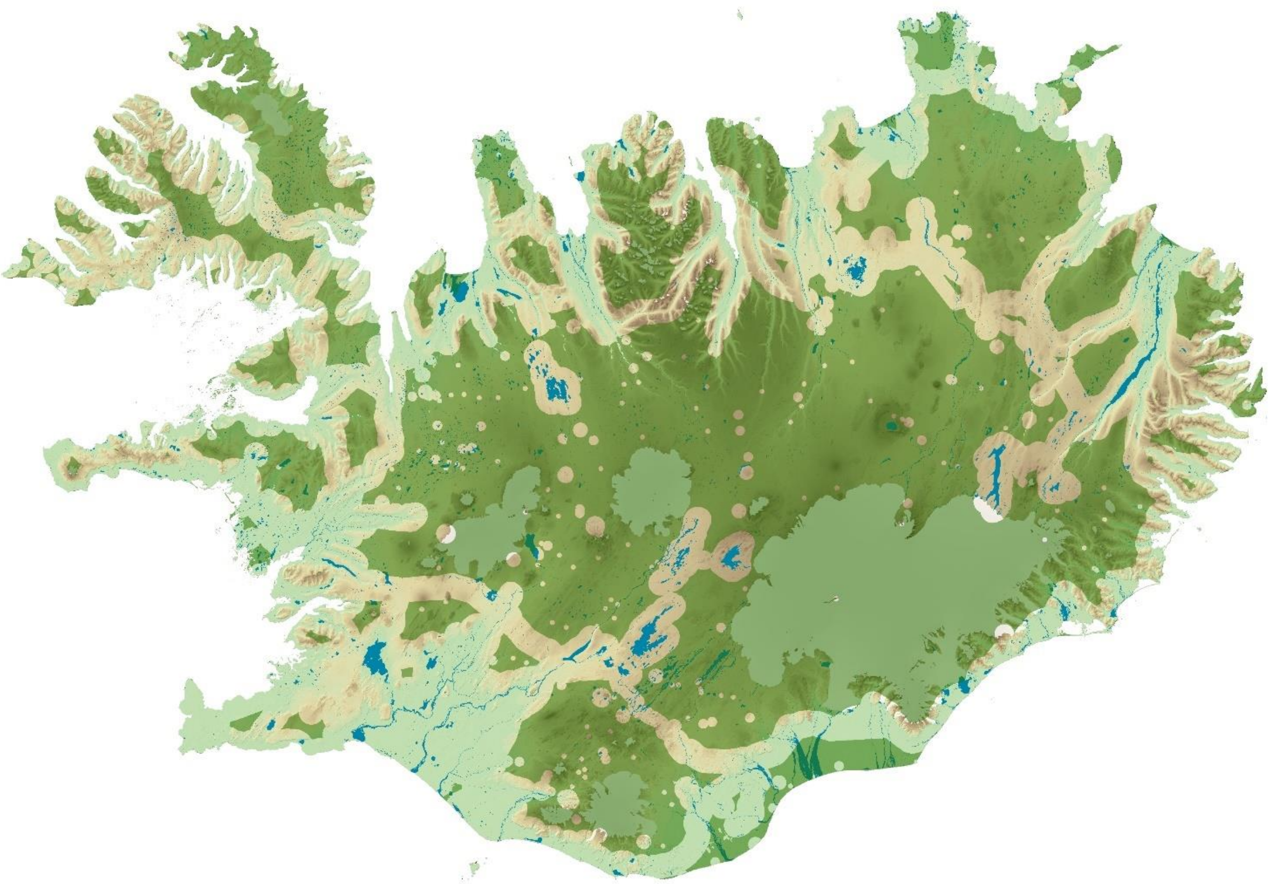
Óbyggð víðerni á Íslandi – greining og kortlagning á landsvísu



David C. Ostman, Ole Neumann og Þorvarður Árnason

Háskóli Íslands – Rannsóknasetur á Hornafirði

HÁSKÓLI ÍSLANDS

Rammaáætlun

Óbyggð víðerni á Íslandi – greining og kortlagning á landsvísu

David C. Ostman, Ole Neumann og Þorvarður Árnason

HÁSKÓLI ÍSLANDS

Rannsóknasetur á Hornafirði

Höfn, október 2021

Verkefni unnið fyrir Áætlun um vernd og orkunýtingu landsvæða (Rammaáætlun)

Titill: Óbyggð víðerni á Íslandi – greining og kortlagning á landsvísu

Höfundar: David C. Ostman, Ole Neumann og Þorvarður Árnason

Útgefandi: Rannsóknasetur Háskóla Íslands á Hornafirði, Nýheimum, Höfn, 780 Hornafjörður

Sími: (+354) 895-9003

Rafpóstur: thorvarn@hi.is

Veffang: https://www.hi.is/rannsoknaseturhofn

ISBN: 978-9935-9480-5-2

Forsíðumynd: Tilgátukort af óbyggðum víðernum á Íslandi – © David C. Ostman, Ole Neumann og Þorvarður Árnason (2021).

EFNISYFIRLIT:

Formáli

Skýrsla þessi er unnin á vegum faghóps 1 í fjórða áfanga *Áætlunar um vernd og orkunýtingu landsvæða* (Rammaáætlunar).[1] Óbyggð víðerni eru eitt þeirra náttúruverðmæta sem faghópi 1 ber að meta; grunnforsendan fyrir slíku mati er aðgengi að korti sem sýnir mörk og umfang óbyggðra víðerna, samkvæmt skilgreiningu íslenskra náttúruverndarlaga. Slíkt kort var síðast útbúið af Umhverfisstofnun árið 2009 en aldrei formlega gefið út. Í þriðja áfanga Rammaáætlunar (2013-2017) var þróuð endurbætt aðferðafræði til kortlagningar á óbyggðum víðernum innan miðhálendisins, í samvinnu við og að frumkvæði Skipulagsstofnunar.[2] Hálendiskortið var síðar uppfært eftir að Skipulagsstofnun hafði lokið við heildstæða skráningu á mannvirkjum og þjónustu innans miðhálendisins árið 2018.[3]

Tildrög þess verkefnis sem hér er til umræðu voru þau að – ólíkt fyrri áföngum Rammaáætlunar – voru flestar fyrirhugaðar virkjanaframkvæmdar sem komu til mats í fjórða áfanga staðsettar utan miðhálendisins. Til þess að unnt væri að meta áhrif ólíkra virkjanahugmynda á óbyggð víðerni með samræmdum hætti var nauðsynlegt að vinna grunnkort af óbyggðum víðernum á landsvísu, með sams konar aðferðafræði og áður hafði verið beitt á miðhálendið. Þar sem byggingar, vegir, raflínur, ræktað land og aðrar breytingar sem fylgja langtíma búsetu manna setja mjög víða mark sitt á láglendissvæði landsins, var ákveðið að beita tvísskiptri aðferð. Í fyrri áfanga voru afmörkuð þau svæði þar sem telja mátti víst að óbyggð viðerni væri **ekki** að finna og þau síðan „síuð í burtu", þ.e. ekki greind frekar. Svæðin sem eftir stóðu voru í seinni áfanga greind með sömu aðferðafræði og áður hafði verið notuð innan miðhálendisins, með lítilsháttar breytingum. Kortagerðarvinnan var að stærstum hluta unnin af Ole Neumann, sem starfaði sem lærlingur hjá Rannsóknasetrinu á Hornafirði veturinn 2020-2021, undir verkstjórn David C. Ostmans sem yfirfór alla kortagerðarvinnu og gékk jafnframt endanlega frá kortinu til birtingar, þ.m.t. að skeyta því saman við kortið af óbyggðum víðernum innan miðhálendisins.

Greining á áhrifum bygginga á rannsóknasvæðunum byggði að stofni til á IS 50V gagnagrunni Landmælinga Íslands um mannvirki en jafnframt var rýnt í kort og loftmyndir af öllum rannsóknasvæðum, til að kanna hvort fleiri byggingar og mannvirki væri þar að finna sem ekki væru skráðar í gagnagrunninn. Samtals reyndust 637 byggingar vera skráðar í gagnagrunn Landmælinga Íslands innan rannsóknasvæðanna en frekari rýni leiddi síðan í ljós 287 óskráð mannvirki til viðbótar, þannig að alls voru áhrif 924 mannvirkja könnuð. Þessi mannvirki voru fjölbreyttari að gerð en þau sem skoðuð voru innan miðhálendisins, þannig að flokkar þeirra á landsvísu reyndust vera 21, en voru 13 innan hálendisins. Almennt séð voru skerðingaráhrif mannvirkja á rannsóknasvæðum utan miðhálendisins hlutfallslega heldur meiri en mannvirkja innan hálendisins; meginskýringin á þeim muni milli svæða er að mjög stór hluti bygginga innan miðhálendisins eru fremur lítil mannvirki (t.d. fjallaskálar, gangnamannakofar, hesthús) sem ekki hafa jafn mikil skerðingaráhrif og stærri og/eða ágengari mannvirki, samkvæmt þeirri stigskiptu aðferðafræði sem hér er beitt.

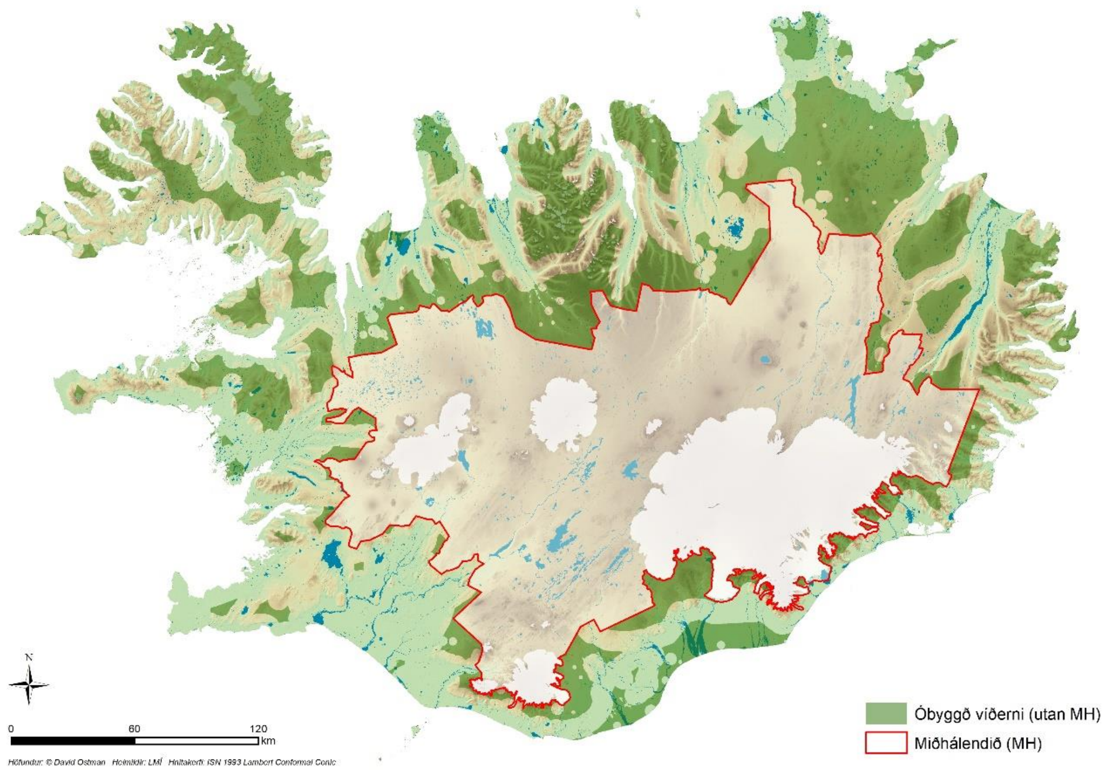
Á heildina litið var það heildarniðurstaða greiningarinnar að 56,115 km^2 (55%) landsins alls gætu talist óbyggð víðerni, miðað við þær forsendur sem lagðar voru greiningunni til grundvallar. Þar af voru óbyggð víðerni innan miðhálendisins 33,199 km^2 (83% rannsóknasvæðis) en óbyggð víðerni utan

[1] Sjá nánar: https://www.ramma.is/

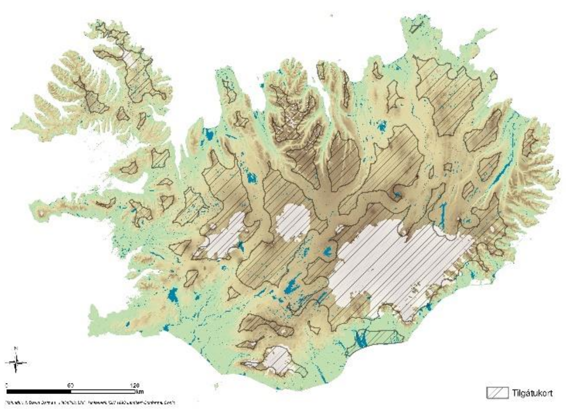
[2] Þorvarður Árnason, David Ostman og Adam Hoffritz (2017). *Kortlagning víðerna á miðhálendi Íslands: Tillögur að nýrri aðferðafræði*. Höfn: Rannsóknasetur Háskóla Íslands á Hornafirði: https://www.ramma.is/media/rannsoknir-f1-ra3/Kortlagning_Viderna_Web2.pdf

[3] David C. Ostman og Þorvarður Árnason (2020). Kortlagning víðerna á miðhálendinu: Framhaldsverkefni um þróun aðferðafræði. Höfn: Rannsóknasetur Háskóla Íslands á Hornafirði: https://www.ramma.is/media/banners/OstmanArnason2020_KortlagningViderna_WEB.pdf

hálendisins 23,490 km^2 (37% rannsóknasvæðis). Eins og sjá má á myndinni hér að neðan, þá finnast stór, samfelld óbyggð víðerni talvert víða utan miðhálendisins, meðal annars á Norðausturlandi, Ströndum og Tröllaskaga. Jafnframt eru víða svæði við jaðar miðhálendislínunnar sem teljast óbyggð víðerni samkvæmt þeirri aðferðafræði sem beitt var í verkefninu.



Áður en lengra er haldið er rétt að geta þriggja annarra kortlagningarverkefna sem unnin hafa verið hérlendis á allra síðustu árum. Eitt þeirra er tilgátukort af óbyggðum víðernum á landsvísu sem unnið var af Náttúrufræðistofnun Íslands, í tengslum við vinnu stofnunarinnar að mótun tillagna um svæði á B-hluta Náttúruminjaskrár. Þekjuna (tilgátukortið) má m.a. finna í vefsjá sem útbúin var vegna vinnu við stefnumótun um skipulag vindorkunýtingar á Íslandi.[4] Á myndunum hér að neðan má sjá tilgátukortið eitt og sér (til vinstri) og síðan samsetta mynd (til hægri) sem sýnir skörunina á milli tilgátukortsins og þess korts af óbyggðum víðernum sem kynnt er til sögunnar í þessari skýrslu.



[4] https://iinh.maps.arcgis.com/apps/webappviewer/index.html?id=f843cb215b1244778856859d4911373e

Eins og sjá má er nokkuð gott samræmi á milli kortanna tveggja; meginmunurinn liggur í ólíkum viðmiðum um skerðingaráhrif vega og slóða af mismunandi toga, sérstaklega þá innan miðhálendisins. Viðmið tilgátukortsins voru skilgreind á eftirfarandi hátt:

> **Lúpína, skógrækt, tún, flugvellir, þéttbýli, raflínur – all með 5 km buffer. Vegir voru flokkaðir eftir slitlagi og vegflokkun. Allir vegir notaðir nema „Annað óbundið slitlag" og „Malarvegur, Almennir vegir" og „Malarvegur, Einkavegir". Allt með 5 km buffer. Mannvirki, öll nema 1340 (þ.e. neyðarskýli, gangnamannakofar, skálar, sæluhús oþh.) með 5 km buffer.**

Þá hafa íslensk náttúruverndarsamtök leitað eftir erlendri sérfræðiráðgjöf um kortlagningu óbyggðra víðerna á tveimur afmörkuðum landsvæðum: áhrifasvæði fyrirhugaðrar Hvalárvirkjunar og innan Vonarskarðs. Bæði þessi kortlagningarverkefni voru unnin af Wildland Research Institute við Háskólann í Leeds.[5] Aðferðafræðin sem beitt var í ofangreindum verkefnum var upphaflega þróuð vegna greiningar á villtu landslagi (e. wild land) í Skotlandi og hefur síðan verið notuð í allmörgum öðrum löndum, auk greiningar sem náði yfir alla Evrópu. Þar sem þessi tvö kort frá Íslandi eru gerð í öðrum skala en það sem kynnt er í þessari skýrslu, verða þau ekki tekin til frekari skoðunar hér.

Óbyggð víðerni á Íslandi hafa verið í mikilli deiglu á allra síðustu misserum. Þannig var náttúruverndarlögum tvívegis breytt m.t.t. óbyggðra víðerna á starfstíma fjórða áfanga Rammaáætlunar. Fyrri lagabreytingin varðaði skýrari framsetningu á skilgreiningu fjarlægðarmarka út frá þeim mannvirkjum sem gætu haft áhrif til skerðingar á óbyggðum víðernum. Við kortlagningu óbyggðra víðerna hefur skilgreiningin á óbyggðum (áður „ósnortnum") víðernum oftast verið útfærð þannig að annaðhvort hefði tiltekið mannvirki ***full*** áhrif (þ.e. miðað við 5 km jaðar) til skerðingar á víðernum eða ***engin***. Þessi útfærsla er þó álitamál sem byggir á túlkun sem sætt hefur töluverðri gagnrýni. Til að skera úr um þennan ágreining lagði Umhverfis- og auðlindaráðuneytið fram frumvarp til breytingar á lögum nr. 60/2013 sem samþykkt var af Alþingi í maí 2020. Eftir þessa breytingu hljóðar skilgreiningin á óbyggðu víðerni (sbr. 19. tölulið 5. greinar) í gildandi náttúruverndarlögum nú svo:

> **Svæði í óbyggðum sem er að jafnaði a.m.k. 25 km^2 að stærð eða þannig að hægt sé að njóta þar einveru og náttúrunnar án truflunar af mannvirkjum eða umferð vélknúinna farartækja og að jafnaði í a.m.k. 5 km fjarlægð frá mannvirkjum og öðrum tæknilegum ummerkjum, svo sem raflínum, orkuverum, miðlunarlónum og uppbyggðum vegum.[6]**

Með því að bæta orðunum „að jafnaði" framan við 5 km fjarlægðarmörkin (sem afmarka þá jafnframt skerðingaráhrif mannvirkja á óbyggð víðerni, ef um slík áhrif er að ræða) opnast möguleiki á að nálgast neikvæð áhrif einstakra mannvirkja á óbyggð víðerni með breytilegum eða jafnvel stigskiptum hætti, líkt og gert var í okkar kortlagningarvinnu. Í skýringum við frumvarpið segir meðal annars:

> **Jákvætt er að orðin „að jafnaði" hafi bæst við fyrir framan stærðarmörkunina en þar sem þau er ekki lengur að finna fyrir framan fjarlægðarmörkin hefur það þær afleiðingar að ekki er hægt að friðlýsa svæði sem óbyggt víðerni ef innan við 5 km fjarlægð frá mörkum svæðisins er að finna miðlunarlón eða uppbyggðan veg, jafnvel þó svo að þessi mannvirki sé[u] hinum megin við stóran fjallgarð og hafi ekki nein áhrif á upplifun gesta á svæðinu eða á svæðið sjálft. Þá skiptir ekki máli hvort landfræðilegar aðstæður séu með þeim hætti að umrædd mannvirki hafi engin áhrif á viðkomandi svæði og að hægt sé að njóta þar einveru og náttúrunnar.[7]**

---

[5] Wildland Research Institute (2019). *Hvalá Power Plant Proposal. Review of impacts on wildernessI:* https://rafhladan.is/handle/10802/28566 ; Wildland Research Institute (2021). *Vonarskarð 4x4 Hypothetical Access Route Review of impacts on wilderness*: https://wildlandresearch.org/wp-content/uploads/sites/39/2021/09/Vonarskard-Report-v1.7.pdf

[6] https://www.althingi.is/lagas/nuna/2013060.html

[7] https://samradsgatt.island.is/oll-mal/$Cases/Details/?id=2607

Síðari lagabreytingin varðar nýtt ákvæði (grein 73.a) um kortlagningu óbyggðra víðerna sem bætt var við náttúruverndarlögin í febrúar 2021:

> **Ráðherra er heimilt að setja reglugerð um kortlagningu óbyggðra víðerna. Í reglugerðinni skal m.a. kveða á um þau viðmið og forsendur sem liggja til grundvallar kortlagningunni.**
>
> **Kort með upplýsingum um óbyggð víðerni skal vera til upplýsinga fyrir stjórnvöld við stefnumótun um verndun landslags og aðra landnotkun.[8]**

Í skýringum við drög að frumvarpinu um breytingu laganna segir nánar um þetta nýja ákvæði:

> **Í ákvæðinu er lagt til að við lögin bætist nýtt ákvæði sem fjallar um skyldu til að láta kortleggja þau svæði á landinu sem teljast til óbyggðra víðerna. Óbyggð víðerni eru skilgreind í 19. tölul. 5. gr. laganna. Með kortlagningu á þeim svæðum sem geta talist til óbyggðra víðerna mun umfang þeirra og fjöldi liggja fyrir. Bent er á að kortlagning óbyggðra víðerna hefur ekki í för með sér að svæði sé friðlýst sem óbyggt víðerni, en slíkt er eingöngu hægt að gera með þeirri hefðbundnu málsmeðferð sem lögbundin er þegar svæði er friðlýst. Kortlagning óbyggðra víðerna mun auðvelda alla vinnu við skipulagslegar ákvarðanir.[9]**

Eftir gildistöku Þingsályktunartillögu um landsskipulagsstefnu 2015-2026 í mars 2016 færðist ábyrgð á stefnumótun um skipulag miðhálendisins til Skipulagsstofnunar. Í landsskipulagsstefnunni voru jafnframt tilgreind ýmis framfylgdarverkefni sem vörðuðu óbyggð víðerni og laut eitt þeirra að ákvörðun á viðmiðum fyrir kortlagningu þeirra. Skipulagsstofnun lagði í mars 2021 fram endanlega tillögu að viðauka við landsskipulagsstefnu 2015-2026 sem m.a. varðar skilgreiningu viðmiða fyrir kortlagningu óbyggðra víðerna. Þessar tillögur hljóða svo:

> **Við kortlagningu óbyggðra víðerna, og mat á skerðingaráhrifum skipulagsáforma á óbyggð víðerni verði eftirfarandi lagt til grundvallar:**
>
> **— Mörk óbyggðra víðerna miði almennt við 5 km frá mannvirkjum og öðrum tæknilegum ummerkjum sem teljast ágeng gagnvart náttúrugæðum óbyggða.**
>
> **— Skerðingarvegalengd verði lengri en 5 km í tilviki mjög stórra mannvirkja og tæknilegra ummerkja, en styttri en 5 km vegna umfangsminni mannvirkja og tæknilegra ummerkja, sem þó teljast skerða náttúrugæði óbyggða.**
>
> **— Skerðingarvegalengd ráðist jafnframt af því hvort landform byrgja sýn að viðkomandi mannvirki.**
>
> **— Innan óbyggðra víðerna geti verið stök, umfangslítil mannvirki og tæknileg ummerki sem samrýmst geta óbyggðaupplifun og náttúrugæðum óbyggða.[10]**

Tillögur Skipulagsstofnunar byggðu m.a. á þeirri þróunarvinnu við kortlagningu sem unnin var í samstarfi við faghóp 1 í þriðja áfanga Rammaáætlunar, svo og rannsóknum á viðhorfum íslensks almennings til skerðingaráhrifa ólíkra mannvirkja á óbyggð víðerni sem einnig voru unnar í samstarfi við Rammaáætlun.[11] Þótt ekki sé víst að þessar tillögur verði samþykktar, er ljóst er þær gefa færi á stigskiptingu skerðingaráhrifa frá mannvirkjum, að teknu tillit til umfangs og eðlis þeirra mannvirkja sem eiga í hlut. Lykilatriðið í þessu samhengi er hvort, eða að hvaða marki, tiltekin framkvæmd telst vera ágeng (e. intrusive). Jafnframt er í þessum tillögum Skipulagsstofnunar gert ráð fyrir viðmiði sem

[8] https://www.althingi.is/altext/151/s/0848.html
[9] https://samradsgatt.island.is/oll-mal/$Cases/Details/?id=2758
[10] https://www.landsskipulag.is/media/landsskipulagsstefna-vidbaetur/LSK-21-tillagaSkst-til-radherra.pdf, bls. 7.
[11] Guðný Gústafsdóttir, Guðný Bergþóra Tryggvadóttir og Sindri Baldur Sævarsson (2020). U*ppbygging innviða í víðernum Íslands. Mat almennings á skerðingaráhrifum mannvirkja*. Reykjavík: Félagsvísindastofnun Háskóla Íslands.

ekki hefur áður verið notað í opinberri kortlagningu óbyggðra víðerna hérlendis, en það varðar áhrif landforma í kringum eða í grennd við mannvirkið á sýnileika þess frá öðrum stöðum.

Í skýringum við ofangreindar tillögur segir meðal annars:

> **Mikilvægi óbyggðra víðerna hefur verið viðurkennt og undirstrikað í löggjöf og stefnu stjórnvalda. Í áranna rás hefur verið gengið á óbyggð víðerni með mannvirkjagerð, til dæmis inni á miðhálendinu, sem hefur enn frekar varpað ljósi á þörf fyrir verndun víðerna. Það sem hefur hinsvegar gert erfitt um vik að taka málefni óbyggðra víðerna föstum tökum er að skort hefur viðurkenndar aðferðir og viðmið til að kortleggja óbyggð víðerni og meta áhrif mannvirkjagerðar á þau með samræmdum hætti. Slíkar viðurkenndar og samræmdar aðferðir eru forsenda þess að hægt sé að ná yfirsýn yfir umfang óbyggðra víðerna og þróun þeirra og taka viðeigandi tillit til þeirra við skipulagsgerð og þegar ákvarðanir um einstakar framkvæmdir eru teknar.[12]**

Brýnt er að skilgreina formlega þær forsendur og þau viðmið sem leggja skal til grundvallar kortlagningu óbyggðra víðerna á Íslandi. Þau kort sem til þessa hafa verið gerð á Íslandi, hvort heldur af opinberum aðilum eða akademískum, hafa byggst á skilgreiningu óbyggðs víðernis (gr. 19. tölulið 5. greinar) í náttúruverndarlögum. Sú skilgreining er að stofni til byggð á tillögum starfshóps sem vann að þessu verkefni á árunum 1997-1998 og má því telja „barn síns tíma“, m.a. vegna mikillar áherslu á neikvæð áhrif mannvirkja, fremur en verðmæti (jákvæð gildi) víðernanna sem slíkra. Talsverðar breytingar hafa átt sér stað á alþjóðlegum vettvangi síðan þessi skilgreining var fyrst sett á blað.[13] Jafnframt hefur verið nokkur vöxtur í íslenskum rannsóknum á óbyggðum víðernum á allra síðustu árum, en slíkar rannsóknir voru ekki fyrir hendi þegar starfshópurinn vann að tillögum sínum.[14]

Í seinni breytingunni á náttúruverndarlögum sem vikið var að hér að ofan er tekið fram (grein 8) að umræddri kortlagningu óbyggðra víðerna alls landsins skuli vera lokið fyrir 1. júní 2023.[15] Það er von okkar skýrsluhöfunda að það kort sem hér er kynnt til sögunnar geti komið að góðum notum við framfylgd þess verkefnis. Jafnframt teljum við þó fyllstu ástæðu til þess að skoða með gagnrýnum, opnum huga þau viðmið sem hingað til hafa verið notuð við slíka kortagerð hér á landi; þar er í senn mikilvægt að horfa til þróunar í hugmyndafræði um víðernavernd á alþjóðavísu og til þeirra náttúrufarslegu og menningarlegu þátta sem skipta mestu máli við verndun óbyggðra víðerna á Íslandi.

*****

Að lokum viljum við færa þeim öllum þakkir sem aðstoðuðu okkur við þetta verkefni. Ber þar fyrst að nefna Dr. Antje Neumann, dósent við Háskólann á Akureyri, sem tók þátt í hugmyndavinnu vegna verkefnisins á ýmsum stigum. Einnig þökkum við starfsfólki Rammaáætlunar, Umhverfis- og auðlindaráðuneytisins, Skipulagsstofnunar og Náttúrufræðistofunar Íslands fyrir margvíslega aðstoð. Síðast en ekki síst færum við meðlimum faghóps 1 okkar bestu þakkir fyrir frábæra samvinnu og gjöfult, þverfaglegt samtal í fjórða áfanga Rammaáætlunar.

[12] https://www.landsskipulag.is/media/landsskipulagsstefna-vidbaetur/LSK-21-tillagaSkst-til-radherra.pdf, bls. 41.

[13] Sjá m.a. IUCN (2016). *Wilderness Protected Areas: Guidelines for management of IUCN Category 1b protected areas*: https://www.iucn.org/news/protected-areas/201612/wilderness-protected-areas-management-guidelines

[14] Sjá t.d. Aðalheiður Jóhannsdóttir (2016). "Wilderness Protection in Iceland". Í K. Bastmeijer (ritstj.), *Wilderness Protection in Europe. The Role of International, European and National Law,* bls. 360-385. Cambridge University Press; Angela M. Jauch (2020). *Understandings of wilderness: Implications for wilderness identification and management in Iceland*. Háskóli Íslands – óbirt meistaraprófsritgerð: http://hdl.handle.net/1946/35064; Þorvarður Árnason (2020). "Exploring wilderness in Iceland: Charting meaningful encounters with uninhabited lands". Í R. Bartel, F. Utley, S. Harris og M. Branagan (ritstj.), *Rethinking Wilderness and the Wild: Conflict, Conservation and Co-existence*, bls. 189-204. Routledge.

[15] https://www.althingi.is/altext/151/s/0848.html

1. Introduction

This report outlines a novel approach to mapping wilderness in Iceland, originally conducted for the Central Highland (CH) in its first iterations and then most recently applied to the rest of the country. The methodology was first developed in the Spring of 2017 (Árnason et al., 2017), in consultation with Iceland's National Planning Agency (Skipulagsstofnun) and the Environment Agency (Umhverfisstofnun), for the purpose of updating the Central Highland wilderness map that had been developed by Icelandic authorities at the time. It was subsequently updated in the Spring of 2019 and again in January 2020 to create a revised version of the map based on the most updated, available data (Ostman, D. & Árnason, Þ., 2020). In the Winter of 2020-2021, the same methodology was applied to the rest of Iceland outside of the Central Highland, with some minor modifications that will be discussed in more detail below.

The goal of the project was to create a systematic, transparent, and dynamic method to map wilderness, based specifically on the impacts of manmade structures and anthropogenic influences (predominantly roads, reservoirs, powerlines, and buildings). Figure 1 outlines the general steps involved in the mapping process:

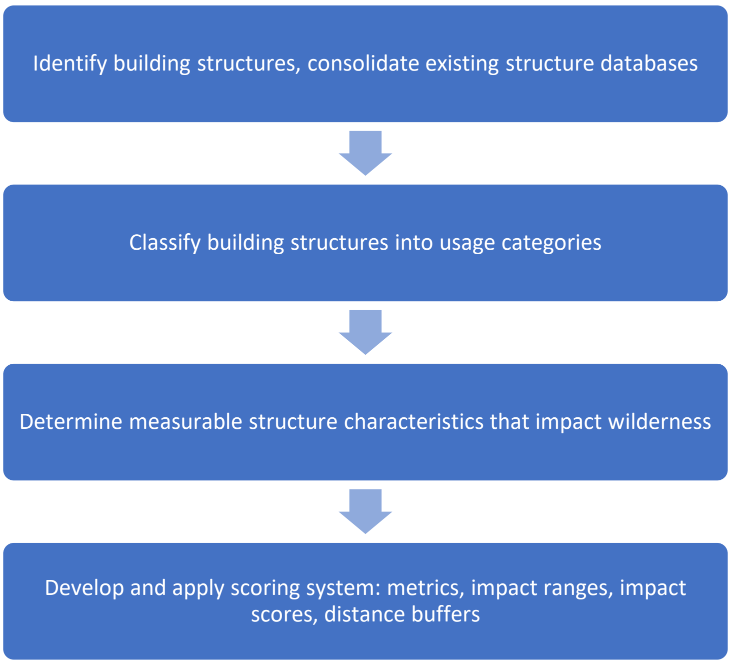


Fig. 1. Flow chart of wilderness mapping process

This report first discusses the original approach of creating the Central Highland wilderness maps (Sections 2.1 – 2.4) and then explains its application to the rest of Iceland (Section 2.5). In both cases, the methodology is meant to act as an adaptable framework for evaluating the impact on wilderness caused by current and future infrastructure. The overall objective is to enhance credibility regarding wilderness conceptualization and mapping in general and strengthen its utility for Icelandic nature conservation, local and national strategic planning, and land use decision-making.

2. Methods

2.1 Identify manmade structures and consolidate databases

The first step in the Central Highland mapping process was to determine and consolidate all of the known manmade structures that exist in the study area. For the purpose of this project, the structures that were identified consisted predominantly of building structures and excluded other, less intrusive, manmade structures such as bridges, signs, and fences. Cultural remains, archaeological ruins and other historically/culturally significant artifacts would ideally have been included, but due to a lack of data at the time, this category of structures was left out of the database and mapping process.

There were four main databases of manmade structures for the Central Highland that were used in the original 2017 map:

- The National Register of Iceland Database (Þjóðskrá Íslands)
- The National Land Survey of Iceland Database (Landmælingar Íslands)
- Vatnajökull National Park Database (Vatnajökulsþjóðgarður)
- Miscellaneous Database consisting of registered structures from municipalities, local plans, The National Register, Mountain Huts of Iceland (Fjallaskálar á Íslandi), and The Travel Association of Iceland (Ferðafélag Íslands)

The 2019 map included newly-identified manmade structures from an additional database provided by Skipulagsstofnun (Skipulagsstofnun 2018):

- Tourism Structures (Ferðaþjónustumannvirki)

There were no new structures added to the database for the 2020 mapping update.

Most of the databases contained similar structures from the other databases as well as new structures not already identified, so each structure in each database had to be assessed one at a time. This was also important since those structures that appeared in more than one database did not always contain the same information. Therefore, it was necessary to cross-reference each database manually, matching up similar structures with each other and adding in any new information.

The structure information from the databases above was copied into a new database in the form of an excel spreadsheet with each database grouped into color-coded columns to distinguish one database's information from another. The data of any similar structures were matched up in the same row (see Figure 2 for a snapshot of the new database format). During the initial 2017 mapping process, a total of 471 manmade structures were identified and logged in the new database. After the 2019 mapping process, an additional 152 structures were identified for a total of 623 structures.

The new database preserved the original database information as well as identified any new information, which included the following:

- New reference number
- Structure category
- Structure cluster (if applicable)
- GPS coordinates (if not already provided)
- Raw data needed for scoring the criteria (discussed below)
- Scores for each criteria and resulting distance buffer (discussed below)

Combined Database									
								Surface Area (m2)	
Number	Structure Category	New Structure Category (Adam/Ester)	New Structure Category (Icelandic)	Structure Name	Structure Cluster	X	Y	Surface Area	Impact Score
228	Shed	Storage	Geymsla	Hellishólmi		403002.391	487818.996	33.5	0
272	Mountain Hut	Mountain Hut	Fjallaskálar	Hvítárnes	Hvítárnes	463747	457626	40.7	0
435	Mountain Hut	Mountain Hut	Fjallaskálar	Bergland		531085.7414	521387.0509	56	1
271	Storage	Storage	Geymsla	Hvítárnes	Hvítárnes	463816.582	457501.3	21	0
264	Mountain Hut	Mountain Hut	Fjallaskálar	Hveravellir	Hveravellir	473781.671	485253.581	45.5	0
350	Sheep Herding Hut	Mountain Hut	Fjallaskálar	Skælingar		523411	386454	32.3	0
221	Mountain Hut	Mountain Hut	Fjallaskálar	Hagavatnsskáli		440148	440687	19.3	0
454	Mountain Hut	Mountain Hut	Fjallaskálar	Skútagil		407973.7163	495669.6776	48	0
127	Mountain Hut	Mountain Hut	Fjallaskálar	Álftavötn		515186	377173	41.6	0
45	Unknown	Mountain Hut	Fjallaskálar	Möðrudalur/lóð 3	Möðrudalur	644933	545281	133	4
212	Stable	Stable	Hesthús	Gilsbakkasel		405686.798	480101.369	58.8	1
312	Mountain Hut	Mountain Hut	Fjallaskálar	Laugafell	Laugafell	531472	503324	31.5	0
36	Church	Farm	Býli	Möðrudalskirkja	Möðrudalur	644931	545317	30.4	0
137	Mountain Hut	Mountain Hut	Fjallaskálar	Ásgarður	Kerlingarfjöll	485669	464798	65.7	1
189	Sheep Herding Hut	Mountain Hut	Fjallaskálar	Bugaskáli/Eyvindarstaðaheiði		479727.1843	524551.8613	86.7	1
224	Stable	Stable	Hesthús	Hallarmúli Afréttur		452310	410931	44.3	0
347	Stable	Stable	Hesthús	Skjaldborg	Skjaldborg	415247.564	430803.236	54	1
418	Mountain Hut	Mountain Hut	Fjallaskálar	Þjófadalir		466330	479551	16.7	0

Þjóðskrá											
MATSNÚMER (Assessment #)	LANDEIGN_NR (Landowner #)	MHLNR	HÆÐ (Height)	EINING	NOTK	TEXTI	FLATARMÁL (Area)	MÆLIEINING (Unit)	BYGGINGARSTIG (Construction Phase)	FJÖLDI_HÆÐA	BYGGINGARÁR
2257397	156923	17	1	1	514	Smíðastofa	126	m²	4	1	
2271080	156923	18			425	Fjárhús með áburðark	336.7	m2	7	1	
2172750	156923	11	1	1	408	Véla/verkfærageymsla	59.5	m2	7	0	
2172751	156923	12	1	1	408	Vélageymsla	32.5	m2	7	1	
2172754	156924	1	1	1	563	Kirkja	30.4	m2	7	1	
2205428	167308	1	1	1	567	Skáli	56.1	m2	7	1	
2202907	166705	1	1	1	572	Fjallaskáli og hesth	94.8	m2	7	1	
2196087	164853	1	1	1	571	Sæluhús	66.3	m²	7	1	

Fig. 2. New database layout showing a sample of some of the new information added to the structures (top). An example of one of the original databases (Þjóðskrá) and some of the information preserved (bottom).

As mentioned above, each structure was identified manually, point-by-point. The goal was to collect as much information as possible to identify the structures, but at least enough information needed for the purpose of this project to evaluate their impact on wilderness. Many of the structures listed in the original databases already contained enough information to identify them, such as geographic location (GPS coordinates) and the structure name, but in many cases, limited information was given, so further investigative methods had to be used in the identification process. These methods included photo and web searches, aerial and satellite image searches (map.is, Loftmyndir, SPOT 5 images, GoogleEarth), and outreach to organizations and municipalities.

2.2 Classify structures into categories

Once all of the original databases were cross-referenced and added to the new database, then each structure was classified into one of thirteen categories (Table 1). These categories were decided upon in consultation with Skipulagsstofnun and based on structure usage. Initially, other more specific categories were assigned to each structure, but these were then consolidated into more general categories.

Table 1. Detailed structure categories (left column) grouped into the final thirteen categories (right column)

Structure Category (detailed)	***Structure Category (final)***
Airport infrastructure, parking lot	Transportation infrastructure
Sanitary facilities, bathroom facilities	Bathroom facilities
Guesthouse, hotel	Hotel or guesthouse
Hydropower plant, power project	Energy structure
Staff house, park ranger office	Staff office
Service center, shared recreational facility	Service center
Restaurant, cooking facilities	Food services
Farm, church	Farm
Turf house, storage, shed	Storage
Stable	Stable
Research station, sheep herding hut, emergency hut, fishing hut, mountain hut and stable, power station (small scale), private residence, summer cottage,	Mountain hut
Radio tower, telecommunication station, telecommunication tower	Telecommunication
Unknown	Unknown

The distribution of structure types in the consolidated database for the latest 2020 Central Highland analysis is represented in Figure 3.

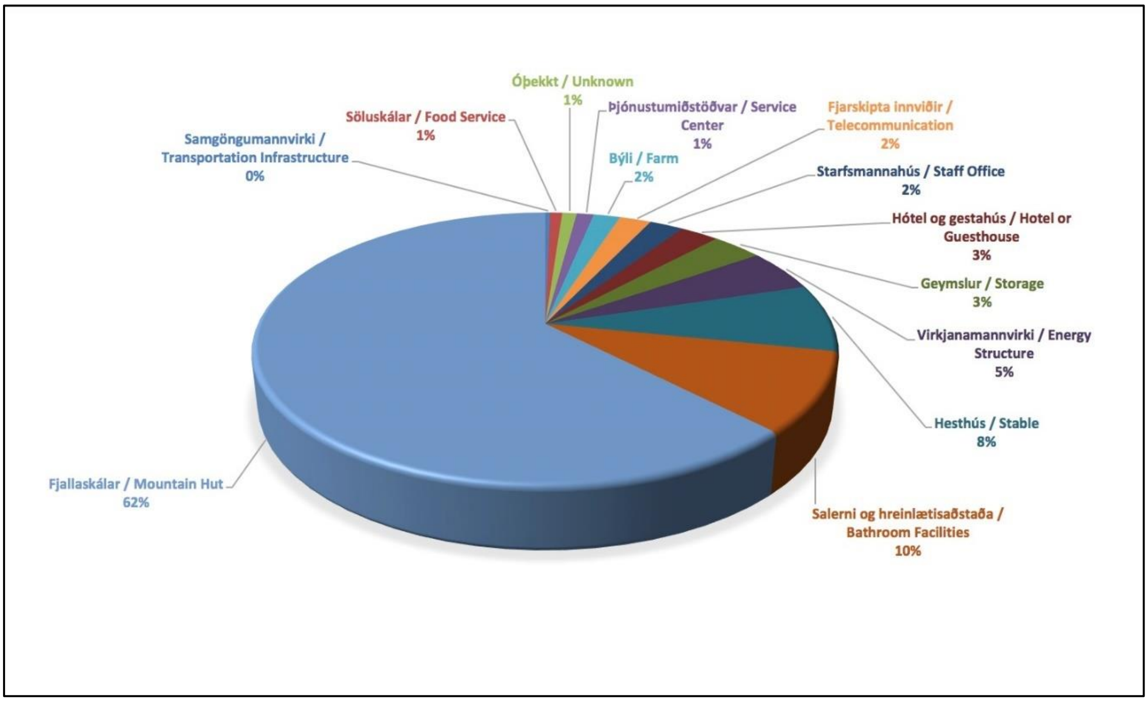


Fig. 3. Distribution of structure categories in the consolidated database for the latest 2020 Central Highland mapping analysis

Figure 4 shows the geographic distribution of all 623 structures in the most recent Central Highland analysis.

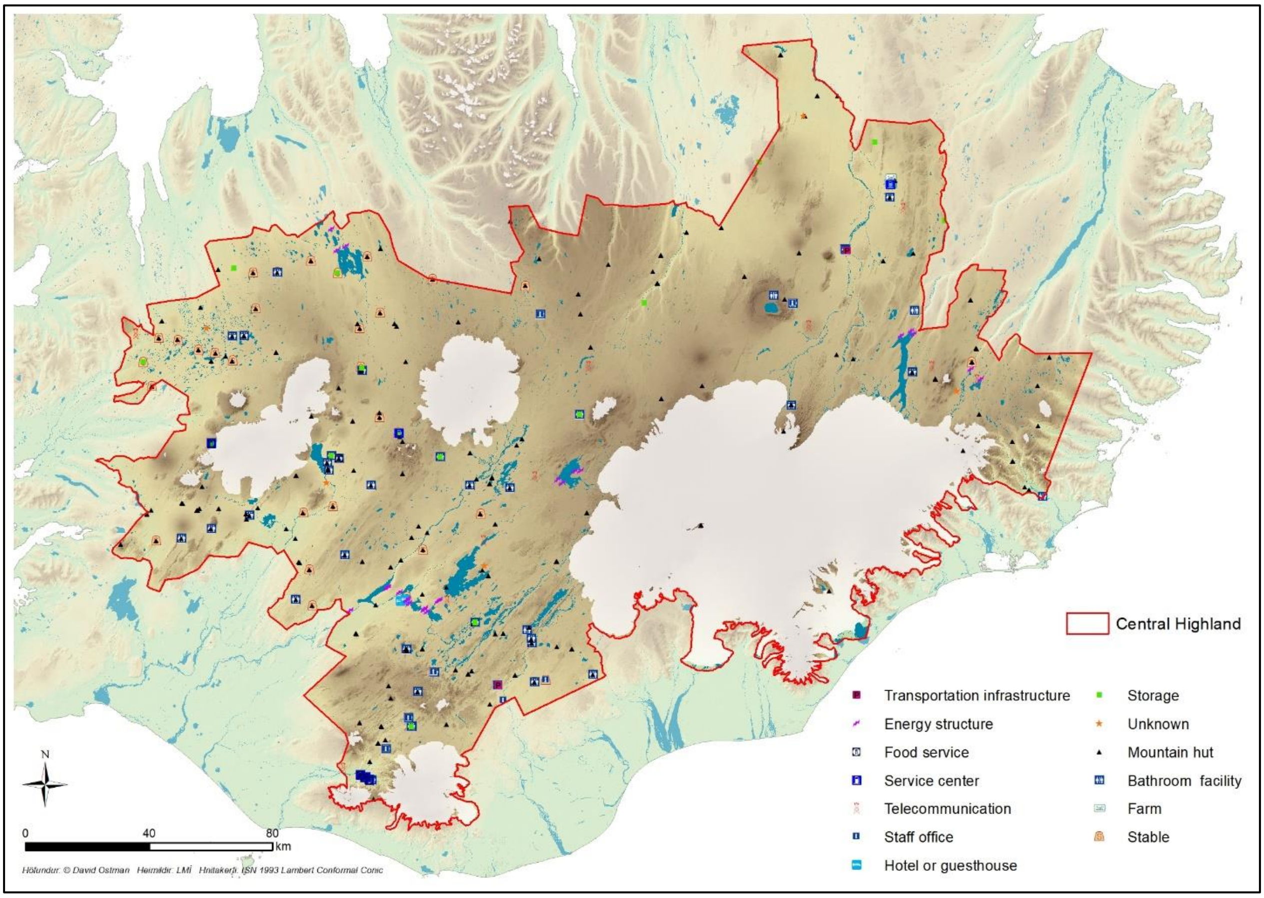


Fig. 4. Geographic distribution of all 623 structures broken down by structure category as of the latest 2020 Central Highland analysis.

2.3 Define structure characteristics that impact wilderness

For the purpose of this project, the selected structure characteristics needed to be objective and measurable, specifically that could be used or calculated within a GIS environment. ESRI's ArcGIS (ArcMap) was used for most data analysis and map processing (QGIS was also used in some aspects of the nationwide mapping discussed below). The same criteria and mapping procedure were used in the original 2017 map and subsequent 2019 and 2020 iterations. Ultimately, six criteria were selected to evaluate each structure and determine its impact on wilderness:

- Structure usage
- Surface area
- Clustering
- Connectivity (distance to closest road)
- Connectivity (type of closest road)
- Visibility

Structure Usage: This criterion refers to the main purpose of the structure or the service(s) it provides. Usage may also indirectly speak to various factors that influence a wilderness experience, such as perceived intrusiveness, zoning (residential vs. commercial vs. industrial), or permanence. The original Central Highland databases from which the structures came often contained usage information, but for those structures that were unclear, the usage was determined manually (web and image searches based on the structure name, consultation with Skipulagsstofnun).

Surface Area: Size (m^2) of the building structure. The surface area of many of the structures was already provided in the original databases. For the remaining structures without this data, map-measuring tools with satellite/aerial imagery (map.is, ArcMap) were used to measure the surface area.

Clustering: This criterion was defined as the number of structures within a 1 km radius of each other. It was important to make a distinction between, say, the impact of a single, isolated mountain hut and a large grouping of huts. Even though the characteristics of each individual mountain hut may be similar (usage, size), one must consider the potential cumulative impact when in such close proximity of each other. The Point Statistics tool in ArcMap was used for this calculation.

Connectivity: The connectivity of a structure refers to how accessible the structure is based on two sub-criteria: 1) Distance from the closest road and 2) Type of closest road. The road type refers specifically to the level of road quality as defined by the Icelandic Road Authority (Vegagerðin), specifically categories A, B, C, D, F1, F2, F3. The distance to the closest road was measured "as the bird flies"- a straight line from the structure to the nearest road segment. The Near tool in ArcMap was used to determine this calculation. The tool's search radius needed to be large enough so as to not overlook any structures that were quite far from the nearest road, so a radius of 50 km was used.

Visibility: How visible the structure is in the surrounding landscape, specifically the number of visible cells from a digital elevation model (DEM) calculated for each structure. ModelBuilder in ArcMap was used to create an automated, iterative process for calculating the visibility for each structure (Figure 5). The model included the Visibility Analysis tool and Iterate Feature Selection tool. In the Visibility tool, the DEM and structure layer were attached as inputs. A general observer offset of 3 m (height of the structure), a surface offset of 1.75 m (representing average eye level height), and a maximum outer radius of 50 km were used. Depending on the number of structure points, the visibility can take some time to process. In the case of the 623 points for the 2019 and 2020 maps, the processing time was about 3.5 days.

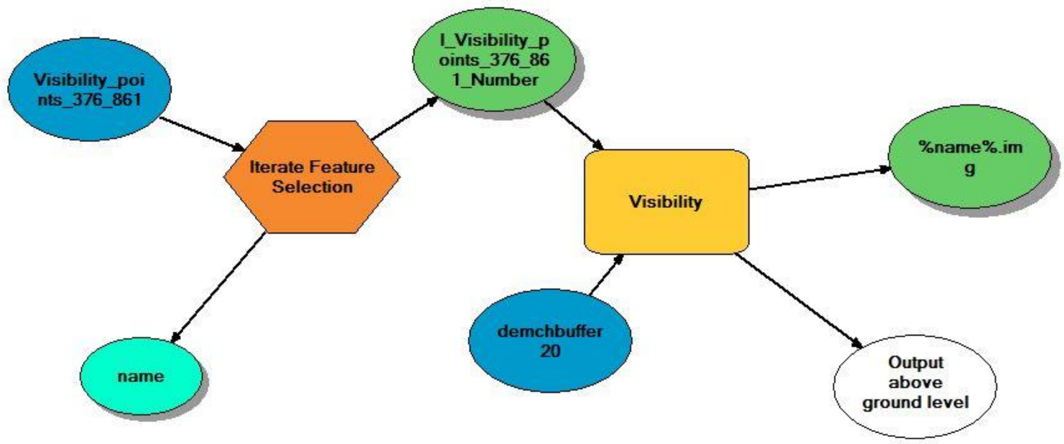


Fig. 5. ModelBuilder created in ArcMap to calculate the building structure visibility

2.4 Develop and apply a scoring system

A simple scoring methodology was created that gave one score for each of the six structure characteristics, which was summated to give a total impact score for each structure. Each characteristic was assigned a metric, impact range, and an impact score based on an existing scoring scheme that was adopted from Iceland's Master Plan for Nature Protection and Energy Utilization (Rammaáætlun). This used a non-linear scoring system of 0, 1, 4, 8, 13, 20. Table 2 shows the final metrics, impact ranges, and scores used for each criterion.

Table 2. Final scoring scheme used to assess each structure

Impact criteria	***Metric***	***Impact range***	***Impact score***
Structure usage	Category	Transportation infrastructure	4
		Bathroom facilities	1
		Hotel or guesthouse	8
		Energy structure	20
		Staff office	1
		Service center	13
		Food services	8
		Farm	4
		Storage	1
		Stable	1
		Mountain hut	1
		Telecommunication	8
		Unknown	1
Surface area	m^2	0 – 49	0
		50 – 99	1
		100 – 149	4
		150 – 199	8
		200 – 249	13
		250 +	20
Clustering	# of points within 1 km radius	0 – 1	0
		2 – 3	1
		4 – 5	4
		6 – 7	8
		8 – 9	13
		10 +	20
Connectivity	Distance to closest road (km)	10 +	0
		8 – 9	1
		6 – 7	4
		4 – 5	8
		2 – 3	13
		0 – 1	20
	Road type	F3	0
		F2	1
		F1	4
		D	8
		C	13
		A – B	20
Visibility	Cell count	0 – 299.999	0
		300.000 – 599.999	1
		600.000 – 899.999	4
		900.000 – 1.199.999	8
		1.200.000 – 1.499.999	13
		1.500.000 +	20

For each structure, the individual scores for each of the six criteria were added together to get a total impact score (out of 120). Each total impact score fell within a range that was equivalent to a distance buffer (0 – 7 km) as shown in Table 3.

Table 3. Summated impact score ranges and distance buffer equivalents applied to each structure

Total impact score	***Distance buffer equivalent (km)***
0 – 15	0
16 – 30	1
31 – 45	2
46 – 60	3
61 – 75	4
76 – 90	5
91 – 105	6
106 – 120	7

For non-building structures such as roads, reservoirs, and powerlines, a simplified buffering method was used to determine their impact on wilderness. The roads were assessed using the road quality categorization as defined by Vegagerðin. There has been ongoing deliberation as to what kind of roads within the Central Highland should affect wilderness; the majority of the roads there are unpaved, and some are more heavily traveled than others. For the purpose of this project, it was decided that all category C roads that were paved should receive a distance buffer above "0" (predominantly only category C roads within the Central Highland are paved). The more heavily traveled roads were experimented with having some impact but were ultimately given a buffer of "0" in the final assessments (these roads included Sprengisandsleið, Kaldidalur, Kjalvegur, and Fjallabak, which are coded as a special road group "8" under "Vegflokkun" according to Vegagerðin). Powerline buffers were based on the voltage (kV), and reservoirs were given a standard buffer. Table 4 provides a breakdown of the metrics, impact ranges, and buffers used for the non-building structures.

Table 4. Criteria used for non-building structure types (roads, reservoirs, and powerlines).

Non-building structure	***Metric***	***Impact range***	***Distance buffer (km)***
Roads	Road type	F3	0
		F2	0
		F1	0
		D	0
		C (unpaved)	0
		C (paved)	5
Powerlines	Voltage (kV)	132	3
		220	5
Reservoirs	-	-	5

Once the GIS analysis and respective scoring scheme were applied to all building structures for the six criteria, the resulting raw data and scores were added to the database and uploaded to ArcMap. In addition to any information contained in the original structure databases, the updated database thus included the following:

- Unique reference number
- Structure category
- Structure name
- Structure cluster (if applicable)
- GPS coordinates
- Surface area (m^2)
- Number of points in cluster
- Road type of closest road (A, B, C, D, F1, F2, F3)
- Distance to closest road (km)
- Visibility cell count (# of visible cells)
- Individual impact scores for all six criteria
- Total impact scores
- Equivalent impact distance buffers (km)

The building structures were separated out into their own layers based on their impact buffers (0-7). The Buffer tool was applied to create a buffer for each respective layer. The most updated non-building structure layers (i.e. roads, reservoirs, and powerlines) also needed to be imported to ArcMap, clipped for the Central Highland boundary, and have their respective buffers applied to them. The most recent iterations of the road and water (reservoir) layers were downloaded from the publicly-accessible database through the National Survey of Iceland (Landmælingar Íslands) website. Since the powerlines layer was not available for public download, their locations were estimated based on the public, interactive map (webviewer) accessible through the National Grid Authority (Landsnet) website.

Once all of the buffers for all of the structures were created, they were merged together using the Merge tool. Then the Clip tool was used to cut the buffers for the Central Highland boundary. Lastly, the Erase tool was used to create the inverse of the merged buffers, and this remaining polygon resulted in the final Central Highland wilderness layer.

2.5 Application outside of the Central Highland

The same methodological procedure for mapping wilderness as described above was applied outside of the Central Highland to the rest of Iceland, with a few notable modifications. Firstly, it is important to keep in mind that the Central Highland is predominantly uninhabited, and thus the amount of infrastructure and general anthropogenic presence remains quite sparse compared to the populated lowlands and coastal areas. The total number of building structures are simply much larger in the latter areas and would be less manageable to assess on an individual level, as was done within the Central Highland. Therefore certain criteria were used at the beginning of the mapping process to exclude areas where wilderness (as understood in the context of this anthropogenic methodology) would likely not exist, which subsequently reduced the overall number of building structures that would need to be assessed. These exclusion areas included most urban areas and agricultural regions as well as areas within a certain distance of paved roads and powerlines (Table 5). The urban and agricultural regions were defined using the CORINE land cover classification (© European Union, Copernicus Land Monitoring Service 2018, European Environment Agency (EEA)). The paved roads and powerlines were already anthropogenic impacts used in the Central Highland mapping and so were deemed as logical exclusion areas.

A second methodological difference was that the powerlines were given a standard 5 km buffer, and reservoirs, which have a significantly smaller presence outside of the Central Highland, were not included.

Table 5. Exclusion areas outside of the Central Highland

Exclusion area	***Distance buffer (km)***
Urban areas (CORINE categories 1.1, 1.4)	2
Agricultural areas (CORINE category 2)	0
Paved roads	5
Powerlines	5

The most comprehensive database that existed for structures outside of the Central Highland at the time of the analysis was from Landmælingar Íslands, so this was the database used for the nationwide assessment. After the exclusion areas were applied and removed, 637 building structures remained within the study area, and an additional 287 that had not already been identified by the Landmælingar Íslands database were found manually using satellite and aerial images, totaling 924 structures. A varied approach had to be taken in relation to the connectivity criteria, specifically dealing with island structures and those structures in which one would have to traverse open water (sea, fjords) to get to the nearest road, which was not a factor in the landlocked Central Highland. It was ultimately determined that all structures whose nearest road involved having to cross open water would automatically be given a score of "0" for both connectivity criteria (distance to nearest road and road type).

The last methodological change was the fact that new structure categories and usage types emerged with the newly-identified structures outside of the Central Highland (e.g. lighthouses, permanent residences). Therefore the original list of thirteen categories (Table 1) had to be expanded to account for these new structures. Since the Landmælingar Íslands database already contained assigned categories, these were used for the additional structures. The 287 structures found manually (i.e. not in the Landmælingar Íslands database) were automatically categorized as “unknown”. The expanded list of categories, now 21, and respective impact scores are shown in Table 6, and the distribution of structure types is shown in Figures 6 and 7.

Table 6. Updated list of structure categories including new categories identified outside of the Central Highland

Structure category	***Impact score***
Transportation infrastructure	4
Bathroom facilities	1
Hotel or guesthouse	8
Energy structure	20
Staff office	1
Service center	13
Food services	8
Farm	4
Storage	1
Stable	1
Mountain hut	1
Telecommunication	8
Unknown	1
Detached house	4
Holiday home	4
Business facilities	13
Meeting places or facilities	8
Churches and houses of worship or related	8
Companies	13
Utilities	8
Lighthouses	4

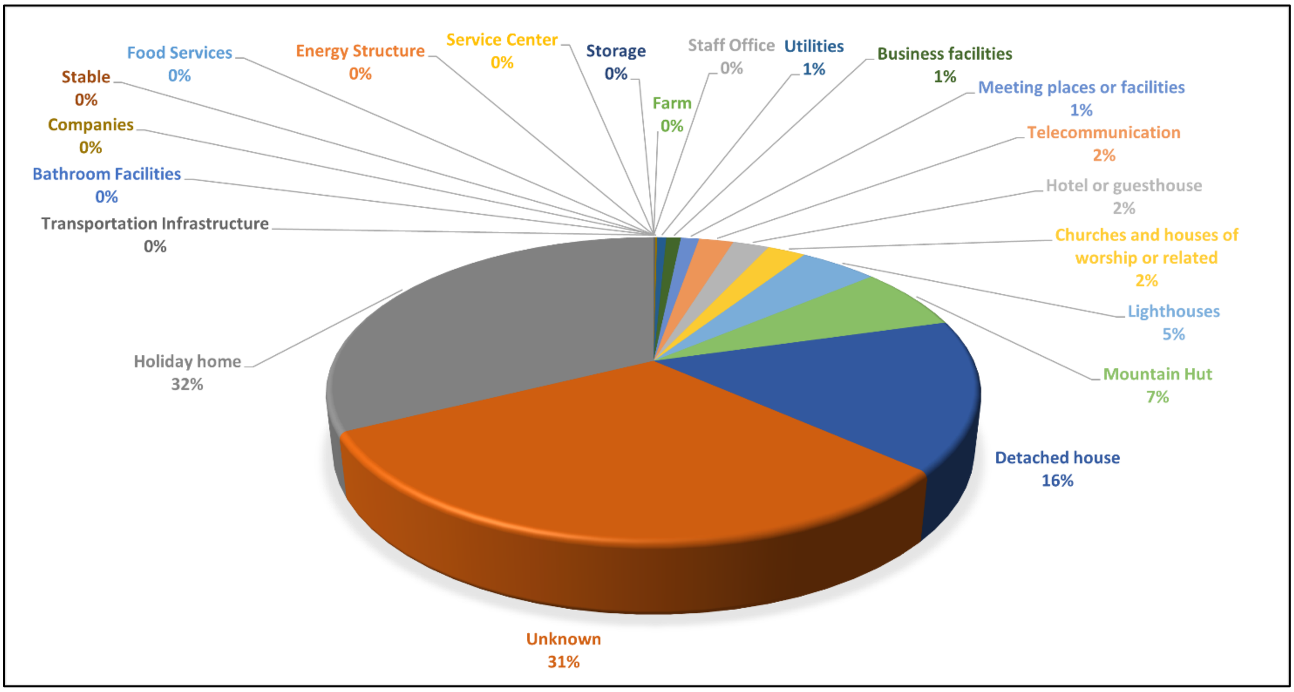


Fig. 6. Distribution of structure categories, as a percentage, outside of the Central Highland (Winter 2020-2021)

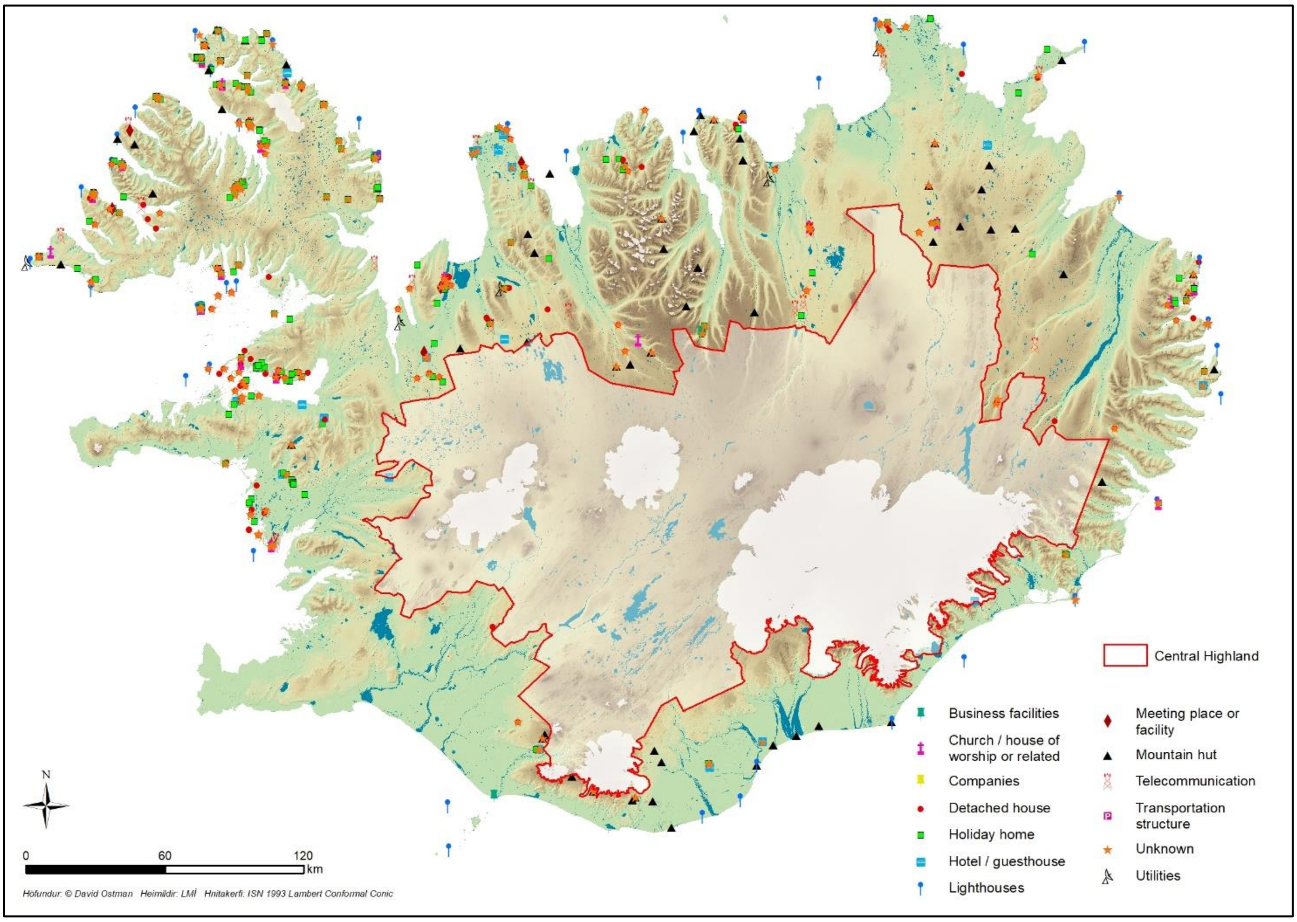


Fig. 7. Geographic distribution of all 924 structures identified outside of the Central Highland (Winter 2020-2021), broken down by structure category

With the exception of the changes mentioned above, the 924 building structures were evaluated using the same GIS analysis, scoring, and buffering process for all six characteristics as was done for the Central Highland. Once all structures were scored and buffered, the inverse of the merged structure buffers and exclusion areas resulted in the final, nationwide wilderness area.

When merging the final wilderness layers inside and outside of the Central Highland, the full extent of all structure buffers and exclusion areas along the border were included to account for any edge effects and to maintain continuity.

3. Results

Figure 8 shows the final wilderness map for the most recent Central Highland analysis in 2020, Figure 9 shows the final wilderness map for the assessment outside the Central Highland in Winter 2020-2021, and Figure 10 shows the combined layers. The wilderness area within the Central Highland amounted to 33,199 km^2 (83% wilderness), and the wilderness area outside of the Central Highland was 23,490 km^2 (37% wilderness). Once edge effects along the border were accounted for when merging both wilderness areas, the total nationwide wilderness coverage was 56,115 km^2 (55% wilderness).

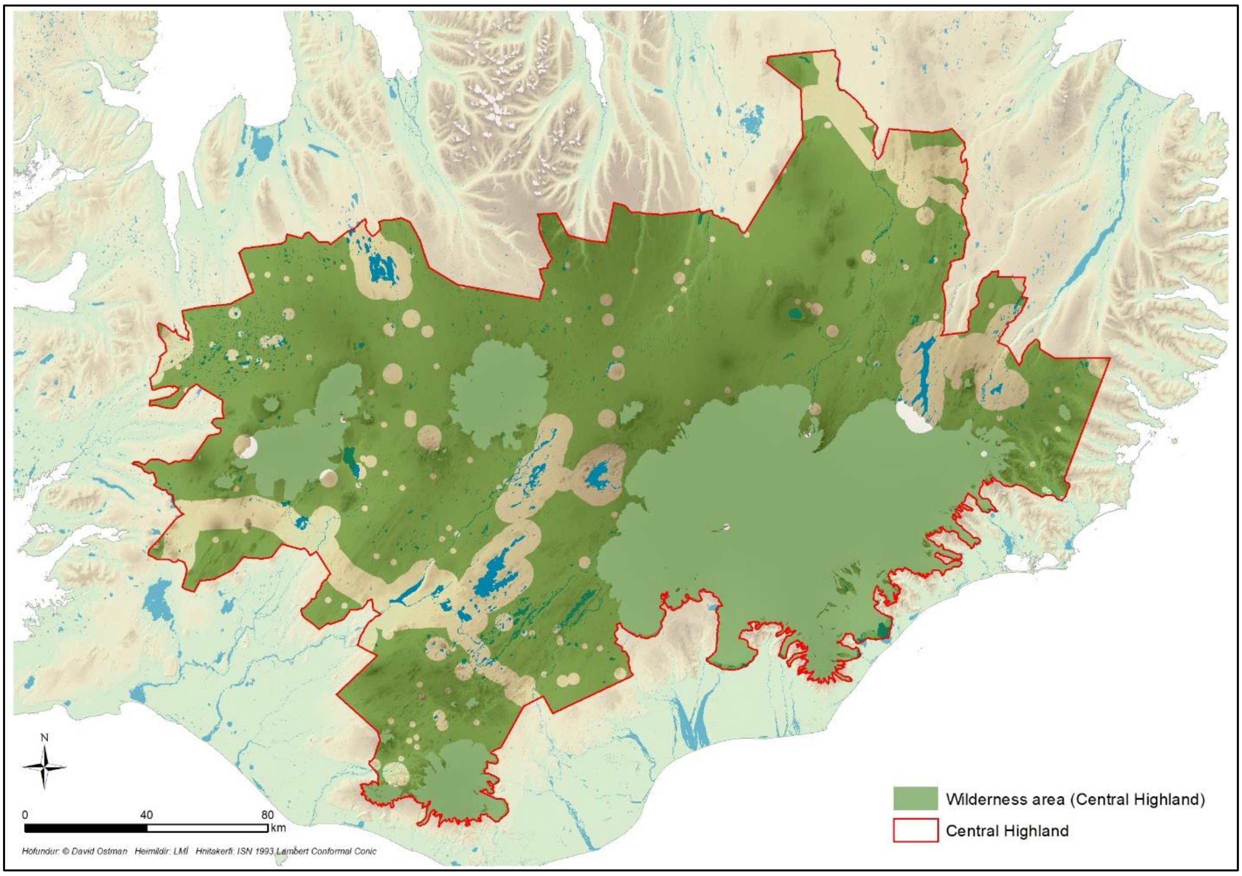


Fig. 8. Final wilderness map for Iceland´s Central Highland (2020 analysis)

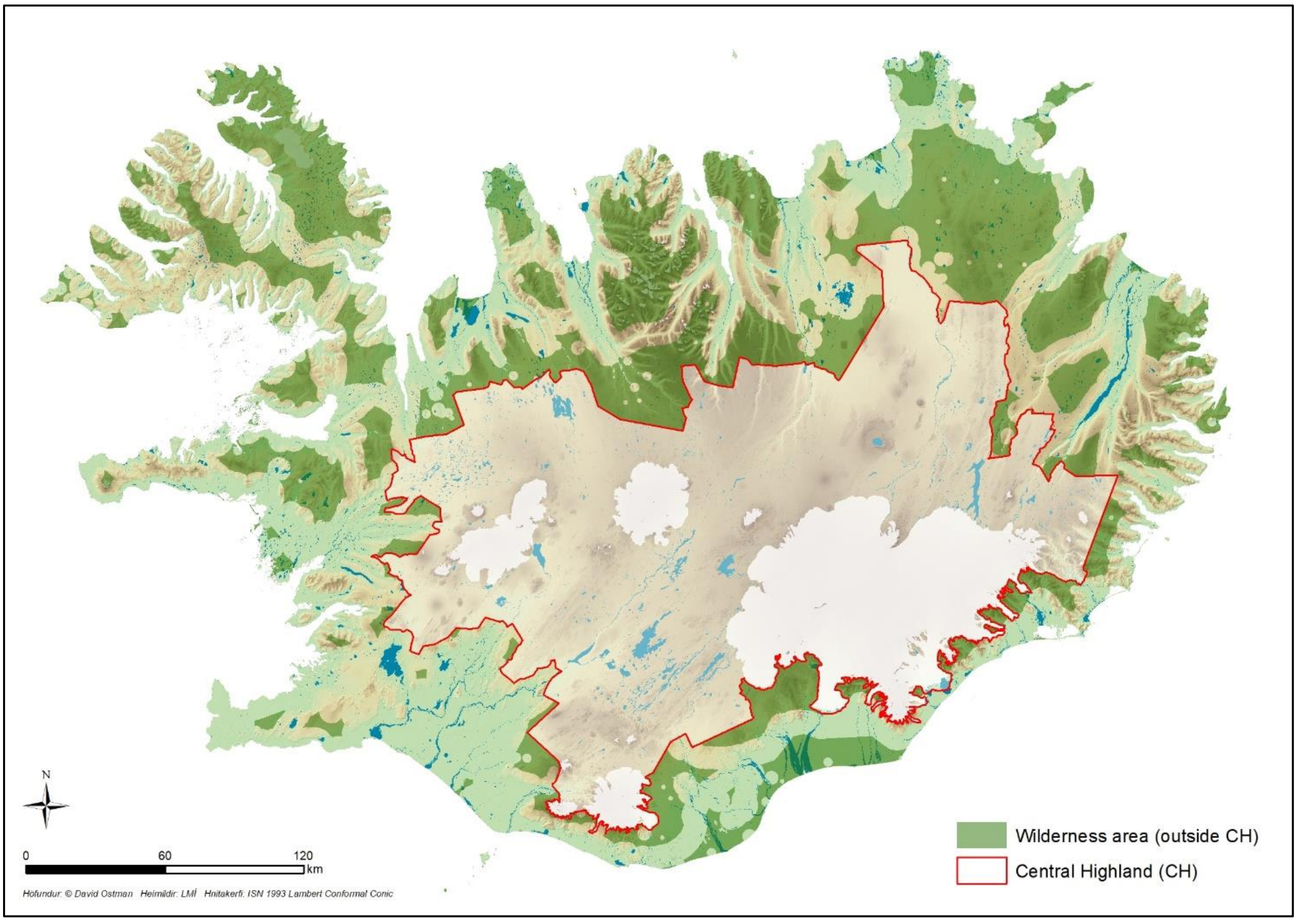


Fig. 9. Final wilderness map outside of the Central Highland (Winter 2020-2021 analysis)

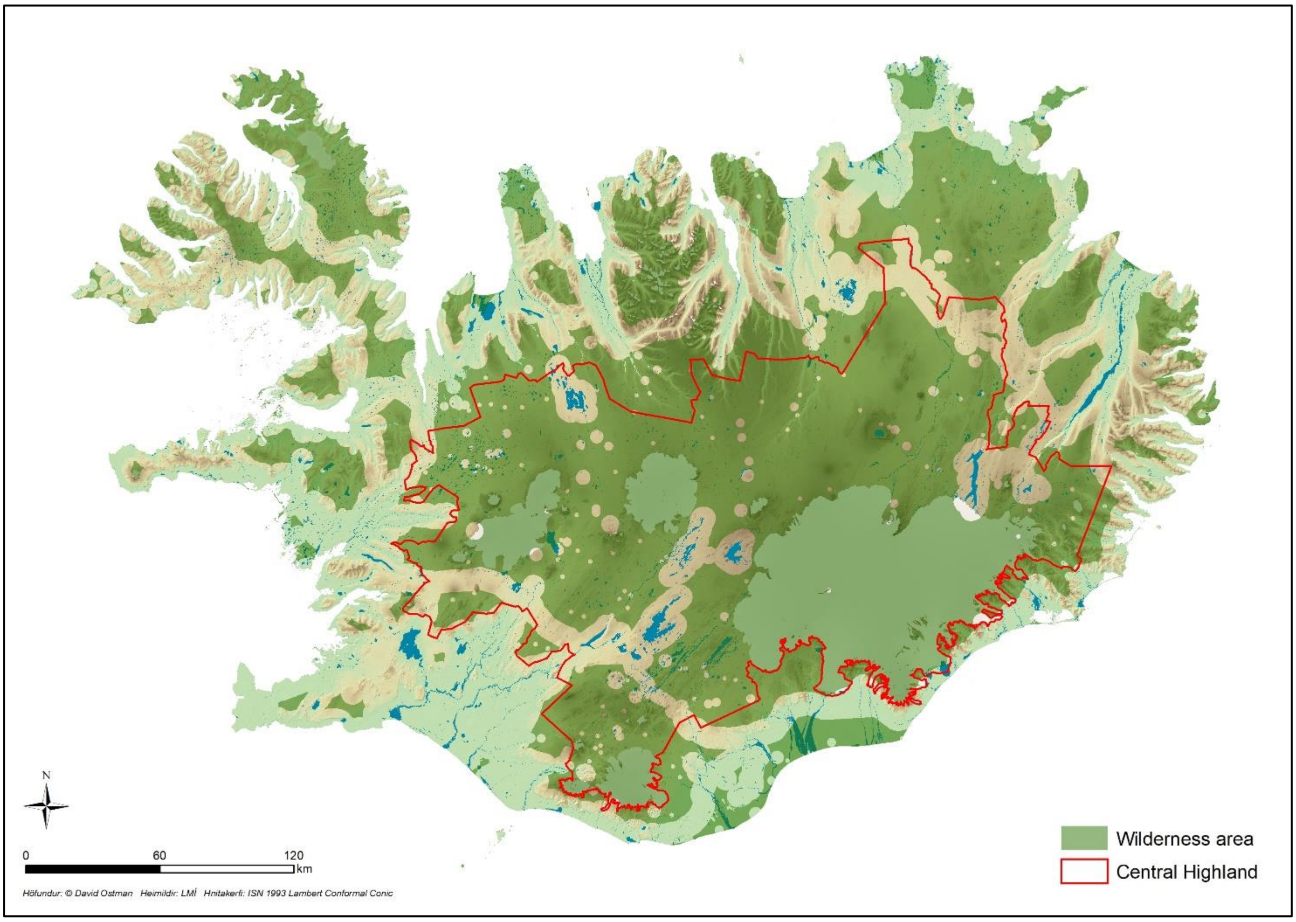


Fig. 10. Combined wilderness layers, accounting for edge effects

Figure 11 shows the distance buffers for the Central Highland analysis based on the type of structure (road, reservoir, powerline, or building structure). Figures 12 and 13 show the initial exclusion areas and the building structure distance buffers for the rest of the country, respectively.

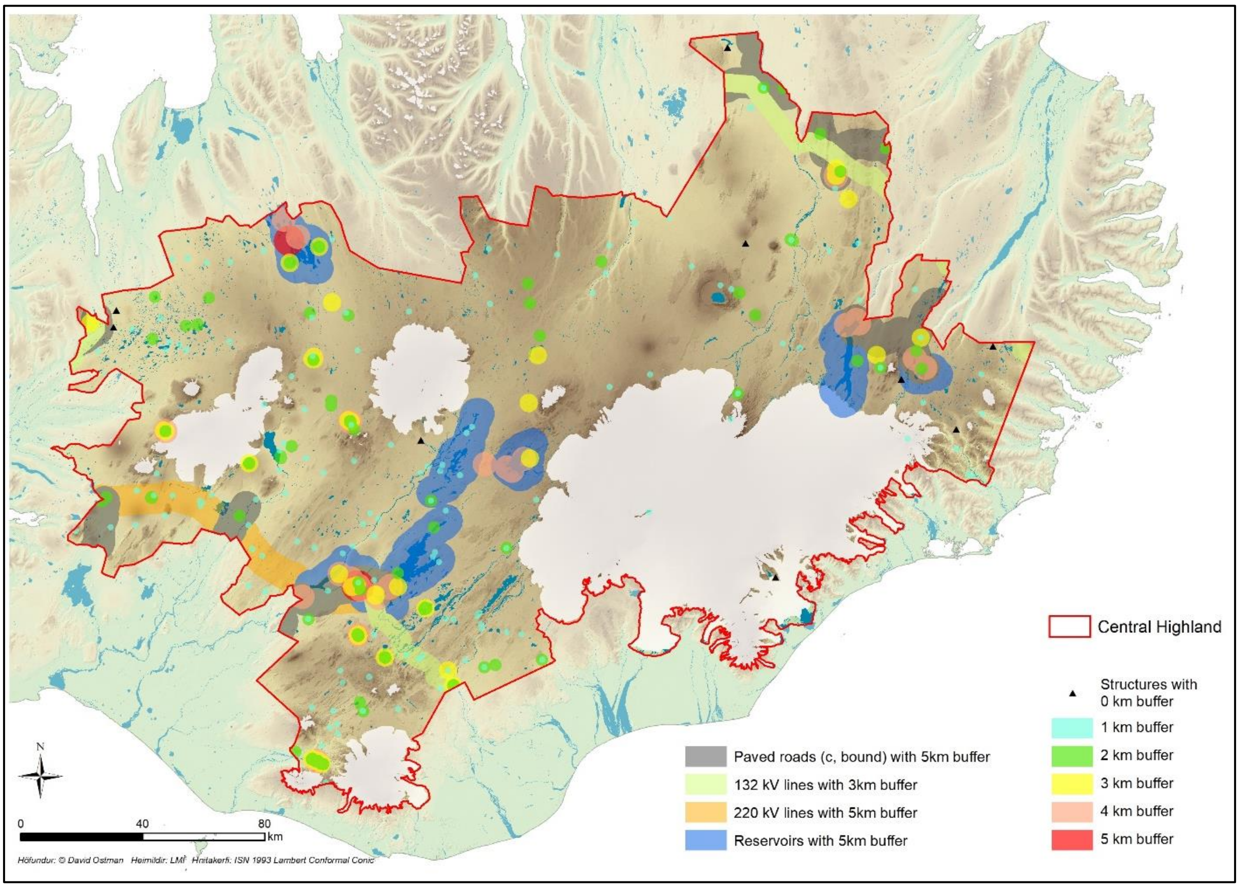


Fig. 11. Distance buffers of building and non-building structures for the Central Highland analysis

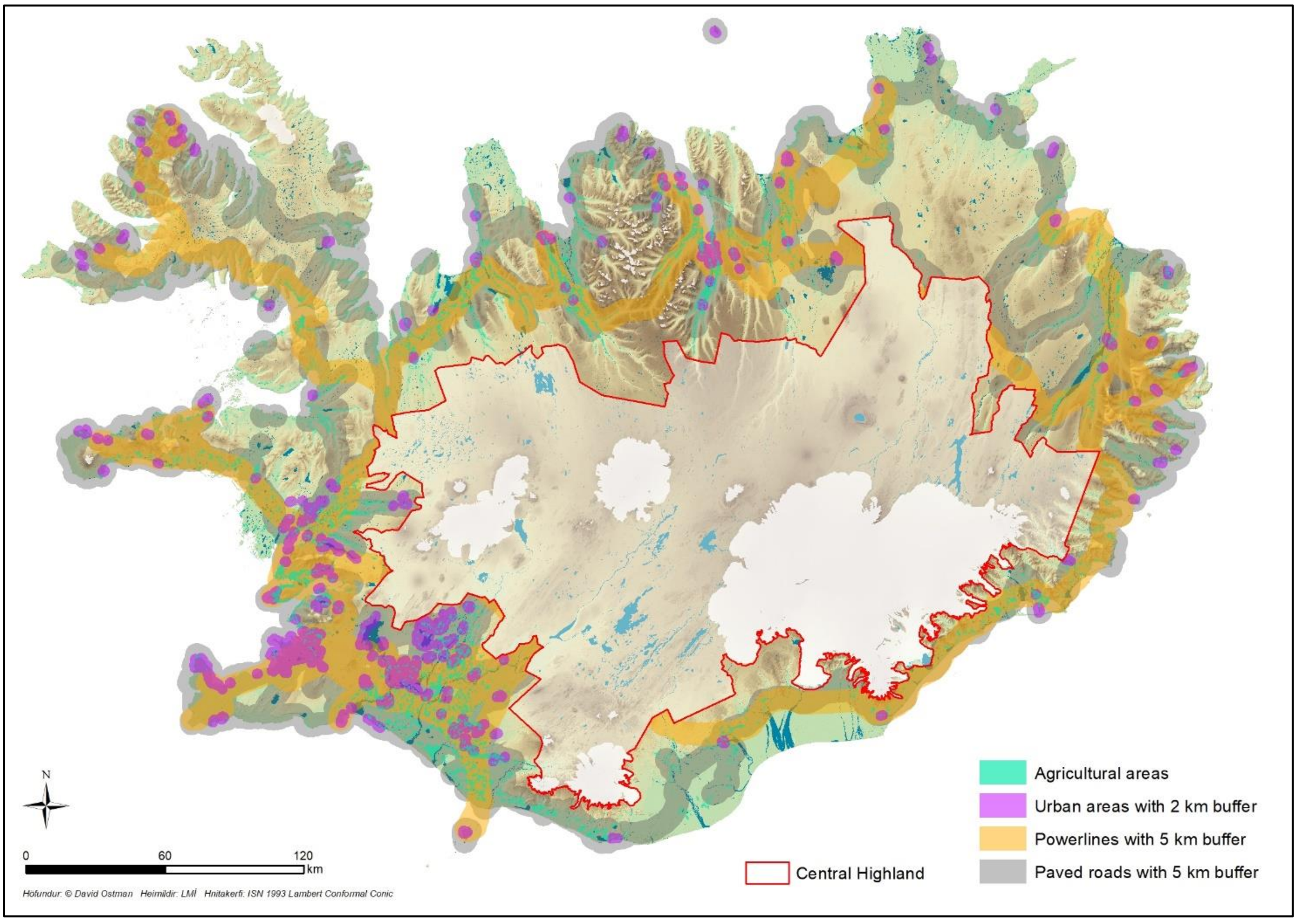


Fig. 12. Exclusion areas and distance buffers of non-building structures (CORINE categories, powerlines, roads) for the analysis outside of the Central Highland

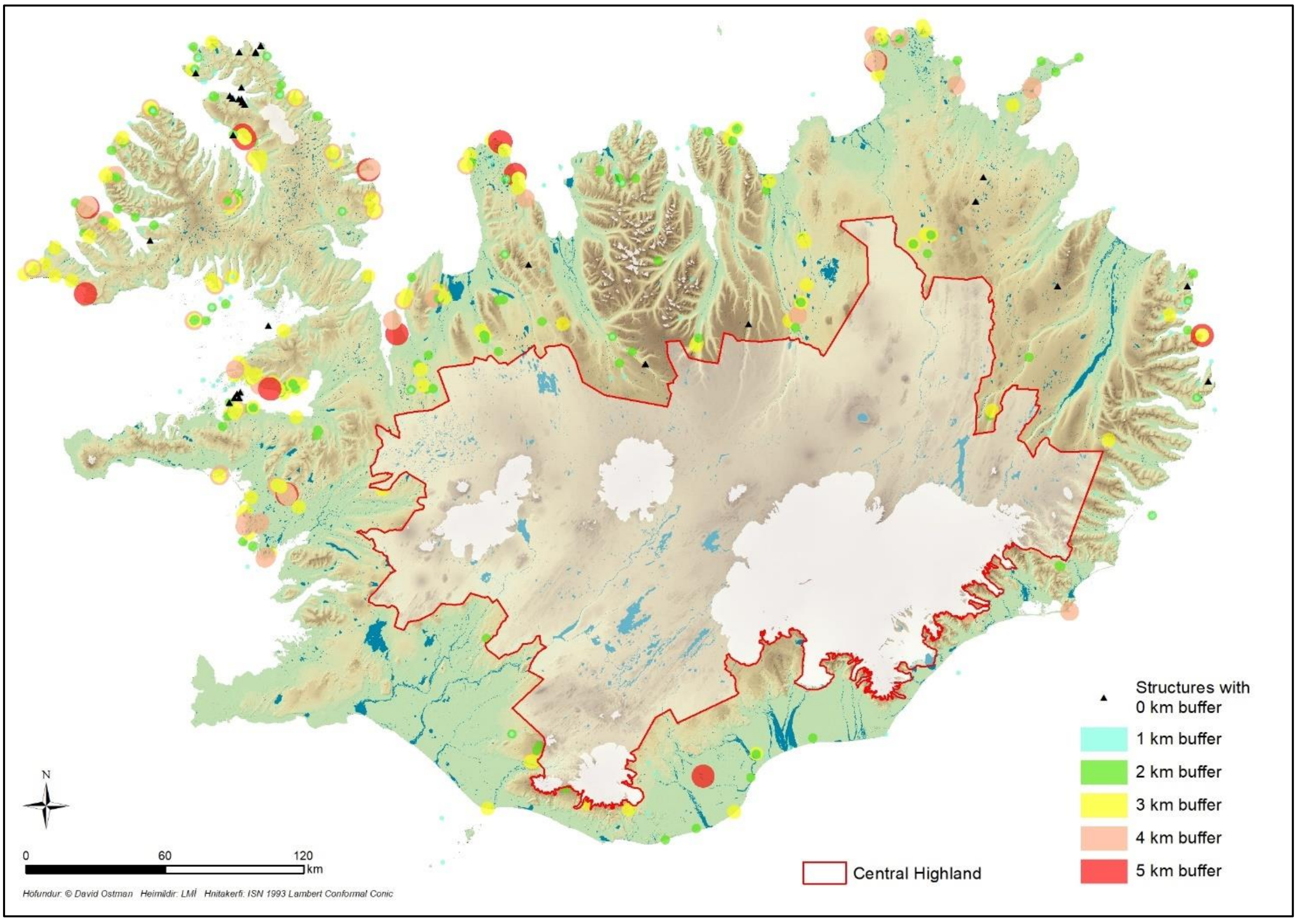


Fig. 13. Distance buffers of building structures for the analysis outside of the Central Highland

In both mapping analyses, the resulting distance buffers for the building structures ranged from 0 – 5 km with no structures scoring a "6" or "7" buffer. The distribution of the number of building structures for each distance buffer is shown in Figure 14, and Figure 15 shows the same distribution as a percentage of the total number of structures.

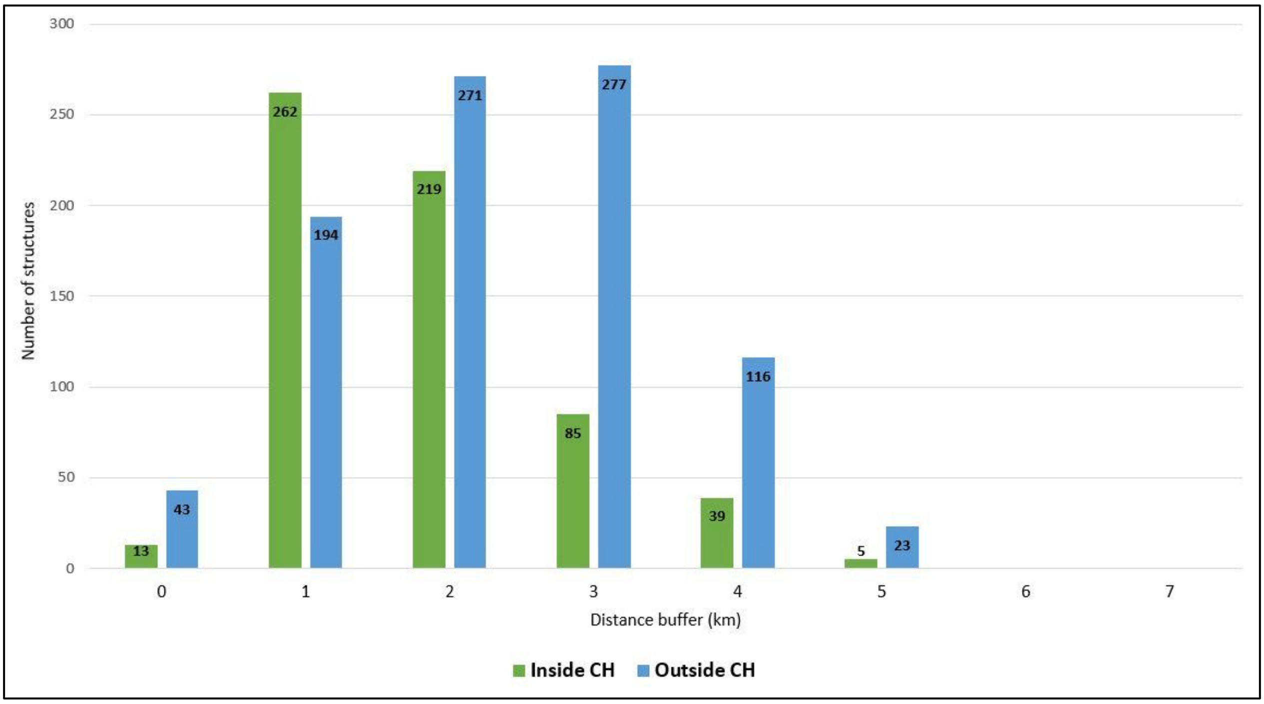


Fig. 14. Distribution of number of structures for each distance buffer

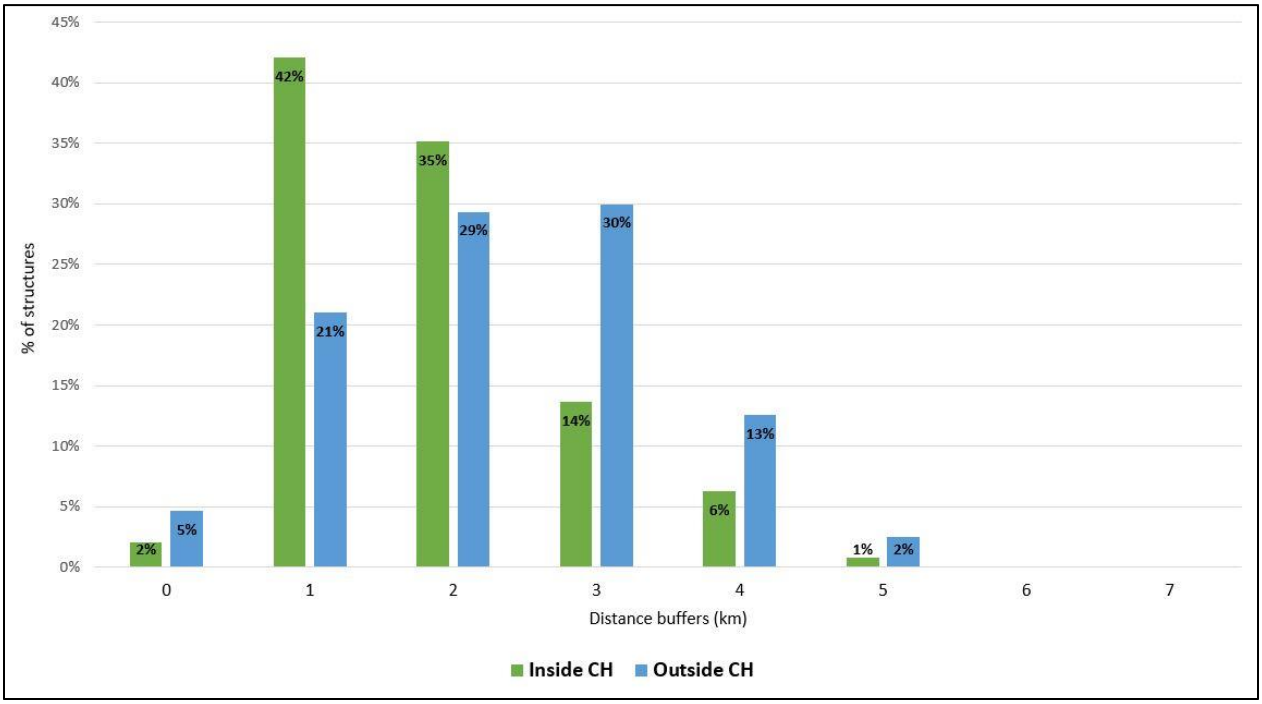


Fig. 15. Distribution of number of structures for each distance buffer as a percentage of the total number of structures

4. Discussion

No minimum size requirement was used for the resulting wilderness areas, so all areas, or “patches”, no matter how small, were included in the final map. Though great emphasis is put on wilderness areas being large and unfragmented, predominantly for ecological stability and integrity, there does not seem to be a generally accepted “one-size-fits-all” requirement (Cao et al., 2019) and ultimately this should depend on the ecological and geographical context (Kuiters et al., 2013). However, if a minimum size is deemed necessary for Iceland, this can easily be implemented into the existing methodology or at a later planning stage.

The methodology in this report applied a fairly standard analysis of roads, reservoirs, and powerlines. The impact of roads, for instance, was determined only by the *quality* of the roads – predominantly whether or not they were paved. But a more multi-dimensional assessment could include factors such as seasonal usage, traffic amount, and visibility. Similarly, reservoirs were treated with a rather coarse evaluation, but they could also be given different impact buffers based on, say, surface area. In fact, reservoirs were not included in the nationwide application since their size and influence were much less significant than those found within the Central Highland. Also powerlines could be further distinguished based on height, visibility, and above vs. underground. It would be interesting to explore these more nuanced approaches to these anthropogenic features in future mapping revisions.

The accuracy of the mapping outputs is largely dictated by the accuracy and comprehensiveness of the data originally collected for each structure. It is important to have the most updated information when compiling the structure database, such as any newly-built structures, precise geographic coordinates, and surface area and height measurements. For instance, due to the lack of pre-defined height information for most of the structures, a generic height for all structures had to be used for the visibility analyses, which indeed hindered the overall accuracy of the resulting cell counts. In this case, it is recommended that structure height data be formally included as part of current and future structure databases.

It should be made clear that, due to the use of the initial exclusion areas in the nationwide assessment, the 924 identified structures are of course not a comprehensive collection of *all* structures outside of the Central Highland. The exclusion areas were used as a filtering system to mitigate redundancies and make the structure identification process more manageable. It is certainly the case that many of these structures that fell within the exclusion areas (and thus were not assessed) may very well have had their own wilderness impact and corresponding distance buffer based on their individual characteristics (visibility, usage, etc), but for the purpose of this assessment, the focus was on structures in areas that had a much greater potential to be considered wilderness and would not have necessarily been overshadowed by more “intrusive” anthropogenic influences.

The nationwide assessment outside of the Central Highland differed slightly when it came to the connectivity criteria, specifically as it related to island structures and other structures close to the shoreline that would have had to cross large water bodies moving “as the bird flies” to get to the nearest road, as this was not as large of a concern in the Central Highland. For the latter structures, it would have been ideal to find an automated method to measure the distance of a realistic walking route (not necessarily a marked path) around the water body (e.g. hugging the coastline of a fjord). But the only other option at the time of the analysis was to manually measure each route one structure at a time, which was not possible due to time restraints. In order to maintain consistency with the treatment of these unique cases, a default score of “0” was given to these structures for both connectivity criteria. Also, many of them would have been given a “0” score anyway since they were often more than 10 km from the nearest road.

Another notable difference that was not a factor in the Central Highland assessment was the visibility of structures from the sea. The visible cell counts for many structures near or along the shoreline were significantly higher than structures within the landlocked Central Highland where topography played a larger role in limiting visibility. The visible cells from the sea were still counted as part of this assessment, but it raises the question as to the general significance or necessity of including sea coverage and if the scoring ranges for the cell counts would need to be re-evaluated to account for this discrepancy.

The distribution of structures by distance buffer (as shown in Figures 14 and 15) indicate that the majority of structures *within* the Central Highland tended to receive slightly smaller buffers (42%, 35%, and 14% of the structures received 1, 2, and 3 km buffers, respectively) compared to the structures *outside* of the Central Highland (21%, 29%, and 30%). As an example, 13% of the structures outside of the Central Highland received the two highest impact scores for surface area (scores of "13" or "20") as opposed to 7% of structures inside of the Central Highland. Also, 49% of structures outside of the Central Highland received the highest impact score of "20" for visibility as opposed to only 4% of structures inside of the Central Highland. These are unsurprising trends as it would be expected that larger and more "intrusive" structures are found in the more accessible and inhabited areas of the country (e.g. in the lowlands and coastal regions). The difference in visibility scores is also largely related to the sea coverage issue mentioned above, which requires further deliberation.

This mapping methodology results in a hard, "on-off" wilderness boundary, intended for planning purposes and attempts to adhere to a loose interpretation of Icelandic law, which has largely remained anthropocentric. As Cao et al. (2019) suggests, this sort of Boolean approach that clearly demarcates wilderness vs. non-wilderness can be particularly helpful, especially in the legal context for zoning and delineating potential conservation areas. Yet, this binary method can often overlook the complexities of the wilderness concept and may obfuscate the importance of relative wilderness quality. Increased interest in energy development and utilization, especially in Iceland's more remote areas of the Central Highland and Westfjords, has also accentuated the necessity to further explore advanced mapping techniques.

A defensible argument arises here, then, for a non-Boolean, or potentially mixed, mapping approach, which may account for a varied and more nuanced interpretation of wilderness. The methodology presented in Carver et al. (2012), and a similar approach recently applied to an Icelandic case study involving the Hvalá hydropower plant proposal in the Westfjords and its potential impacts on wilderness (Wildland Research Institute, 2019), appeals to this wilderness quality concept as a continuum or gradation, while also incorporating more nature-based criteria such as terrain (ruggedness) and land cover (perceived naturalness). Cao et al. (2019) introduces a mixed methodology that integrates a Boolean and continuum (weighted linear combination- WLC) approach to help maximize the strengths of both systems. It is therefore worth exploring a similar non-Boolean or hybrid application in the next round of Icelandic wilderness assessment.

5. Conclusion

This report outlines a working methodology of wilderness mapping in Iceland based on certain impacts from manmade structures, originally conducted for the Central Highland and then most recently applied to the rest of the country. This undertaking involves six impact criteria and a scoring system that is designed to function as a flexible framework for evaluating the anthropogenic influences on wilderness, acknowledging that different types of manmade structures yield different impacts. Components of the methodology such as the kinds of manmade structures that are (or are not) considered, exclusion areas, impact criteria, the scoring scheme, and distance buffers are intentionally dynamic and can be adjusted in new mapping iterations. As part of the ongoing deliberation to better understand the wilderness concept in general and to maximize its utility for planning and policy purposes, it will be important to consider other mapping approaches such as non-binary or hybrid models in future rounds of analysis, as is already being done in international applications, though still ensuring the main methodological pillars remain true to the Icelandic context.

References

Cao, Y., Carver, S., & Yang, R. (2019). Mapping wilderness in China: Comparing and integrating Boolean and WLC approaches. *Landscape and Urban Planning*, *192*, 103636.

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*(3-4), 395-409.

David C. Ostman & Þorvarður Árnason (2020). *Kortlagning víðerna á miðhálendinu: Framhaldsverkefni um þróun aðferðafræði*. Höfn: Rannsóknasetur Háskóla Íslands á Hornafirði.

Kuiters, A. T., Van Eupen, M., Carver, S., Fisher, M., Kun, Z., & Vancura, V. (2013). *Wilderness register and indicator for Europe*. Alterra: Wildland Research Institute.

Landmælingar Íslands (2020). *IS 50V Mannvirki*. https://gatt.lmi.is/geonetwork/srv/api/records/4C05F02C-7095-4C65-97A1-AC91AE427664

Skipulagsstofnun (2018). *Mannvirki á miðhálendinu. Framfylgdarverkefni Landsskipulagsstefnu 2015–2026*. Reykjavík: Skipulagsstofnun.

Wildland Research Institute. (2019). *Hvalá Power Plant Proposal: Review of Impacts on Wilderness*. https://rafhladan.is/handle/10802/28566

Þorvarður Árnason, David Ostman & Adam Hoffritz (2017). *Kortlagning víðerna á miðhálendi Íslands: Tillögur að nýrri aðferðafræði*. Höfn: Rannsóknasetur Háskóla Íslands á Hornafirði.