes of Eyvindarfjarðarvatn, Hvalávatn and

Nyrðra/Syðra Vatnalautavatn. Figures 4.7 and 5.7 show the ruggedness in the area around the proposed power plant before and after development, respectively. Figure 5.8 highlights the degree of change in the ruggedness layer should the proposed development be consented. The new reservoirs reduce ruggedness, while the dams have the localised effect of increasing apparent ruggedness through their steep downstream walls.

6.6 The remoteness from mechanised access attribute would be significantly affected by the changes to the access roads associated with the proposed development. Whilst access to the public for motorised use is at this point uncertain, the new roads will be accessible to the public on mountain bikes and so would still have a marked localised impact on reduced remoteness of the area in the immediate vicinity of the site. Two models for post-construction impacts on remoteness are therefore given; one assuming fast public access using motorised vehicles, and one assuming slower public access on mountain bike. This is shown in Figures 4.8 and 5.9-5.10 which illustrate the remoteness from mechanised access around the proposed development both before and after access roads are built. Figures 5.11 and 5.12 highlights the degree of change in the remoteness from mechanised access layer should the proposed development be consented. The effect of the new access roads and the power line road would be to greatly reduce the overall remoteness in the region by reducing off-road access times to much of the southern half of the Drangar Peninsula south of the Drangajökull itself. Access times in this part of the peninsula would be reduced by as much as 7 hours 50 minutes.

6.7 The current wilderness map for the landscape around the Hvalá power plant proposal is shown in Figure 3.2. The four modified attribute layers and their variants are combined to give a new wilderness map for the Drangar Peninsula that includes the modelled impacts from the Hvalá development. This is shown in Figures 5.13-5.16. The four attribute maps are combined by a simple un-weighted multi-criterion overlay as described in section 3. This can then be compared to the current wilderness map shown in Figure 3.2. Figures 5.17-5.20 highlight the degree of change in the spatial distribution and patterns of wilderness should the proposed development by consented. Again, it is apparent looking at these figures that the wilderness quality values in southern portion of the Drangar Peninsula would be significantly and adversely affected by the construction of the Hvalá power plant.

6.8 Relative reductions in the wilderness area are predicted and shown in Figures 5.21-5.25 above by following and repeating the same mapping methodology for before and after the proposed development. This enables direct comparison and highlighting of the area that will be impacted. It can be seen from these maps that the greatest impact is, as expected, in the immediate vicinity of the proposed site but extends across the southern/central portion of the Drangar Peninsula and particularly around the new reservoirs, access road and power line corridor. This is perhaps the area of greatest significance in terms of impact on core areas wilderness located within this area, with the proposed development being visible from a wide area due to the nature of the local terrain. There are smaller patches of significant impact at greater distance, depending on the various access (fast/slow) and power line (overhead/underground) options, but particularly on the south eastern slopes of the Drangajökull where this faces onto the proposed development site wherein most of the site will be in full view.

6.9 The reduction in total wilderness in the areas impacted by the proposed development can be estimated using these wilderness maps as a basis for classifying the core wilderness areas. The current wilderness quality classes are shown in Figures 5.21, while the new and reduced wilderness classes drawn using the new wilderness map are shown in Figures 5.22-5.25. These maps are drawn using the same data and methods used by SNH in the original Phase 2 mapping. These maps highlight the degree of change in the spatial distribution and patterns of wilderness quality classes should the development be consented. This can be seen to be very significant in the southern part of the Drangar Peninsula especially in the area immediately to the south eastern slopes of the Drangajökull itself.

6.10 Using the core wilderness areas from Figures 5.21-5.25, it is estimated that should the proposed development go ahead, the total area of core wilderness in the Drangar Peninsula could be reduced by approximately **26,300ha** or **45%** (minimum) to **28,400ha** or **48.5%** (maximum). These figures are calculated by subtracting the post-construction core, buffer and edge areas from the existing core and buffer areas to identify the predicted areas of change. Examples are shown in Figures 6.2 and 6.3. An important aspect of the Hvalá power plant proposal is that, if consented, this would be the first large scale development in the area and as such represents an even more significant visual impact since the current landscape is free from visual impact of this nature.

Table 6.1 Mountain summits from which the proposed power plant would be visible

Number	Name	Height (m)
1	Krossnesfjall	655
2	Urðartindur	466
3	Þverárdalsfjall	649
4	Glissa	718
5	Búrfell	716
6	Seljanesfjall	364
7	Hádegisfjall	358
8	Ófeigsfjarðarheiði	443
9	Hrolleifsborg	851
10	Skarðsfjall (Drangaskörð)	373
11	Drangavíkufjall	397
12	Southern Drangajökull	
13	Einangursfjall	598

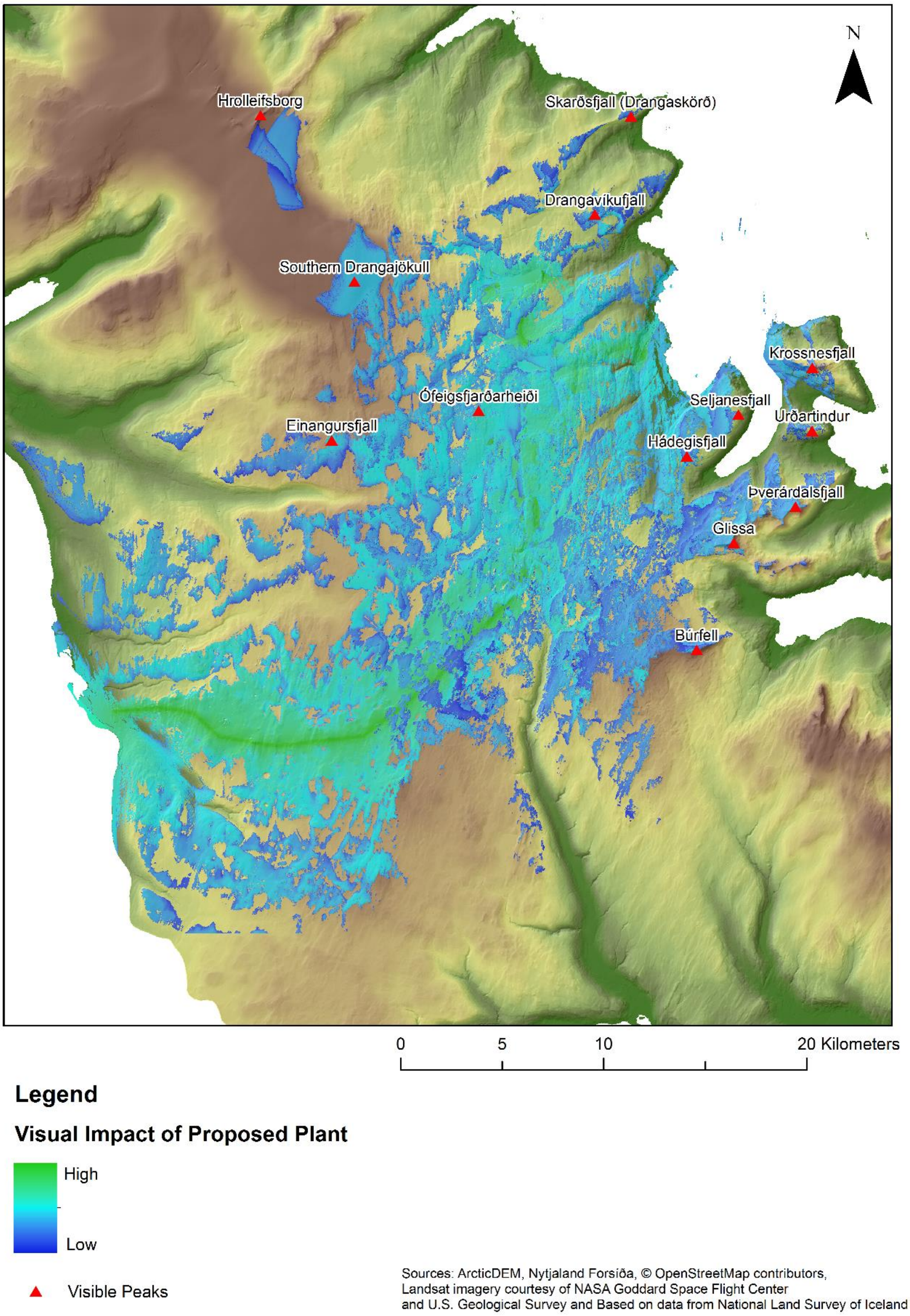

Figure 6.1 Summits with a view of the proposed power plant

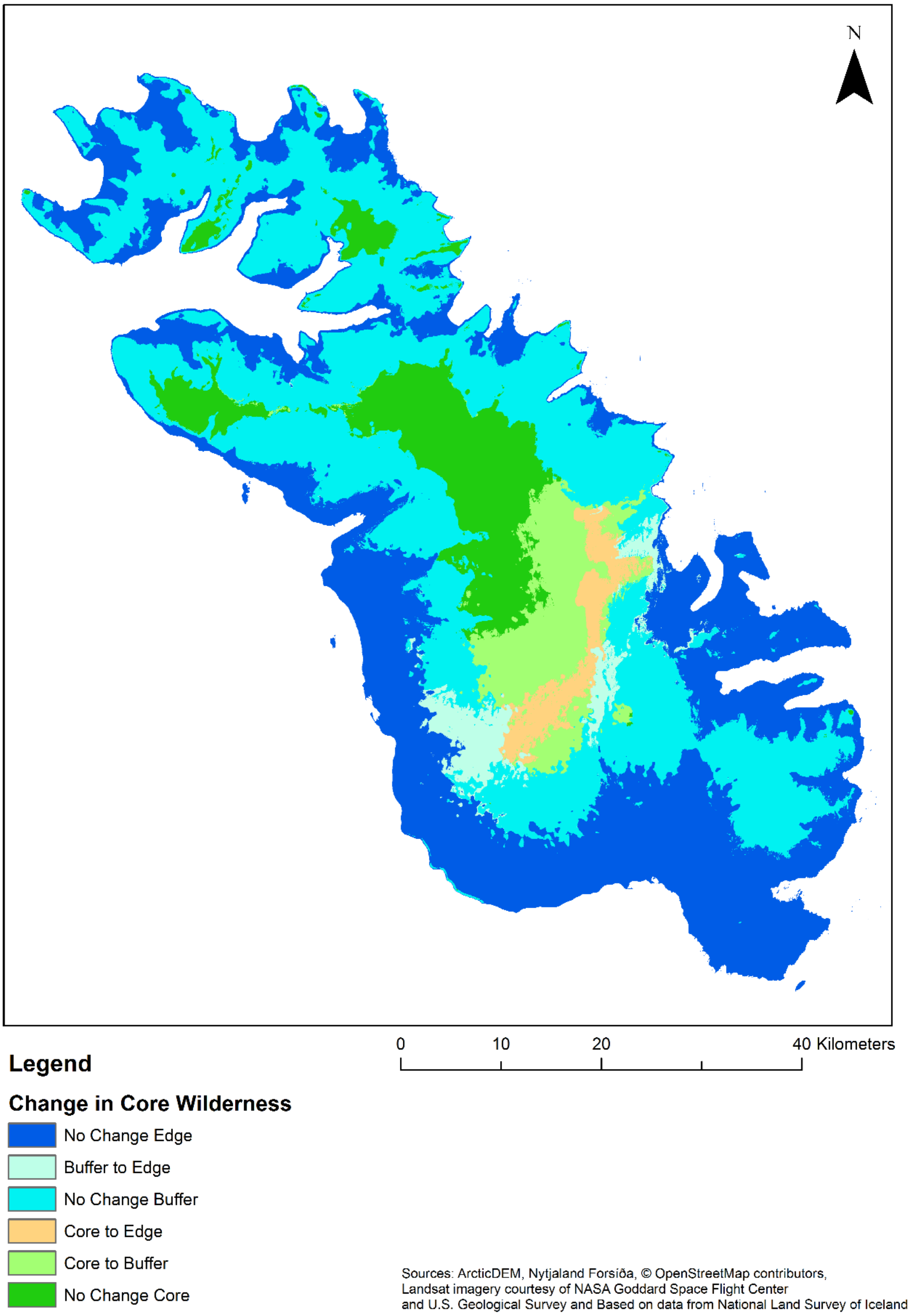

Figure 6.2 Change in core wilderness for slow access and underground power line variants

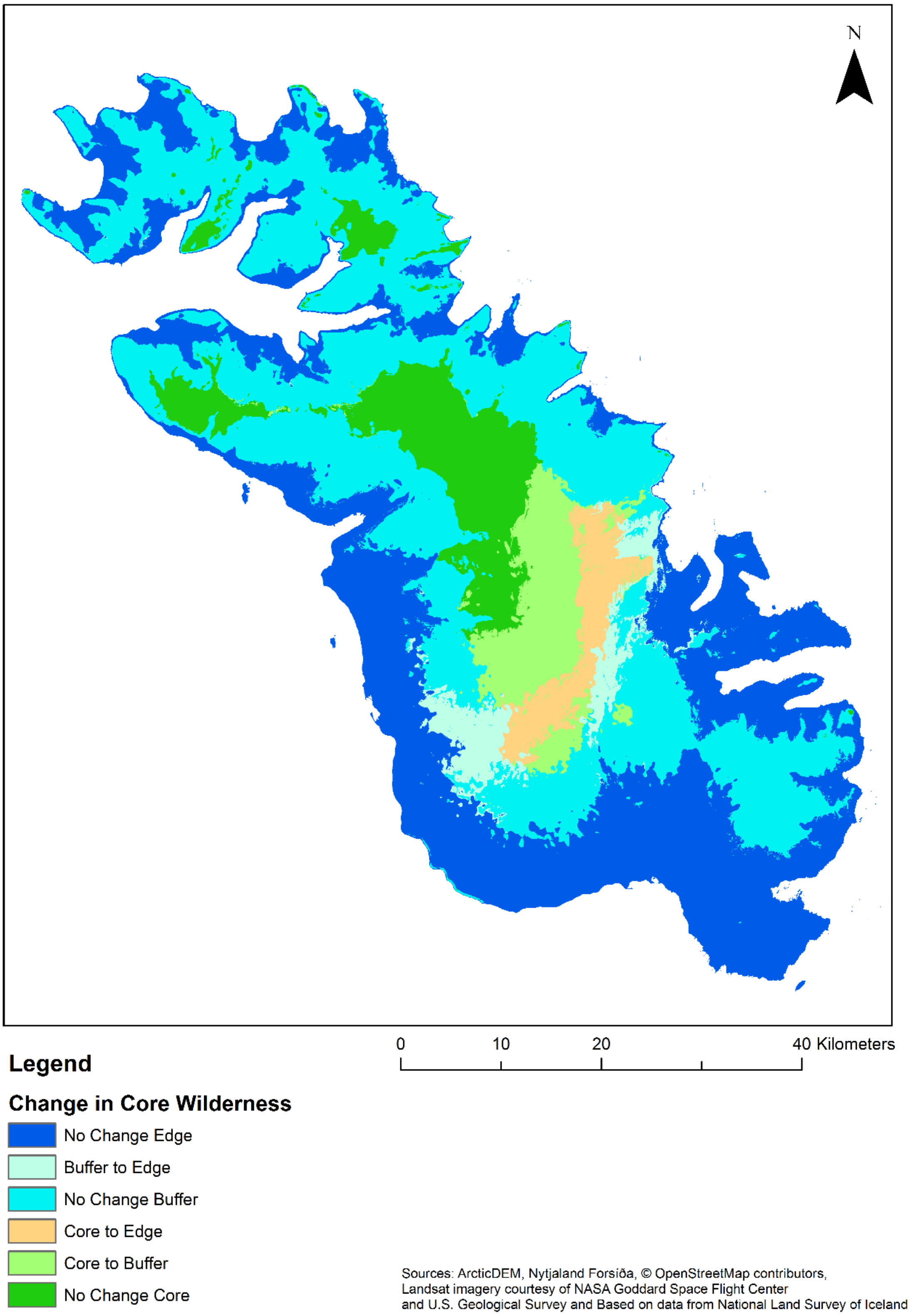

Figure 6.3 Change in core wilderness for fast access and overhead power line variants

7. Conclusions

7.1 Mountains, volcanoes, highlands, lakes, icecaps, free-flowing rivers, waterfalls and rugged coastlines are valued hallmarks of Iceland's landscape, providing a major focus for history, culture, tourism, recreation and conservation. These qualities of the Icelandic landscape are strongly expressed in areas dominated by bare ground, natural vegetation, lack of human intrusion from built structures and the rugged and remote nature of the terrain[70]. They are wildernesses in the truest sense and the Drangar Peninsula possess all the requisite attributes of wildness despite not being currently protected as such[71]. These iconic landscapes are closely linked to Iceland's national identity and represent a key draw for visitors[72 73].

7.2 However, despite recognition of their value, Iceland's wilderness areas face a growing threat from energy developments and improvements to access from road building and upgrades. Previous studies have shown these factors can impact significantly on an area's wildness and result in a gradual attrition of the wild land resource[74].

7.3 WRi are world leaders in the development of mapping methodologies applied to identifying wild land areas. This is underpinned by use of the best available data and techniques, supported by expert advice and information from leading academics and practitioners, and developed over more than twelve years of careful research and development.

7.4 The proposed Hvalá power plant is located inside one of the wildest areas in Europe and Iceland and therefore cannot fail to impact heavily on this wilderness area. The proposed development would also have a significant visual impact on adjacent wilderness areas and be visible from the summits of several local mountains.

7.5 The proposed development would significantly impact on at least three out of the four wilderness attributes. Only the Rugged and challenging nature of the terrain attribute would remain relatively unaffected, but even this would have localised impacts from the flooding and expansion of existing lakes. This inevitably means that the development would have a significant impact on the relative wilderness values in both the immediate vicinity of the site boundary in terms of naturalness, and much further afield in terms of its visual impact and remoteness.

7.6 Should the proposed development be consented then it is expected that the total area of core wilderness in the area would be reduced by between **26,300-28,400ha**, representing an overall reduction amounting to between **45-48.5%**, respectively**.**

7.7 The Hvalá power plant proposal is located in an area that is currently free from any physical or visual impact from existing large infrastructure development. The development of hydro and geothermal energy plants over the past few decades has placed a consistent pressure on Iceland's landscape and wilderness resource and significantly reduced the area of wilderness. Should the Hvalá development be consented and built this would represent a significant impact in the middle of one of these last remaining areas of un-impacted land, considerably reducing the "development free" landscape in the Drangar Peninsula.

7.8 The 2013 Nature Conservation Act states that areas of wilderness should receive adequate legal protection and that this *"protection should aim to safeguard the characteristics of the areas e.g. to maintain diverse and unusual landscapes, panoramas and/or conserve complete large ecosystems, and ensure that present and future generations can enjoy therein solitude and nature without disturbance from man-made*

[70] Olafsdottir, Rannveig, and Micael C. Runnström. "How wild is Iceland? Wilderness quality with respect to nature-based tourism." Tourism Geographies 13, no. 2 (2011): 280-298.
[71] Wilderness register and indicator for Europe Final report 2013 (draft) Contract N°: 07.0307/2011/610387/SER/B.3. See page 65-67. https://ec.europa.eu/environment/nature/natura2000/wilderness/pdf/Wilderness_register_indicator.pdf
[72] Sæþórsdóttir, Anna Dóra, C. Michael Hall, and Jarkko Saarinen. "Making wilderness: Tourism and the history of the wilderness idea in Iceland." Polar Geography 34, no. 4 (2011): 249-273.
[73] https://www.westfjords.is/en/town/index/recreation
[74] Carver, S., & Wrightham, M. (2003). Assessment of historic trends in the extent of wild land in Scotland: A pilot study. Scottish natural heritage commissioned report No. 012 (ROAME No. FO2NC11A).

infrastructures or traffic from motor vehicles". Given the results of the wilderness mapping presented here, the location of the Hvalá power plant proposal within such a wilderness area and the undeniably significant impacts that would result, this makes this proposal untenable.