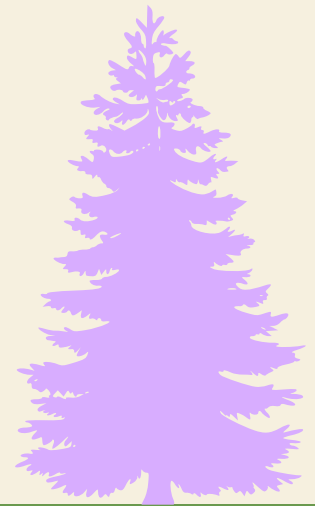




WPI

SUPPLEMENTARY MATERIALS

Assessing Lupine as an Environmental Conservation Tool in Iceland



Team Members

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An Interactive Qualifying Project
submitted to the faculty of Worcester
Polytechnic Institute in partial fulfillment
of the requirements for the Degree of
Bachelor of Science

METHODOLOGY SUPPLEMENTARY MATERIALS

Appendix A. Interview Questions for the Icelandic Forestry Service

How long have you been with the Icelandic Forestry Service and what is your role there?

What are the biggest successes of the Icelandic Forestry Service?

What environmental governmental policy have you advocated for?

What are the most important initiatives in the Icelandic Forestry Service to promote reforestation? What future plans do you have to promote reforestation?

What are the most important initiatives in the Icelandic Forestry Service to control soil erosion? What future plans do you have to control soil erosion?

How has the soil quality of Iceland affected your work?

What has been the most effective method you've found to improve soil quality/erosion?

Do you know of any native species in Iceland that can be used to stabilize soil allowing tree growth in the future?

How has the Arctic Lupine affected your efforts in reforestation?

Do you feel Arctic Lupine is still beneficial to the environment?

What do you think should be done about the Arctic Lupine?

Are there any other experts we should contact that you think we would learn from?

Is there anything we have not asked about that you would like to tell us about?

Appendix B. Interview Questions for the Soil Conservation Service of Iceland

How long have you been working for the Soil Conservation Service and what is your role there?

What are the biggest successes of the Soil Conservation Service?

What actions have your organization taken to promote soil conservation?

What actions have been taken to educate or advise others on soil conservation?

What has your organization found to be the biggest issue contributing to soil erosion?

How has the soil quality of Iceland affected your work?

What has been the most effective method you've found to improve soil quality/erosion?

What native species in Iceland can/have been used to stabilize soil?

What is your opinion on alien vs native species being used for soil conservation?

How does using Lupine affect your work?

Do you feel Lupine has been beneficial to the environment?

Are there any other experts we should contact that you think we would learn from?

Is there anything we have not asked about that you would like to tell us about?

Appendix C. Interview Questions for the Icelandic Farmers Association

How long have you been with the Icelandic Farmers Association and what is your role there?

What are the biggest successes of the Icelandic Farmers Association?

What actions have you taken to promote soil conservation?

What advice do you have for farmers dealing with soil erosion?

What are the most important initiatives in the Icelandic Farmers Association?

How has the soil quality of Iceland affected your work?

What has been the most effective method you've found to improve soil quality/erosion?

What native species in Iceland can/have been used to stabilize soil allowing tree growth in the future?

How does using Lupine affect your work?

Do you feel Lupine is still beneficial to the environment?

What do you think should be done about the Lupine?

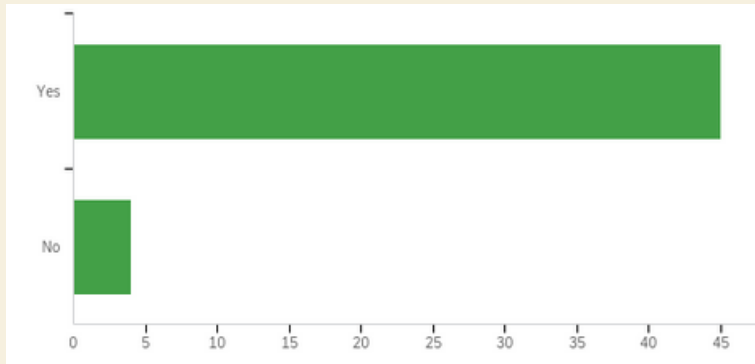
Are there any other experts we should contact that you think we would learn from?

Is there anything we have not asked about that you would like to tell us about?

RESULTS AND FINDINGS SUPPLEMENTARY MATERIALS

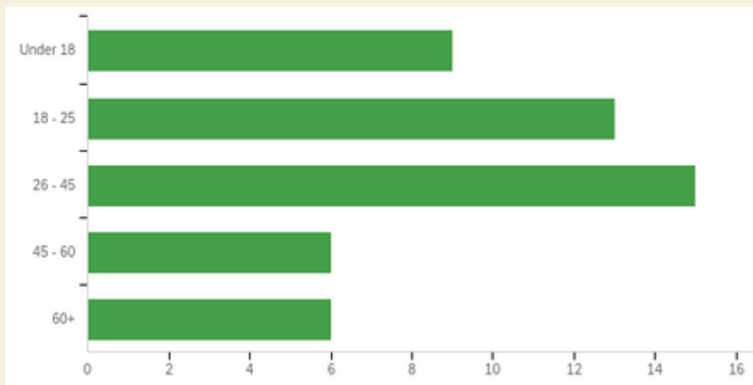
Appendix D. Public Survey Questions and Results

Question 1: Do you live in Iceland?



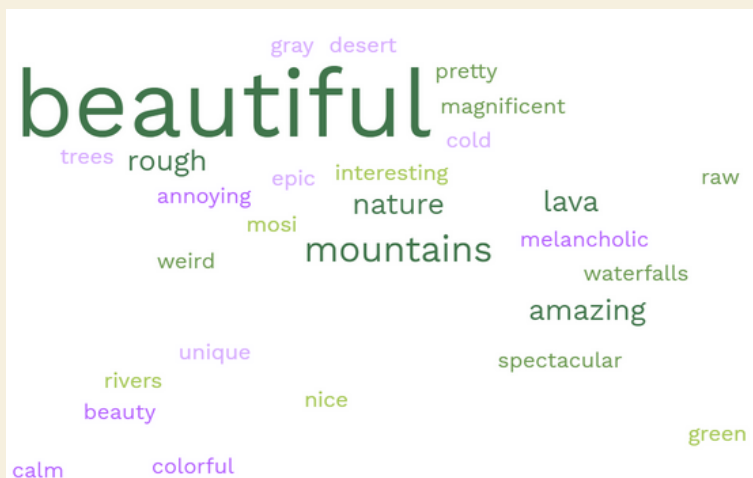
There were 49 total responses. 44 responded "Yes".

Question 2: How old are you?



9 people responded that they were under 18 years old. 13 people responded that they were between the ages 18-25 years old. 15 people responded that they were between the ages 26-45 years old. 6 people responded that they were between the ages 45-60. 6 people responded that they were over the age of 60 years old.

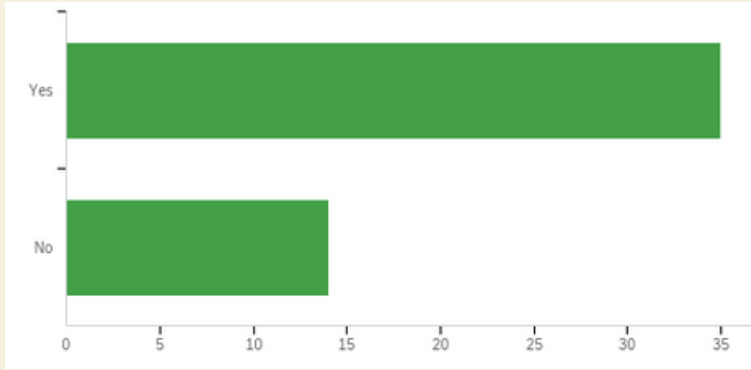
Question 3: Describe the Icelandic landscape in a few words.



The word beautiful was used the most to describe the Icelandic landscape. This is why it appears the largest in the word cloud.

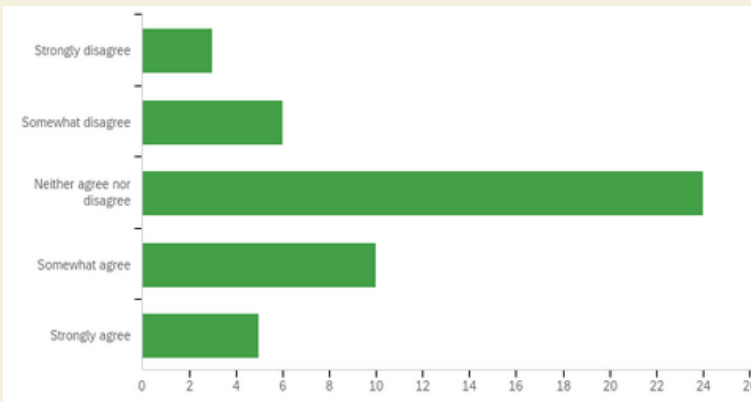
Appendix D. Public Survey Questions and Results

Question 4: Are you familiar with the plant lupine (Arctic, Nootka, Alaskan)?



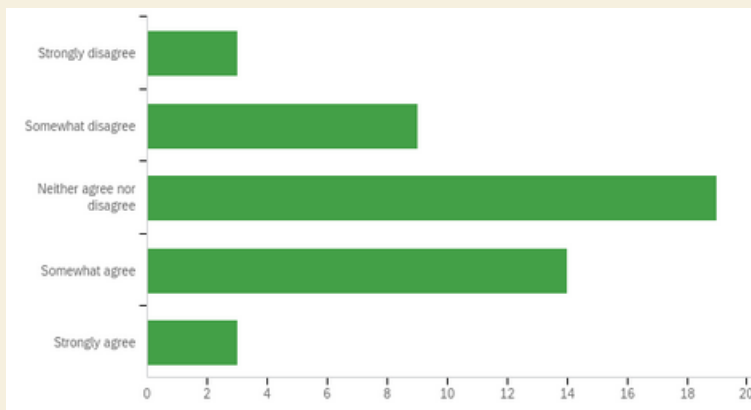
Out of 49 total responses, 35 said they are familiar with lupine

Question 5: I have strong opinions about lupine.



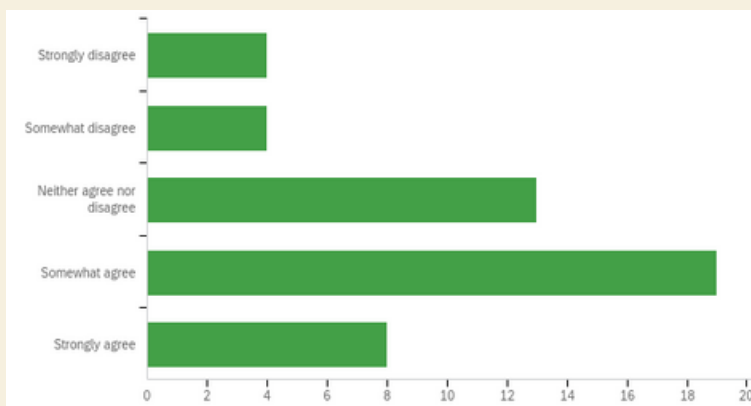
3 people strongly disagree, 6 people somewhat disagree, 24 people neither agree nor disagree, 10 people somewhat agree, 5 people strongly agree

Question 6: Lupine has a positive impact on the Icelandic environment.



3 people strongly disagree, 9 people somewhat disagree, 19 people neither agree nor disagree, 14 people somewhat agree, 3 people strongly agree

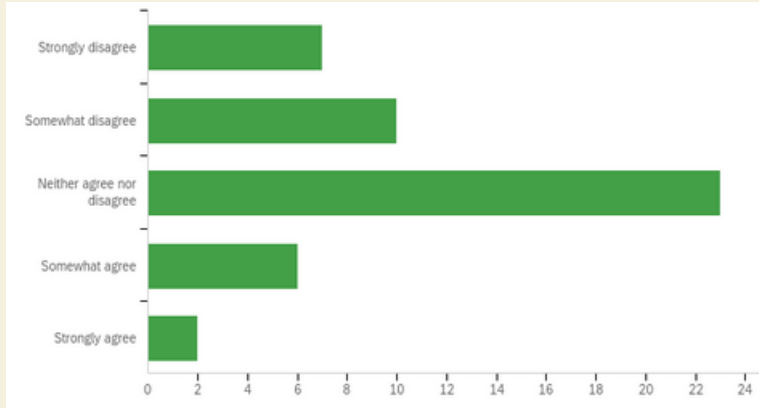
Question 7: Lupine visually improves the Icelandic landscape.



4 people strongly disagree, 4 people somewhat disagree, 13 people neither agree nor disagree, 19 people somewhat agree, 8 people strongly agree

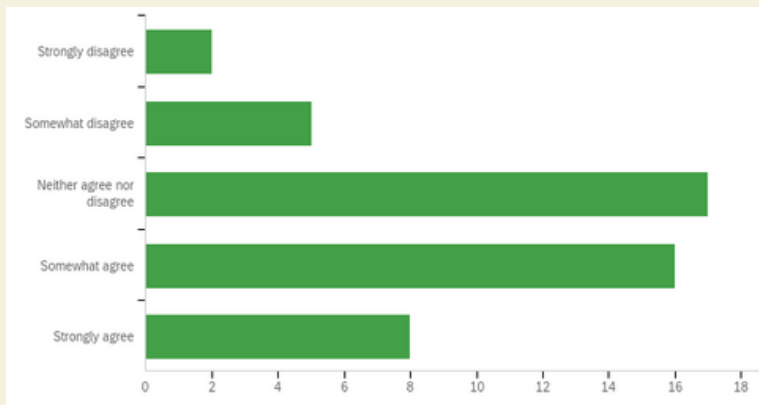
Appendix D. Public Survey Questions and Results

Question 8: Alien species like lupine do not belong in Iceland.



7 people strongly disagree, 10 people somewhat disagree, 23 people neither agree nor disagree, 6 people somewhat agree, 2 people strongly agree

Question 9: Lupine is an invasive species.



2 people strongly disagree, 5 people somewhat disagree, 17 people neither agree nor disagree, 16 people somewhat agree, 8 people strongly agree

Question 10: Do you have anything else you would like to add? Thank you for your time

These are some of the results we received from this question:

"Good luck with ur project"

"Nice survey"

"i love lupin, and thank it for the service it has done growing our land :)"

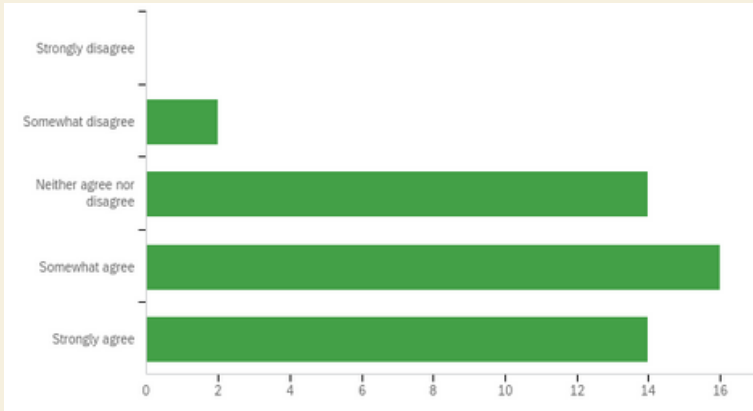
"maybe a picture of the flower"

"good luck guys"

"lupines suck but are nice to look at"

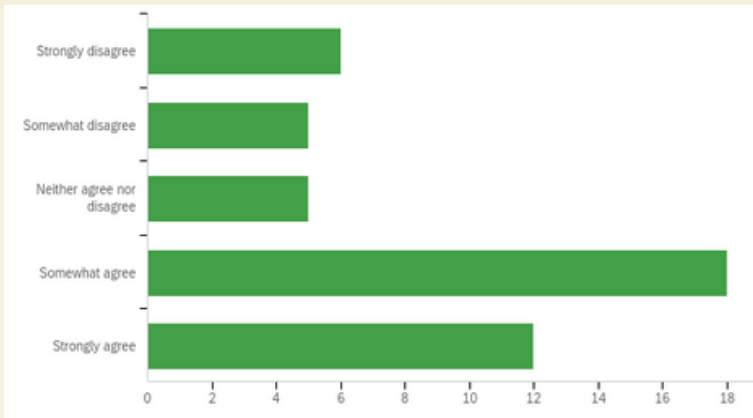
Appendix E. Reddit Online Survey Questions and Results

Question 5: I have strong opinions about lupine.



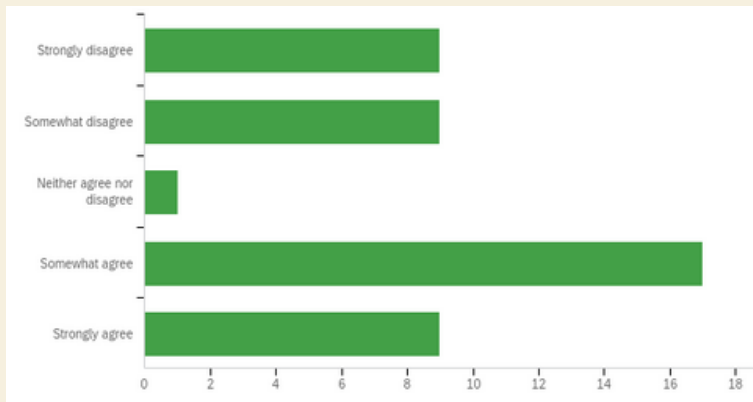
0 people strongly disagree, 2 somewhat disagree, 14 neither agree nor disagree, 16 somewhat agree and 14 strongly agree

Question 6: Lupine has a positive impact on the Icelandic environment.



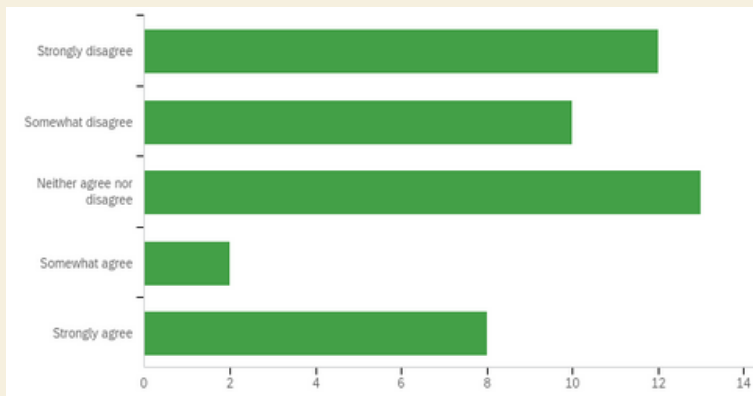
6 people strongly agree, 5 people somewhat disagree, 5 people neither agree nor disagree, 18 somewhat agree and 12 strongly agree

Question 7: Lupine visually improves the Icelandic landscape.



9 people strongly agree, 9 people somewhat disagree, 1 people neither agree nor disagree, 17 somewhat agree and 9 strongly agree

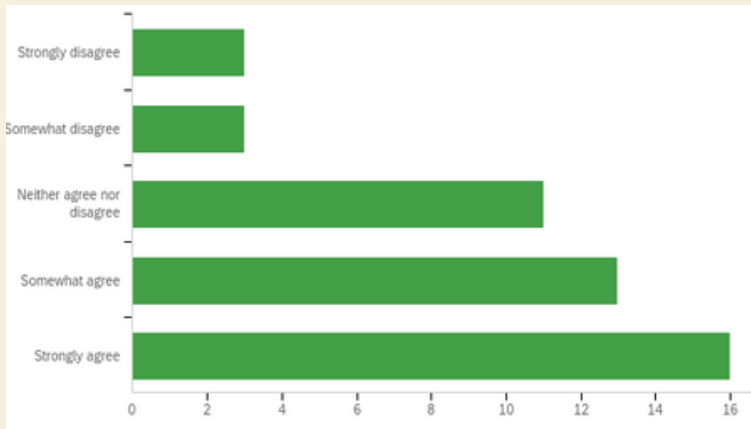
Question 8: Alien species like lupine do not belong in Iceland.



12 people strongly agree, 10 people somewhat disagree, 13 people neither agree nor disagree, 2 somewhat agree and 8 strongly agree

Appendix E. Reddit Online Survey Questions and Results

Question 9: Lupine is an invasive species.



3 people strongly agree, 3 people somewhat disagree, 11 people neither agree nor disagree, 13 somewhat agree and 16 strongly agree

Question 10: Do you have anything you would like to add?

These are some of the results we received from this question:

"Lúpína is trash!"

"The lupine is unlikely to thrive as well in Iceland some decades from now, same goes for the few indigenous species it supposedly threatens. If we don't let the lupine spread and renew the soil now before it gets too warm, then Iceland will be condemned to desertification."

"I have a bsc in biology and have worked in plant ecology, and I am very much opposed to the lupine and have taken part in trying to eradicate it from some locations"

"I used to work for my municipality uprooting lupins within town limits, have a horticultural education pertaining to lupins and am familiar with their history here. I appreciate the plant and don't see the need to control it. Anything that stops soil erosion is a plus."

"I don't have much strong opinion on it, it can be invasive but it's only reserved to the spots on the outskirts of kópavogur and as a child I always found myself playing in them often since they acted as really tall grass"

"Lupine will only work to restore the country if trees like birch are also planted where the lupine has created soil"

"Theres a farmland I know of which had a few lupines planted several years later there were thousands of them going in every direction you could see"

"Lupine is appropriate where the landscape is barren since it doesn't take long for it to make the ground very nutritious for other species. They play well with some species, others not so much. Great for fertilizing the ground for ex. potatoes."

"Lupine should be used with caution but can be extremely useful to create conditions for other flora to flourish."

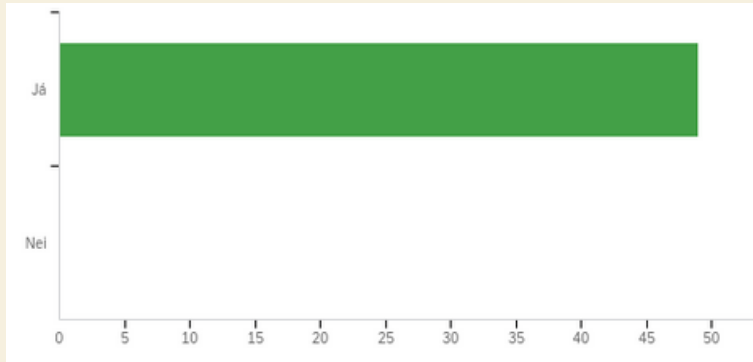
"I've personally seen it destroy blueberryland and nesting grounds for artic terns."

"General consensus of my peers, many of whom who habit the rural regions, is that the lupine is a benefit to their soil quality. Everything else verges on romanticism"

"The lupine is an invasive species, but so are the humans that settled Iceland and we have done way more damage to Iceland then the lupine could ever do."

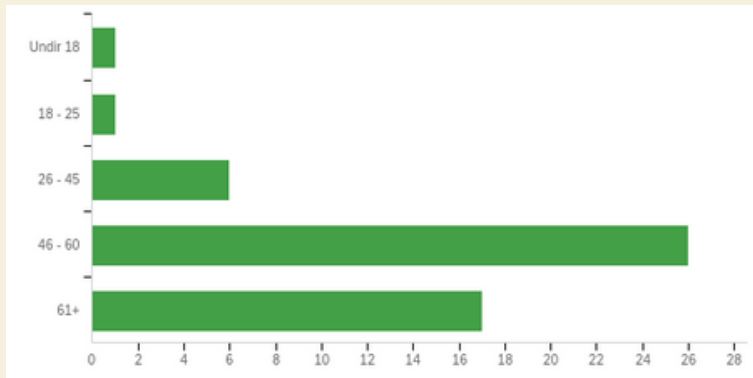
Appendix F. Farmers Newspaper Online Survey Questions and Results

Question 1: Býrðu á Íslandi? (Do you live in Iceland?)



There were 51 total responses. All responded "Yes".

Question 2: Hvað ertu gamall? (How old are you?)



1 person responded that they were under the ages of 18 years old. 1 person responded that they were between the ages 18-25 years old. 6 people responded that they were between the ages 26-45. 26 people responded that they were between the ages of 45-60. 19 people were over the age of 60 years old.

Question 3: Lýstu íslensku landslagi með nokkrum orðum. (Describe the Icelandic landscape in a few words.)

These are some of the responses we received:

"Örfoka og niðunítt"

"Ósnortið að mestu, fjölbreytt, gróið og hrjóstrugt"

"Ílla farið af langvarandi ofbeit"

Question 4: Hvernig myndir þú lýsa jarðveginum á landi þínu? (How would you describe the soil on your land?)

These are some of the responses we received:

"Mikill gróður hér í Glæsibæ í Árbænum."

"Var rýr, grjót, melar, lyng. (Sumarbústaðaland)"

"Frjósamur i dölum og undirlendi en annars rýr"

"Hraun flákar með gróðri á milli."

"Léleg."

"Fokgjarn, fremur ófrjósamur. Mikil eyðing jarðvegs hefur orðið á undanförunum öldum vegna ósjálfbærrar landnotkunar."

"Meirihlutinn fokinn á haf út"

"Mikið af móajarðvegi og sendnum jarðvegi en mýrarjarðvegur finnst líka"

Appendix F. Farmers Newspaper Online Survey Questions and Results

Question 5: Í hvað notar þú landið þitt? (What do you use your land for?)

These are some of the responses we received:

"ánægju"

"á ekki land"

"Útivist"

"Í sauðfjárbreit aðallega."

"Ég á ekki land."

Question 6: Hvaða, ef einhverjar, aðferðir ertu að nota til að bæta jarðvegsgæði á landi þínu? (What, if any, methods are you using to improve soil quality on your land?)

These are some of the responses we received:

"Moltugerð on tilbúinn áburð."

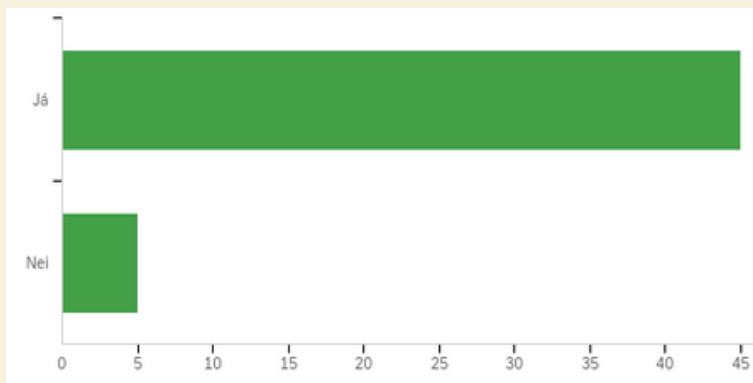
"Er með rauðsmára, hvítmára, elri. Endurvinn allan úrgang, flyt ekkert af landinu. (Hef nánast eytt lupínu af landinu með vistvænum aðferðum)."

"Skjoltarækt og áburðarnotku"

"Lúpínu og tilbúin áburð á stærri svæði"

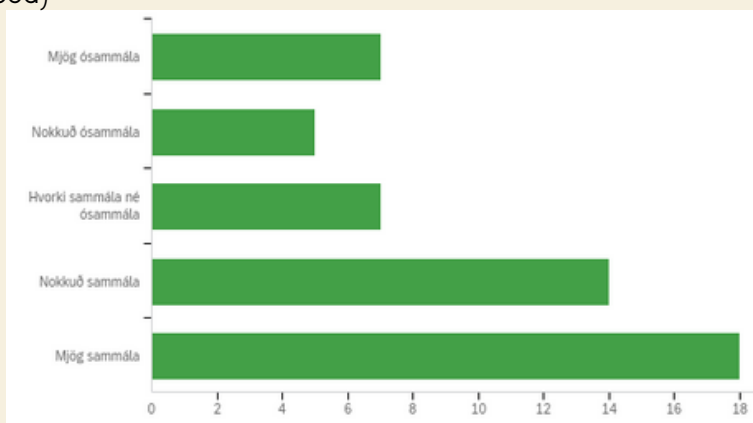
"Reyni að loka sár í gróðurhulu með því að dreifa þar hæsnaskít."

Question 7: Þekkir þú lúpínu sem umhverfisverndartæki? (Do you know lupine as an environmental protection tool?)



There were 52 total responses. 47 responded "Yes" and 5 responded "No".

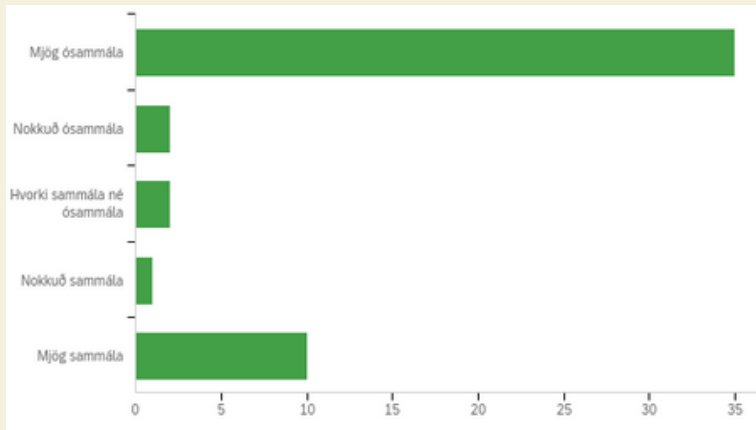
Question 8: Jarðvegseyðing hefur neikvæð áhrif á land mitt og lífsviðurværi (Soil erosion has a negative impact on my land and livelihood)



9 people strongly agree, 5 people somewhat disagree, 7 people neither agree nor disagree, 15 somewhat agree and 18 strongly agree

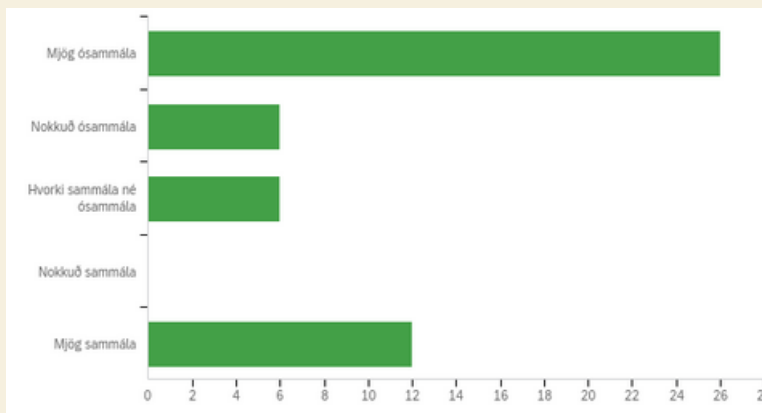
Appendix F. Farmers Newspaper Online Survey Questions and Results

Question 9: Það er meira af lúpínu á landi mínu en ég myndi vilja. (There is more lupine on my land than I would like.)



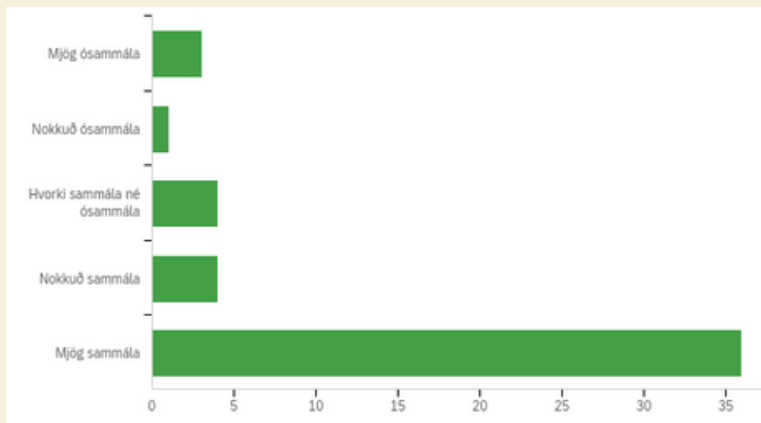
35 people strongly agree, 3 people somewhat disagree, 3 people neither agree nor disagree, 1 somewhat agree and 11 strongly agree

Question 10: Lúpína hefur neikvæð áhrif á innlenda íslenska gróður. (Lupine has a negative impact on native Icelandic flora)



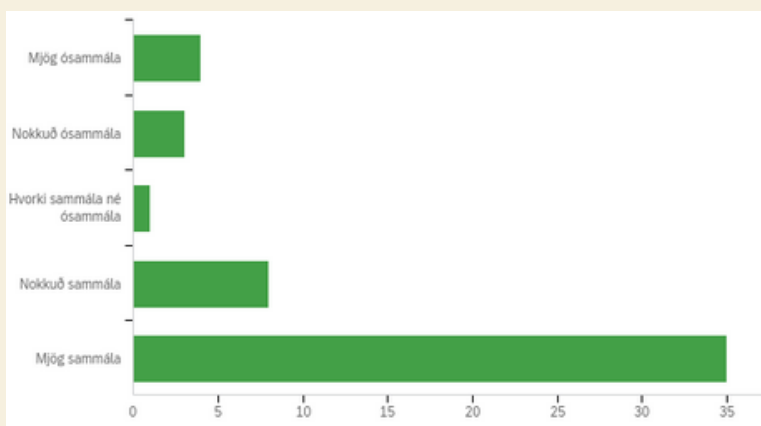
28 people strongly agree, 6 people somewhat disagree, 6 people neither agree nor disagree, 1 somewhat agree and 12 strongly agree

Question 11: Lúpína er gott tæki til að bæta næringarefnum í jarðveginn. (Lupine is a good tool for adding nutrients to the soil)



4 people strongly agree, 1 person somewhat disagree, 4 people neither agree nor disagree, 5 somewhat agree and 37 strongly agree

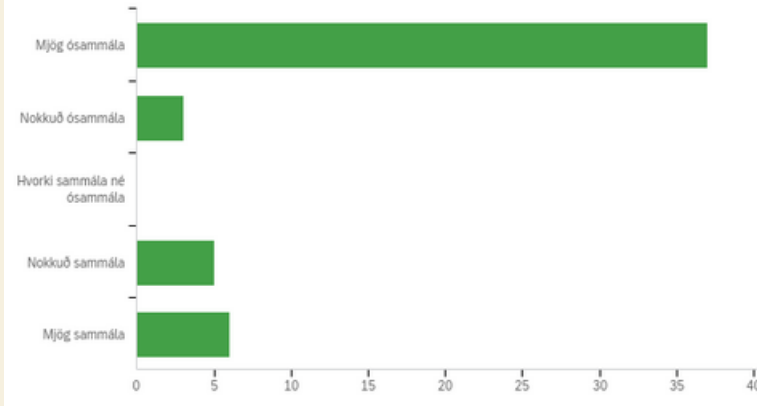
Question 12: Lúpína er gott tæki til að koma í veg fyrir jarðvegseyðingu. (Lupine is a good tool for preventing soil erosion)



4 people strongly agree, 4 person somewhat disagree, 1 people neither agree nor disagree, 8 somewhat agree and 37 strongly agree

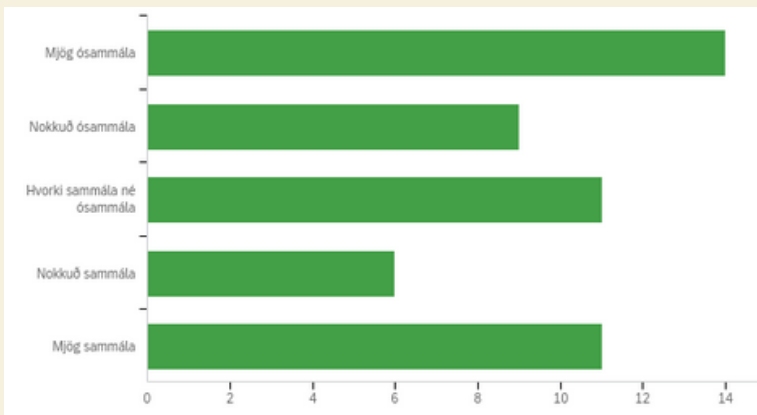
Appendix F. Farmers Newspaper Online Survey Questions and Results

Question 13: Óinnfæddar tegundir eins og lúpína eiga ekki heima á Íslandi. (Non-native species like lupine do not belong in Iceland)



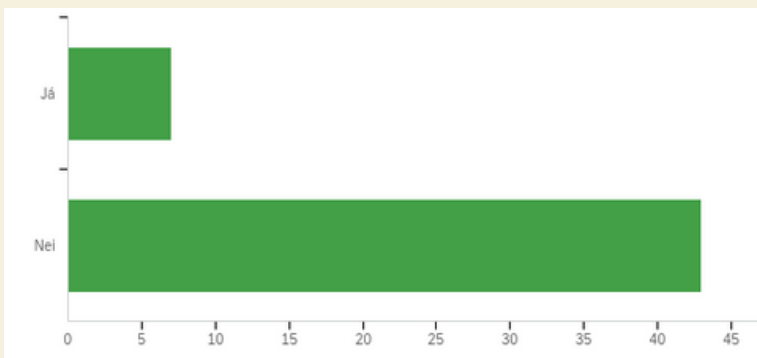
39 people strongly agree, 3 people somewhat disagree, 1 person neither agree nor disagree, 5 somewhat agree and 6 strongly agree

Question 14: Lúpína er ágeng tegund. (Lupine is an invasive species)



14 people strongly agree, 10 people somewhat disagree, 11 people neither agree nor disagree, 8 somewhat agree and 11 strongly agree

Question 15: Efnahagslegar áhyggjur koma í veg fyrir að ég geti tekið á vandamálum um jarðvegsgæði á landi mínu. (Economic concerns are preventing me from addressing soil quality issues on my land.)



There were 53 total responses. 7 responded "Yes" and 46 responded "No".

Question 16: Er eitthvað fleira sem þú vilt bæta við? Þakka þér fyrir. (Is there anything else you would like to add? Thank you.)

These are some of the responses we received:

"Innlend ágeng plantna er að leggja undir sig Elliðaárdal"

"Hef séð lúpínu vaða yfir lyng og annan íslenska fjallagróður. Ég vil hafa fjölbreytileika, en lúpunaner einsleit, ljót 10 mánuði á ári og af henni stafar brunahætta."

"Lupina er góð með ræktun birkiskóga"

"Áríðandi er að bæta jarðveg og gróðurhulu á Íslandi, en nauðsynlegt er að gera það með vistheimt, ekki með því að fjölga hér framandi tegundum."

Appendix G. Observational Results

Photos From Outside Bugar Forest



Trees shown being capable of growing in loose volcanic soil



Trees growing with and without lupine. The foreground shows trees without lupine assistance and the background shows trees with lupine. All trees were planted in the same year



Field of young sitka spruce trees. Some needles appear yellow due to a lack of nitrogen. However, they are still able to grow



Trees growing among other low lying flora in sandy soil



Young trees shown are able to grow on their own in volcanic soil given enough time

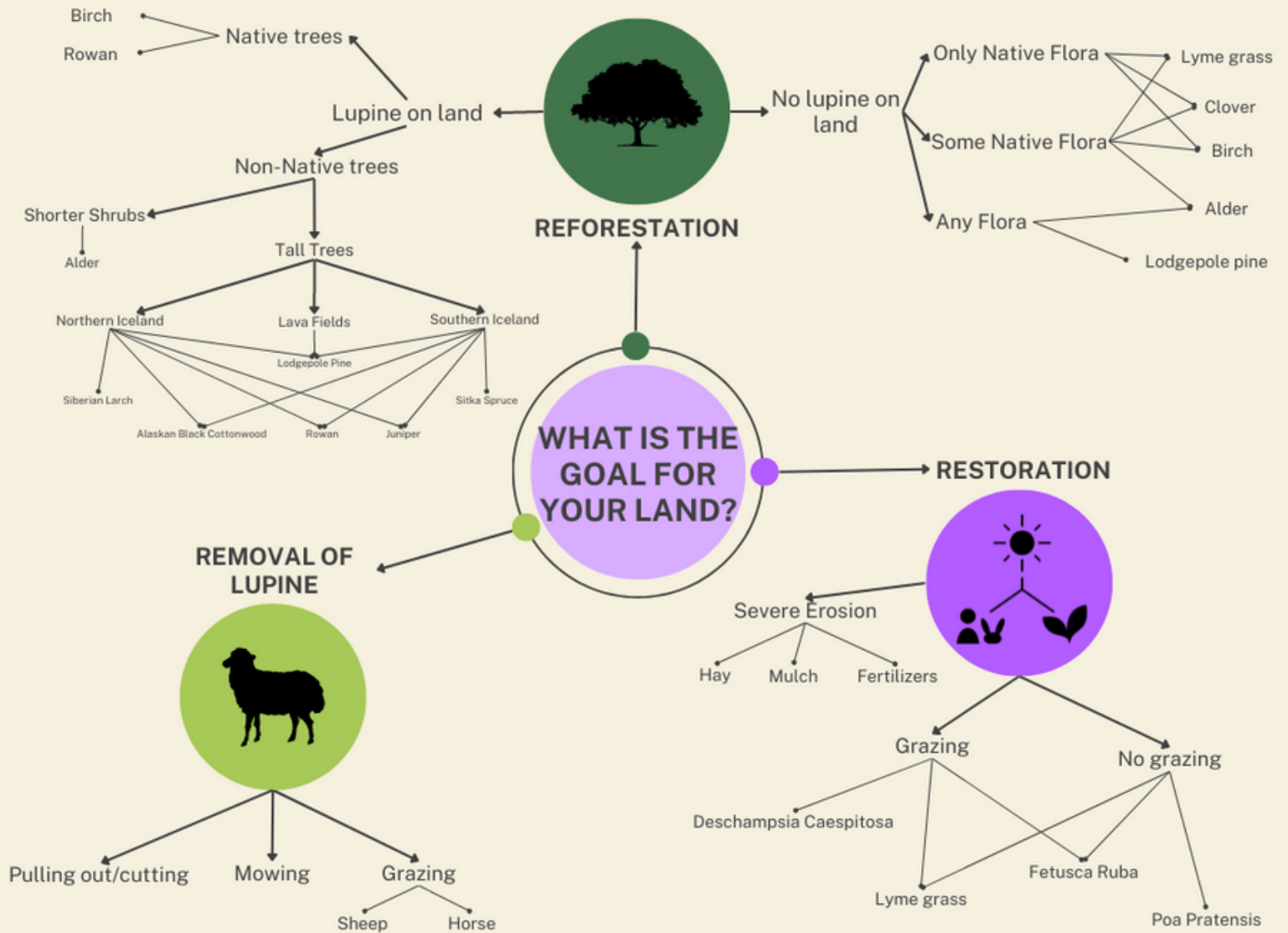


Very small sapling peeking through the soil

RECOMMENDATIONS SUPPLEMENTARY MATERIALS

Appendix H. Decision Guide

Shown below is the decision guide recommending best land use practices to Icelandic land-owners. We recognize there is no umbrella answer for environmental conservation, so this guide is intended only to suggest productive methods to maintain land. For more details on the recommended plant species, see Appendix I.



Appendix I. Flora Sheet

Below are details on the recommended plant species not included in the booklet. Important attributes are listed so that the reader can decide whether or not the flora is appropriate to use on their land. For example, all flora have the temperature they would best thrive in and the location where they would grow the best. Other information includes whether or not the plant can provide nitrogen for the soil or if the plant is native or non native to Iceland.



Juniperus
(Common Juniper)

- Lowest temperature it can survive is -45°C , thrives in Southern Iceland
- Non native to Iceland
- Needs nitrogen fixed soil



Sorbus subsp. Sorbus
(Native Rowan)

- Lowest temperature it can survive is -40°C , thrives in either Northern or Southern Iceland
- Native to Iceland
- Needs nitrogen fixed soil

Deschampsia caespitosa
(Hairgrass)

- Can survive in any temperature and location in Iceland
- Non native to Iceland
- Grazing resistant
- Can be used to add nitrogen to the soil, but needs some fertilizer to grow at first

Populus trichocarpa
(Alaskan Blackwood)

- Lowest temperature it can survive is -47°C , thrives in Southern Iceland
- Non native plant, originates from Alaska
- Needs nitrogen fixed soil

Festuca rubra
(Red Fescue)

- Can survive in any temperature, thrives in Northern Iceland
- Non native to Iceland
- Isn't invasive
- Can be used to add nitrogen to the soil, but needs some fertilizer to grow at first

Appendix J. Typeform Create your own adventure guide

Along with our decision guide, we created a make your own adventure guide that the reader can use to decide how to improve their land. It goes more in depth than the decision guide because it refers to all the plants that can be used for the Icelandic landscape. We hope the reader utilizes our suggestions in this guide to help improve the environment.



QR Code for Make Your Own Adventure Decision Guide

REFERENCES

<https://www.flickr.com/photos/88123769@N02/13576048313> (Birch)

<https://wordpress.org/openverse/image/8d5af9c5-65f0-4739-9e26-afa831fc2500> (Sitka Spruce)

<https://wordpress.org/openverse/image/d2b1e803-699b-438f-9f2d-54693b386596>
(Lodgepole Pine)

"Lodgepole Pine Trees: Yellowstone National Park/Grand Teton" by Jeremy-R-Michael is licensed under CC BY 2.0.

<https://wordpress.org/openverse/image/cf83f46d-e806-4e4c-b9b6-5c5597c70083> (Lyme Grass)

"Lyme grass - *Leymus arenarius*" by Jeremy Halls is licensed under CC BY-NC-SA 2.0.

<https://wordpress.org/openverse/image/cfd381cc-4a0e-4699-930b-40ffec7fe45a> (Sitka Alder, CC-BY-SA)

"File:Alders, Glen Shellish - geograph.org.uk - 1230594.jpg" by Richard Webb is licensed under CC BY-SA 2.0.

<https://wordpress.org/openverse/image/077c7ea7-2855-4509-b29f-00a7f236309c>
(Kentucky Bluegrass)

"Kentucky Bluegrass" by ND Parks and Recreation Department is licensed under CC BY-NC-ND 2.0.

<https://unsplash.com/photos/FFwAlbkdWPI> (Siberian Larch)

<https://unsplash.com/s/photos/white-clover> (White Clover)

<https://unsplash.com/photos/r3LzP-3ZSk0> (Native Rowan)

<https://unsplash.com/photos/zsid11lCvUQ> (Common Juniper)