Effects of climate change on the habitat suitability of 4 relatively new invasive plant species in the Pacific Northwest

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University of British Columbia

October 5, 2022

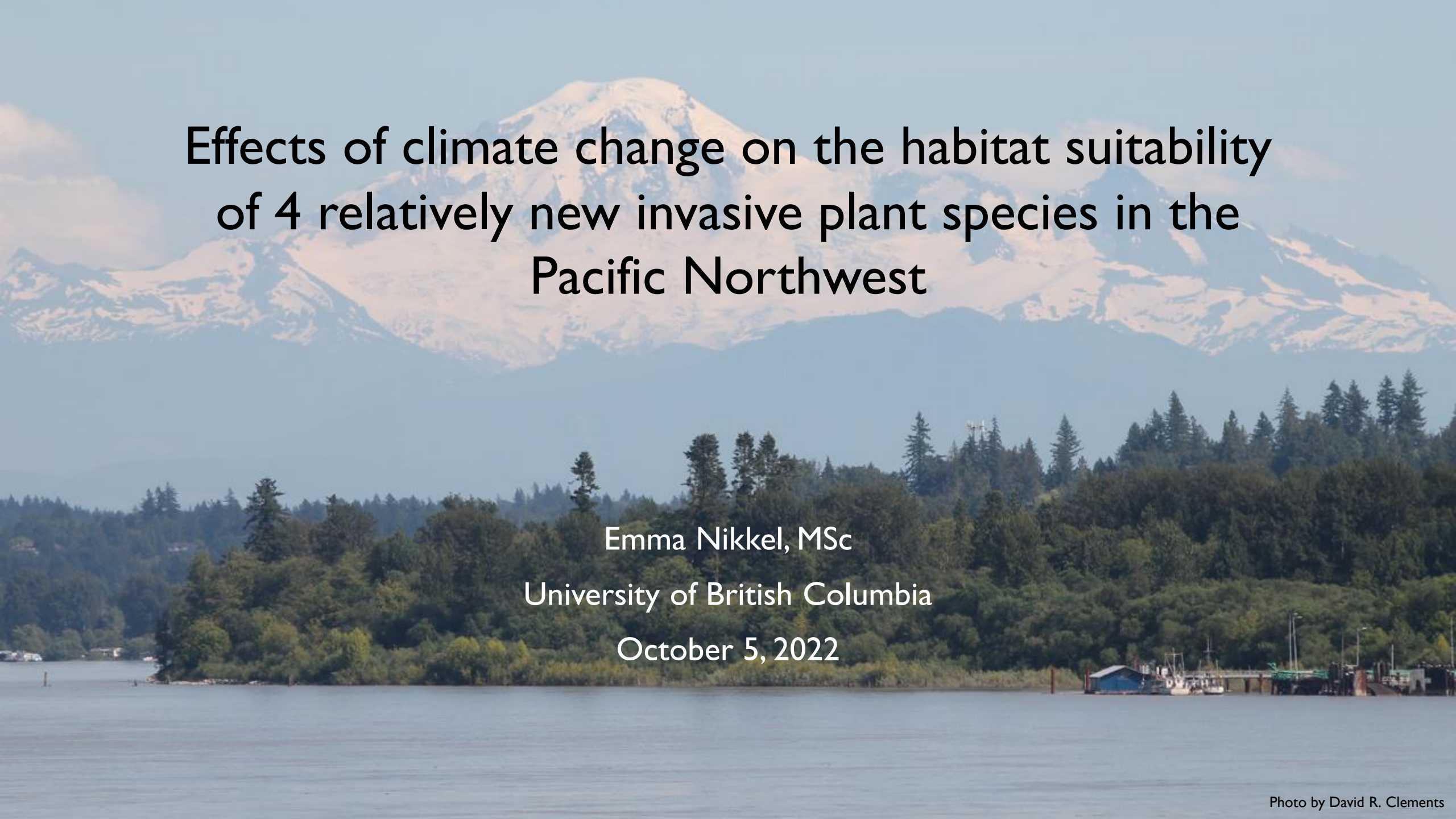
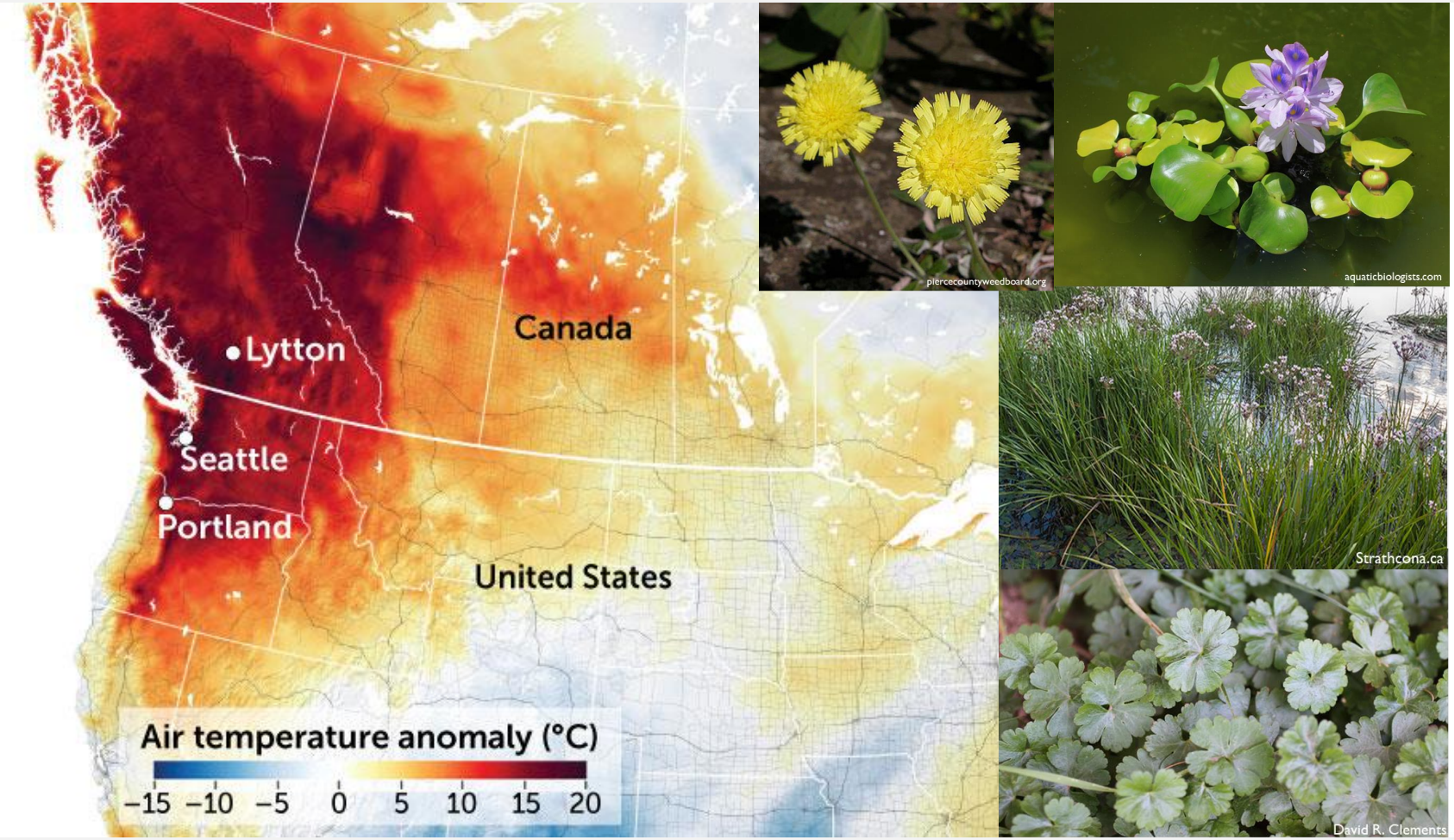


Photo by David R. Clements

CLIMATE CHANGE IN THE PACIFIC NORTHWEST



June 29, 2021, temperature compared to the 2014-2020 average for that day (NASA)

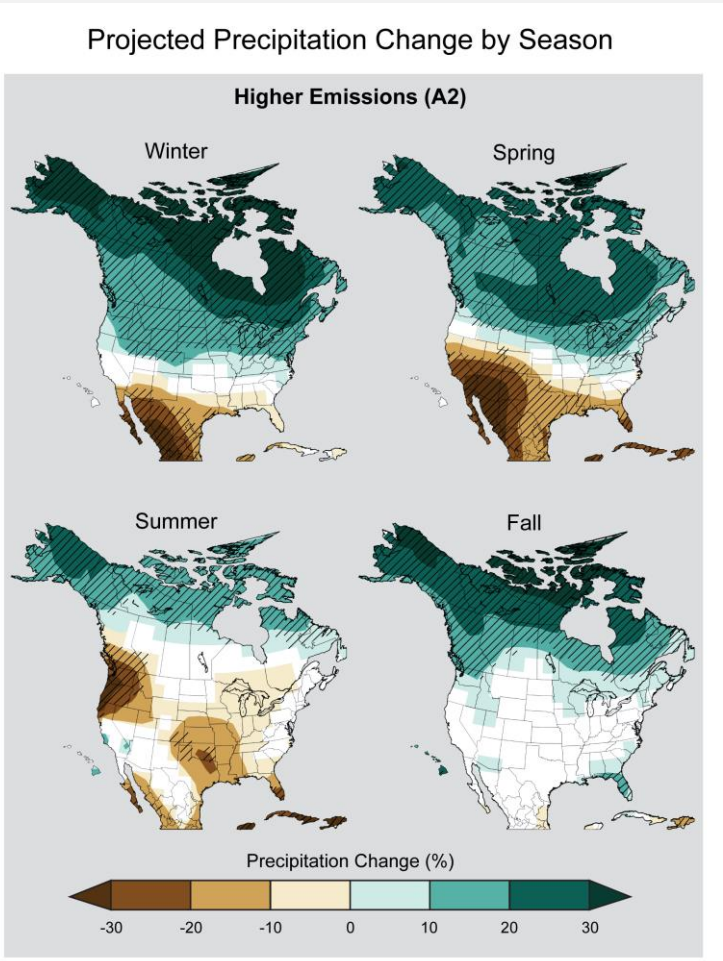
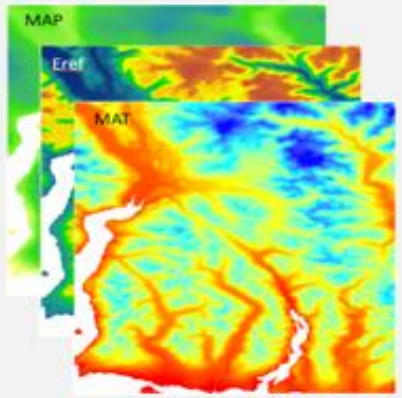


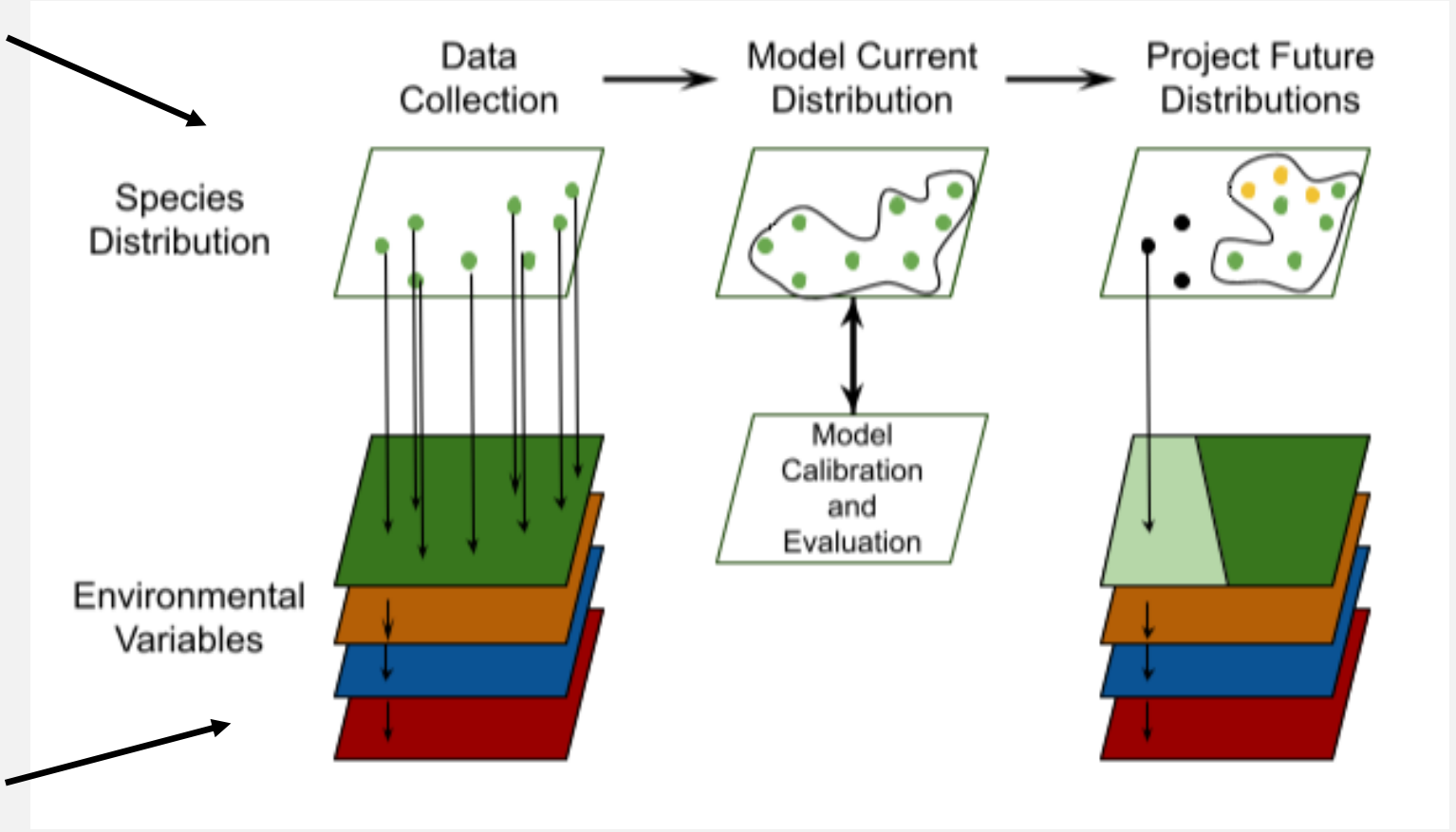
Figure source: NOAA NCDC

HABITAT SUITABILITY MODELING

Species Occurrences



Climate Variables



RESEARCH QUESTIONS

1. What are the relative contributions of climate, land cover, and human influence on modelled current habitat suitability of invasive plant species in the PNW?

2. How do future climate projections change the distribution of each invasive plant species? Are the distributions predicted to expand or contract due to climate change?

TERRESTRIAL SPECIES

Shiny Geranium - *Geranium lucidum*

Mouse-ear Hawkweed - *Hieracium pilosella*

AQUATIC SPECIES

Flowering Rush - *Butomus umbellatus*

Water Hyacinth - *Pontederia crassipes*

DATA COLLECTION

Species Record Collection

Species	Raw Data*	Cleaned Data
Shiny Geranium	2,243	563
Flowering Rush	12,254	509
Mouse-ear Hawkweed	637	226
Water Hyacinth	26,956	649

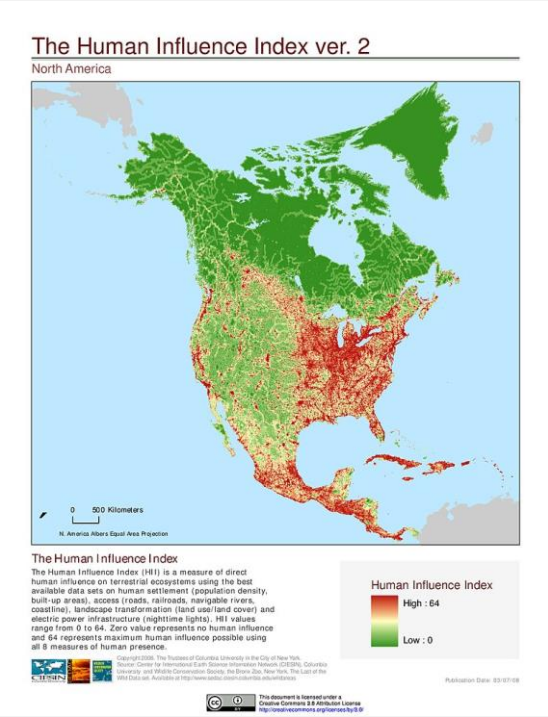
* Records downloaded from the Global Biodiversity Information Facility (GBIF), EDDMaps (North American database), and Invasive Alien Plant Program (IAPP; BC database)

GBIF Global Biodiversity Information Facility

EDDMapS find · map · track

Environmental Variables

- Climate (33 biologically relevant variables from ClimateNA)
- Land Cover (10 types from FAO world database)
- Human Influence Index (SEDAC)



sedac.ciesin.columbia.edu

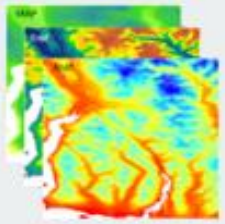
WHAT ARE THE RELATIVE CONTRIBUTIONS OF CLIMATE, LAND COVER, AND HUMAN INFLUENCE ON MODELLED CURRENT HABITAT SUITABILITY?

Species Records

GBIF Global Biodiversity Information Facility

EDDMapS find · map · track

Environmental Variables



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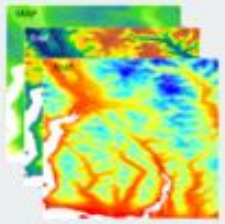


Assess variable collinearity

WHAT ARE THE RELATIVE CONTRIBUTIONS OF CLIMATE, LAND COVER, AND HUMAN INFLUENCE ON MODELLED CURRENT HABITAT SUITABILITY?

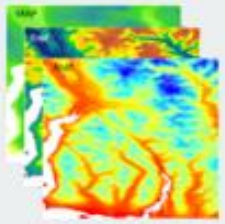
Model Building

Species Records

GBIF Global Biodiversity Information Facility

EDDMapS find · map · track

Environmental Variables



Assess variable collinearity

6 algorithms (GLM, GAM, MARS, RF, GBM, and ANN)

10 pseudo-absence generations

5 cross-validation runs

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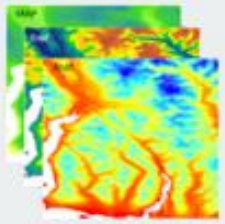

Assess variable collinearity

6 algorithms (GLM, GAM, MARS, RF, GBM, and ANN)

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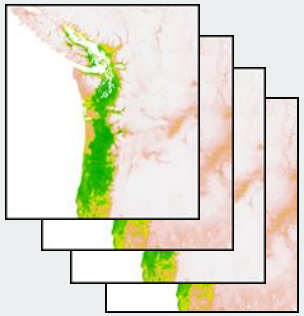
5 cross-validation runs

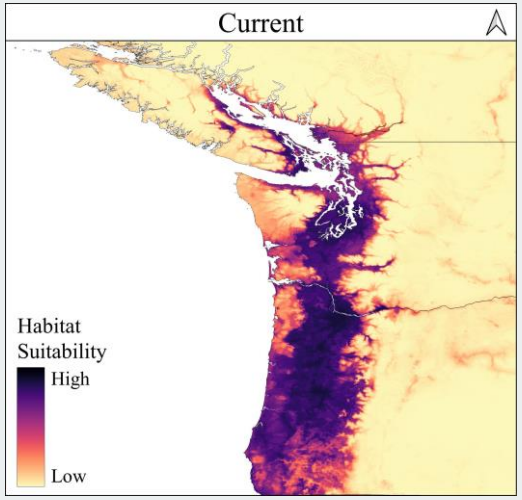
300 models



All models with TSS > 0.7 included in ensemble model

WHAT ARE THE RELATIVE CONTRIBUTIONS OF CLIMATE, LAND COVER, AND HUMAN INFLUENCE ON MODELLED CURRENT HABITAT SUITABILITY?

Current Habitat Suitability Ensemble Model



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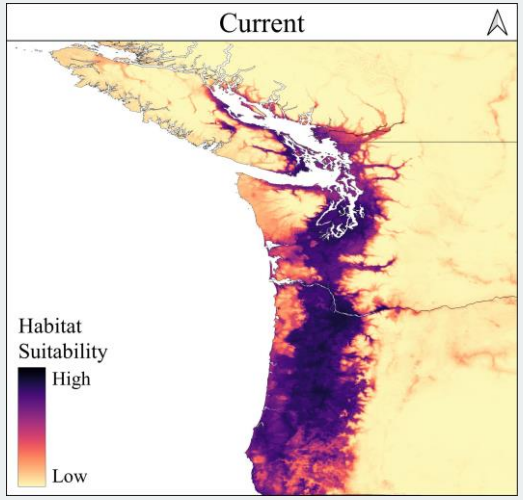
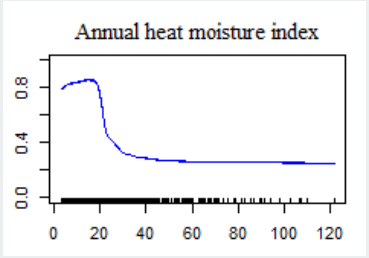
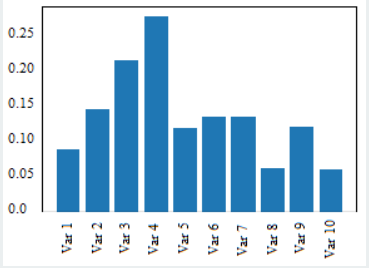


Variable Response Curves



Variable Importance Procedure



HOW DO FUTURE CLIMATE PROJECTIONS CHANGE THE HABITAT SUITABILITY OF EACH INVASIVE PLANT SPECIES?

Current Habitat Suitability

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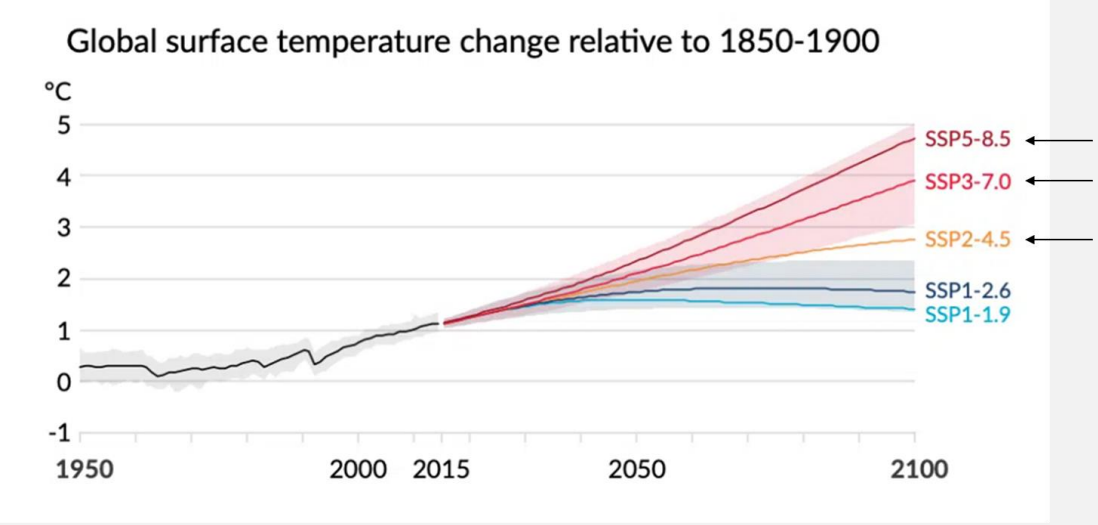
Current Habitat Suitability

3 Future Climate Scenarios

2050 and 2080

Ensemble of 3 General Circulation Models



IPCC Sixth Assessment Report

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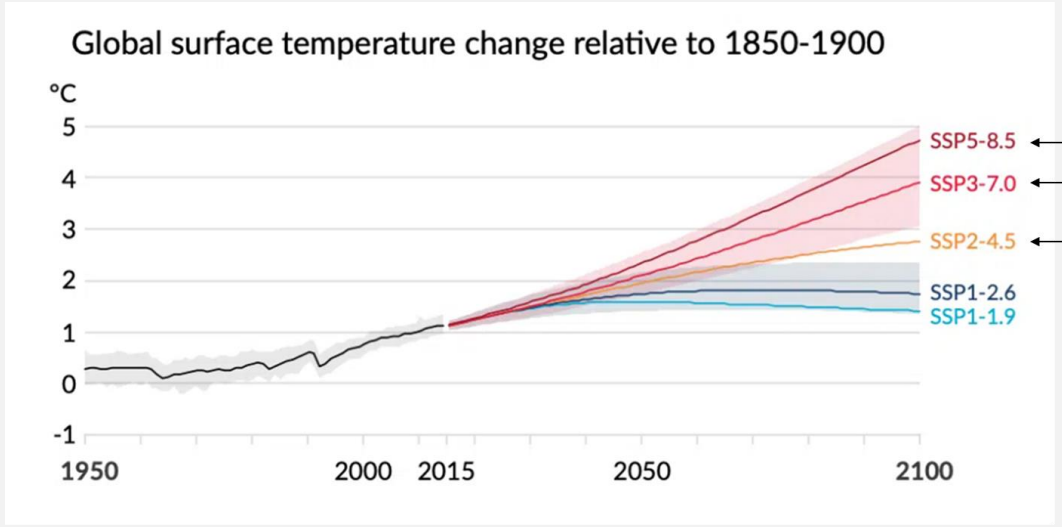
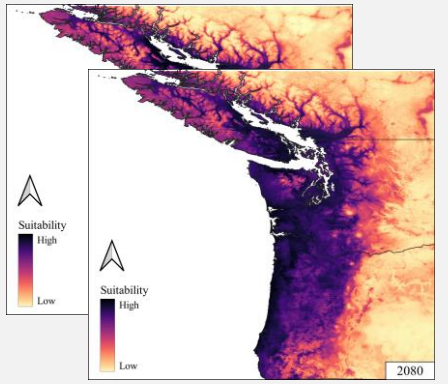
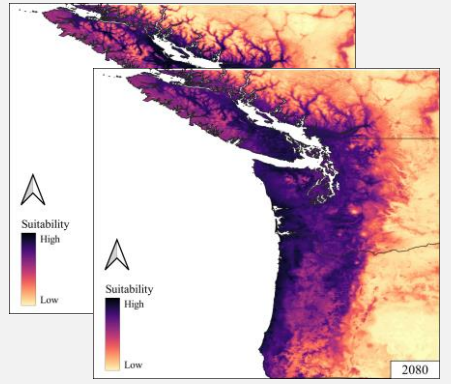


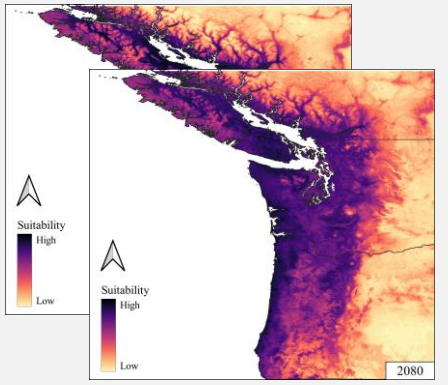
IPCC Sixth Assessment Report



SSP2-4.5

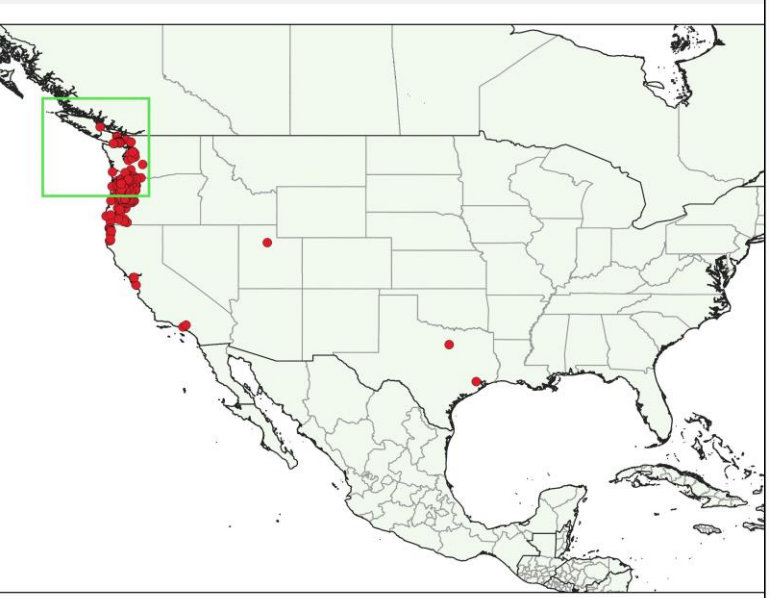


SSP3-7.0

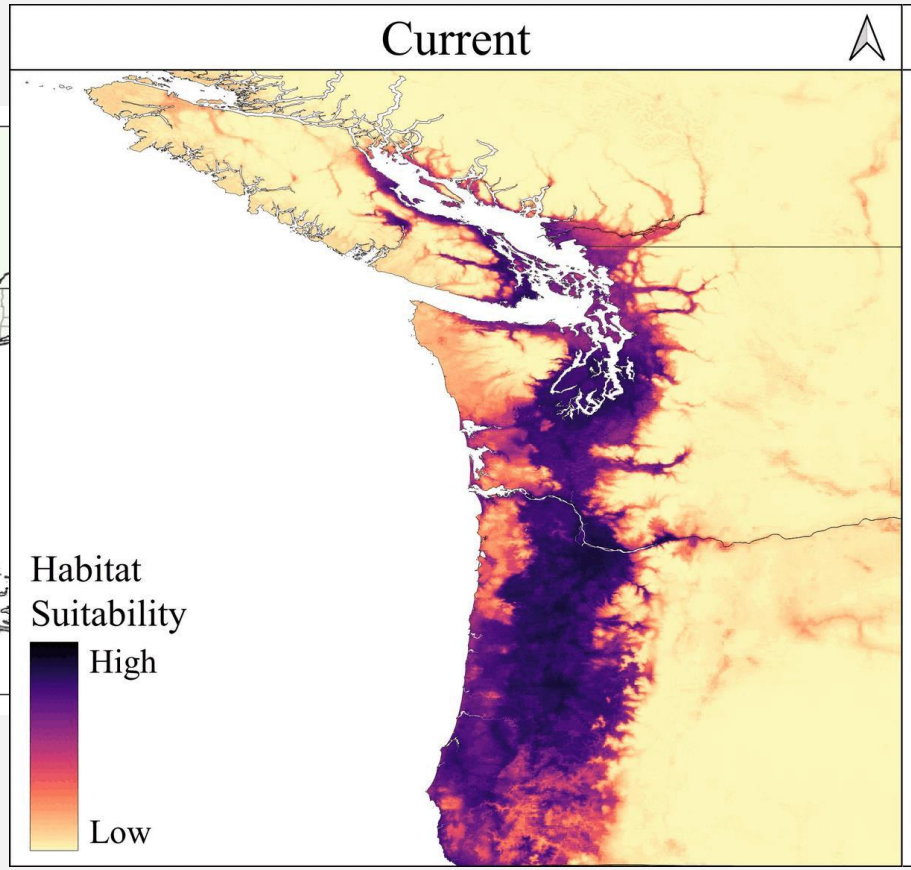


SSP5-8.5

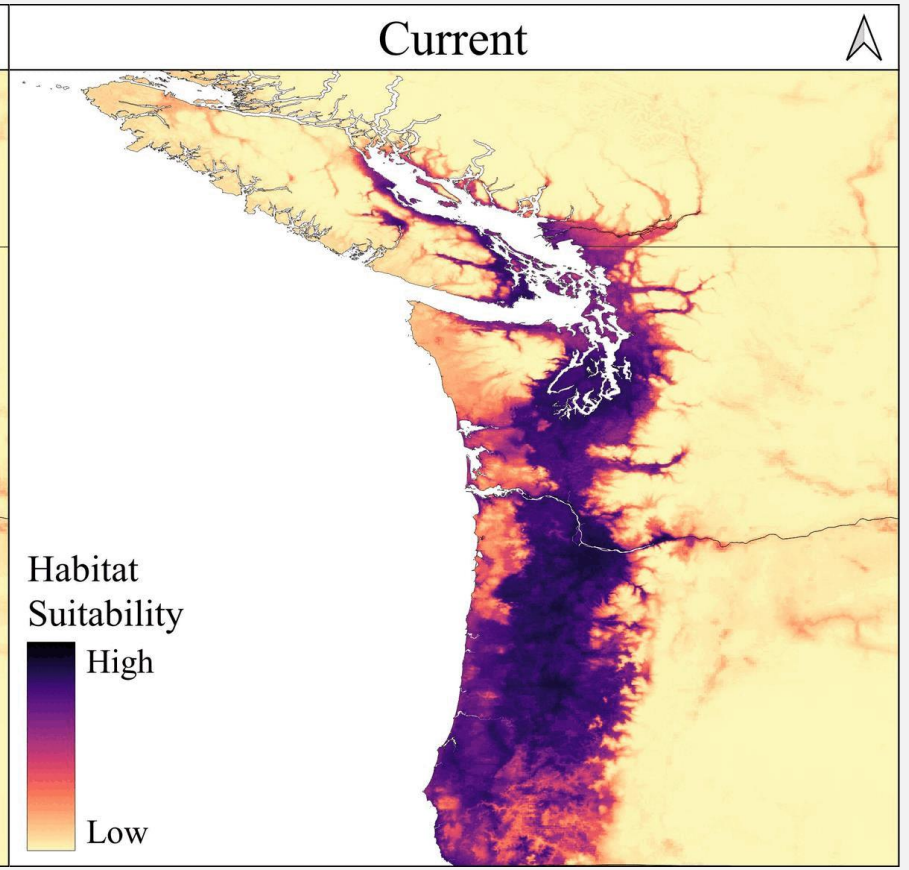
SHINY GERANIUM HABITAT SUITABILITY



Species Occurrences

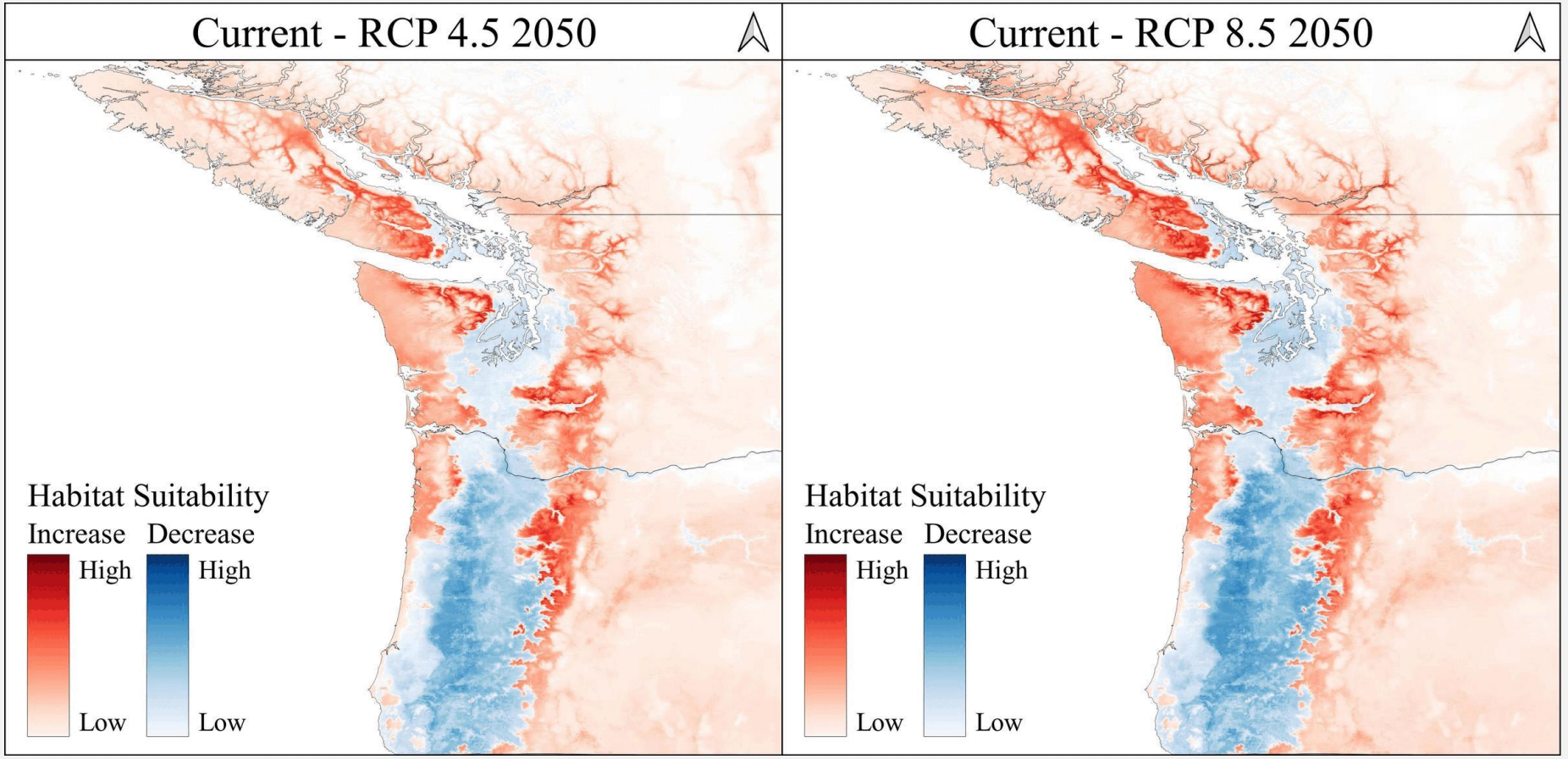


‘Middle of the road’ scenario
SSP2 – RCP 4.5



High CO_2 scenario
SSP5 – RCP 8.5

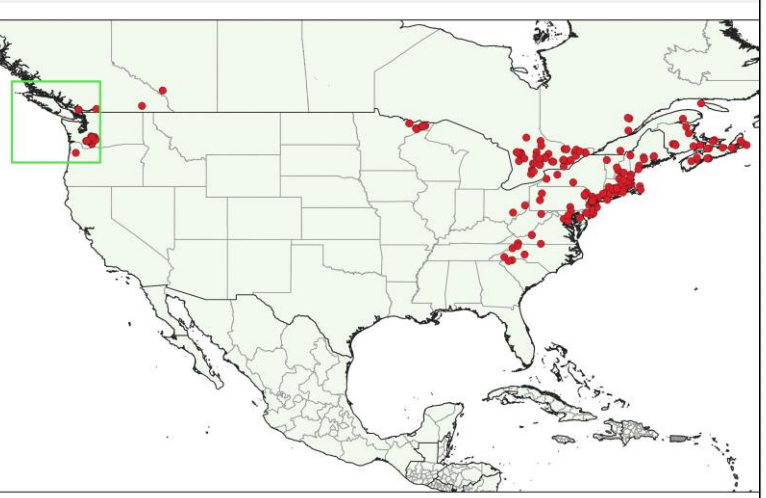
SHINY GERANIUM HABITAT SUITABILITY



Highest contributing variables

Variable	Response
Degree-days below 0˚C	>125 = limiting
Summer precipitation	>150mm = limiting

MOUSE-EAR HAWKWEED HABITAT SUITABILITY



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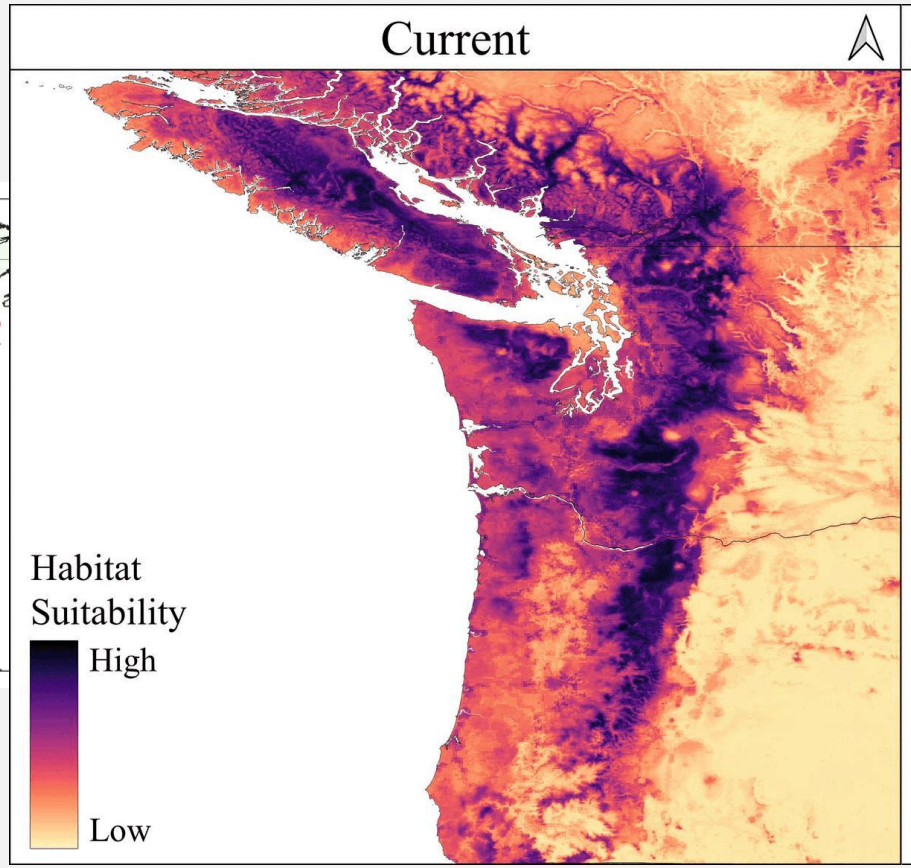

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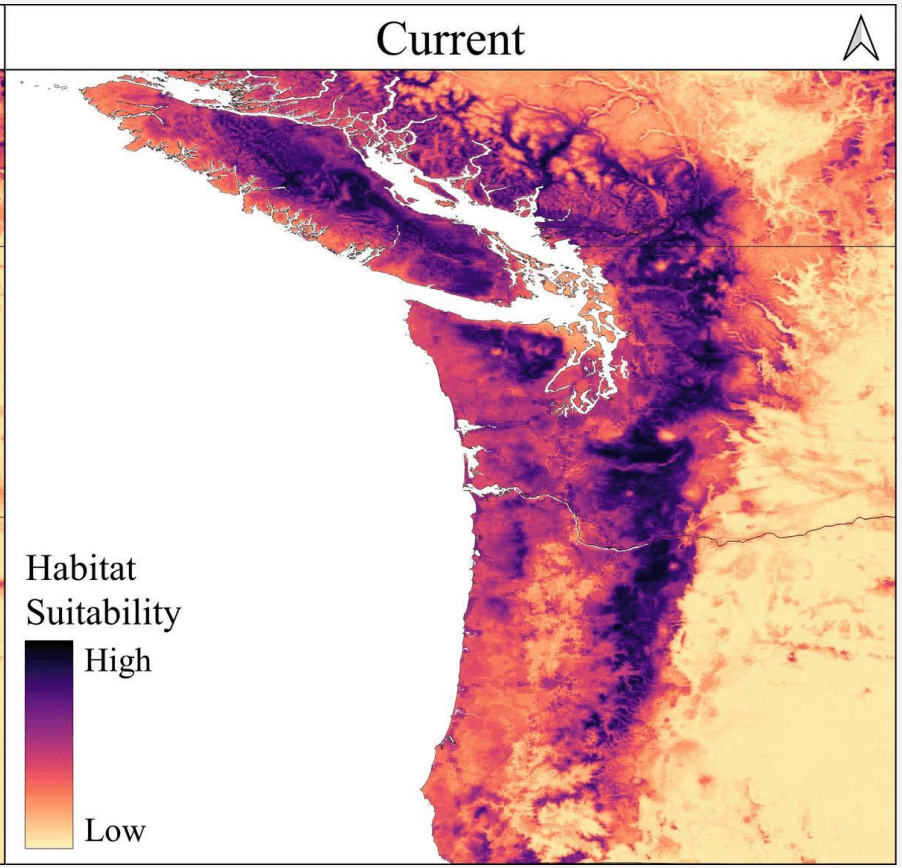

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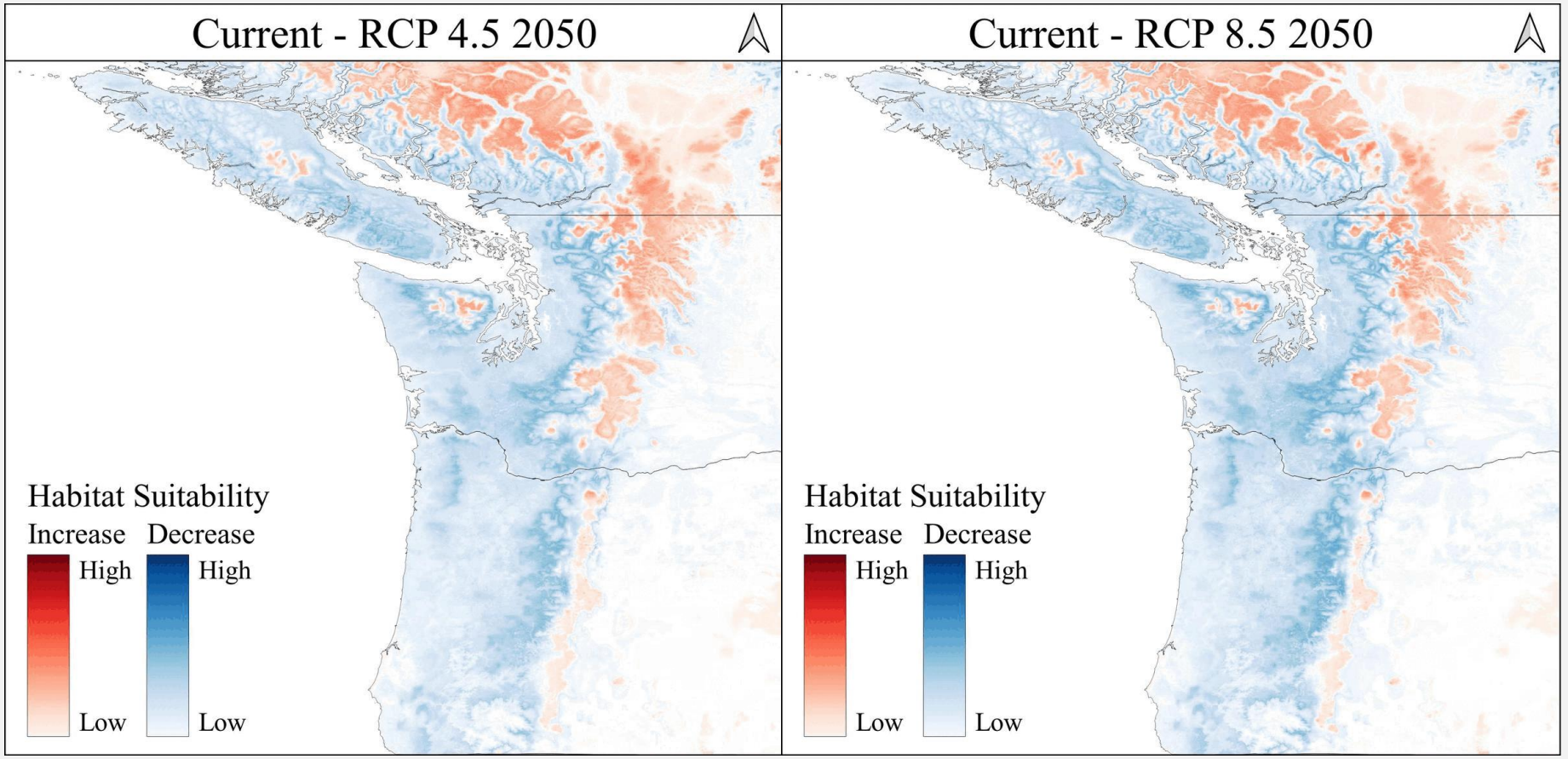
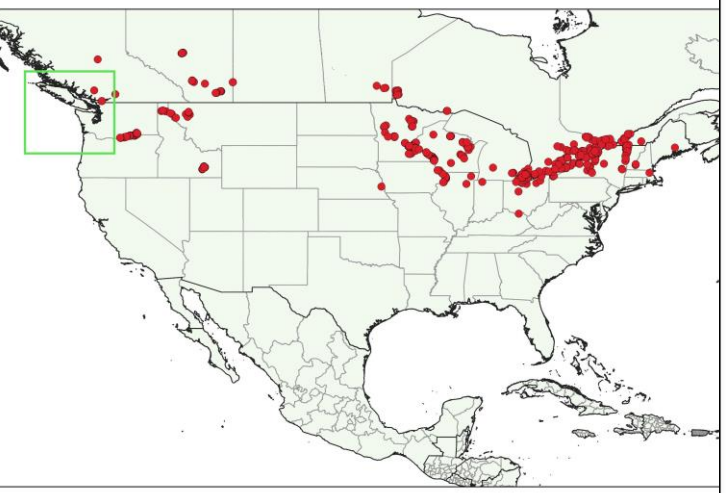
MOUSE-EAR HAWKWEED HABITAT SUITABILITY



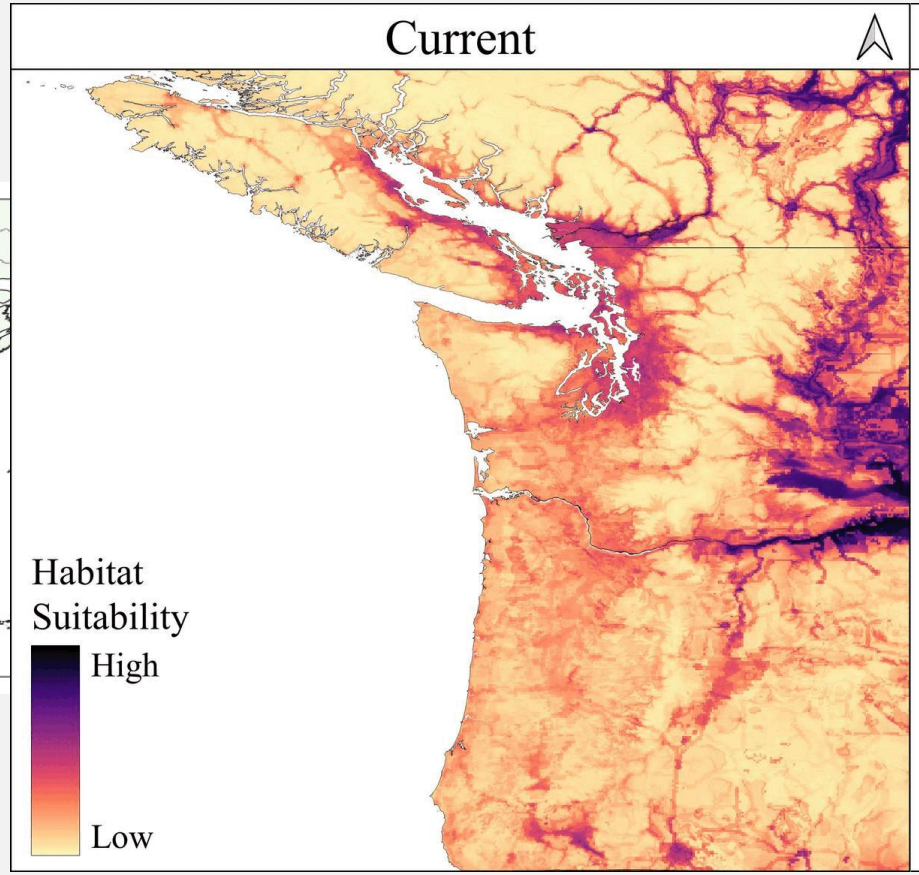
Highest contributing variables

Variable	Response
Degree-days below 0˚C	>750 = limiting
Annual heat moisture index	>20 = limiting

FLOWERING RUSH HABITAT SUITABILITY



Species Occurrences



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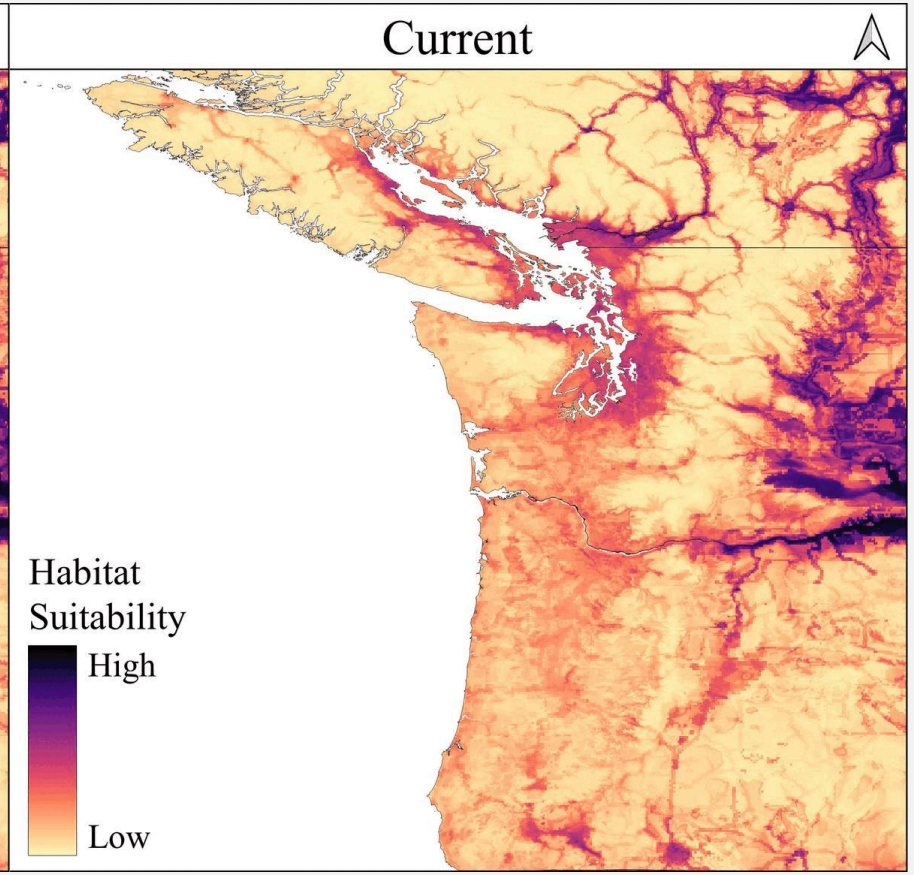

High CO_2 scenario
SSP5 – RCP 8.5

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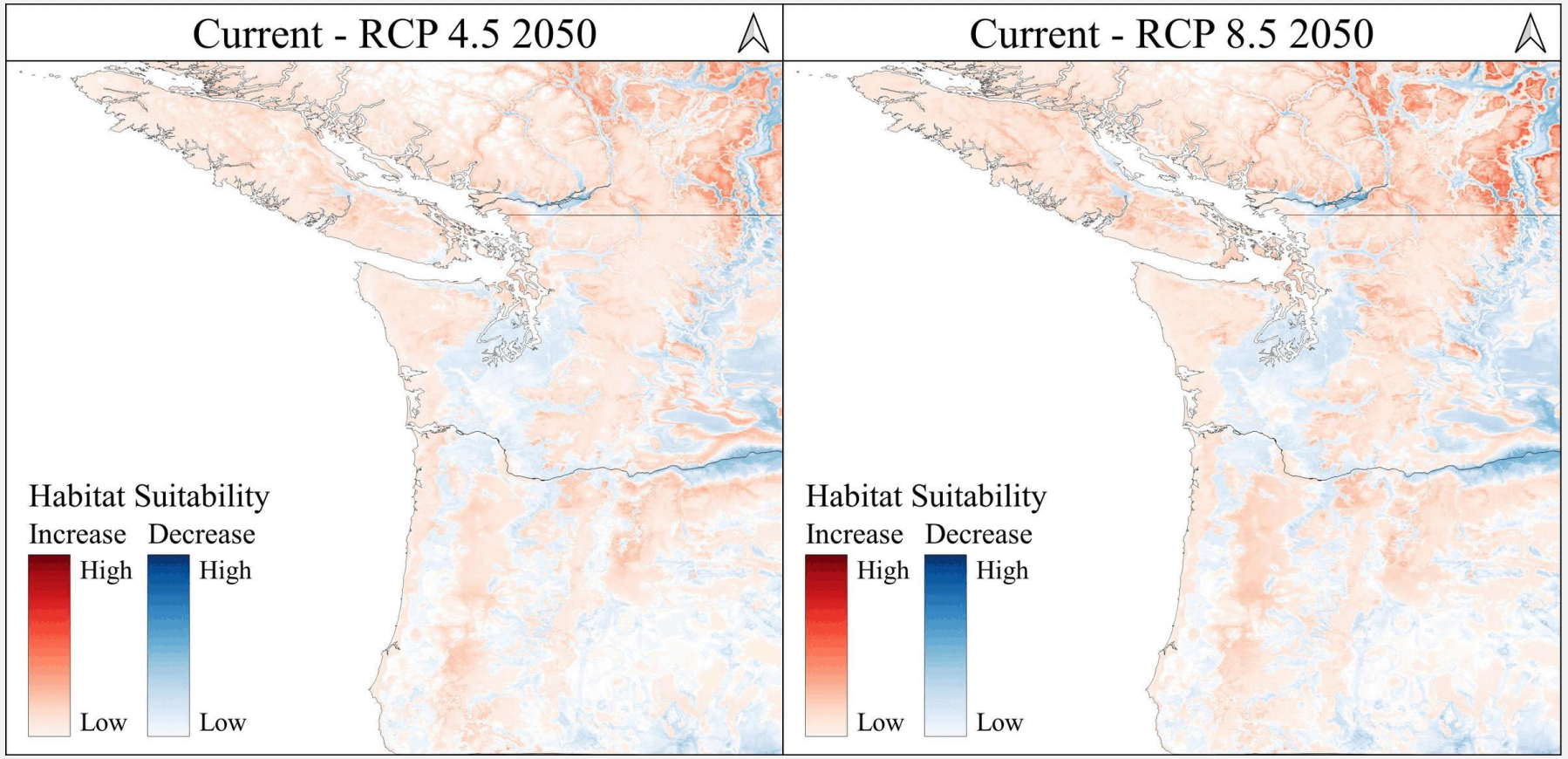
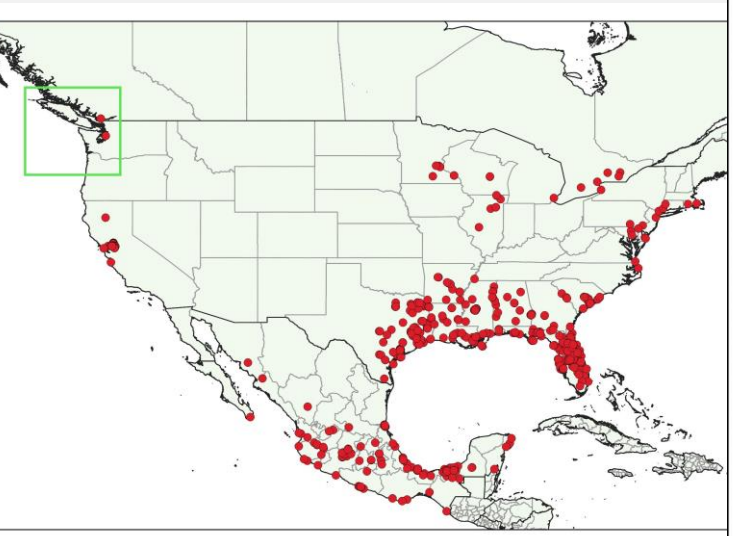


Highest contributing variables

Variable	Response
Extreme maximum temperatures	<34 = limiting
Relative humidity	<53% = limiting
Summer precipitation	>350mm = limiting

WATER HYACINTH HABITAT SUITABILITY



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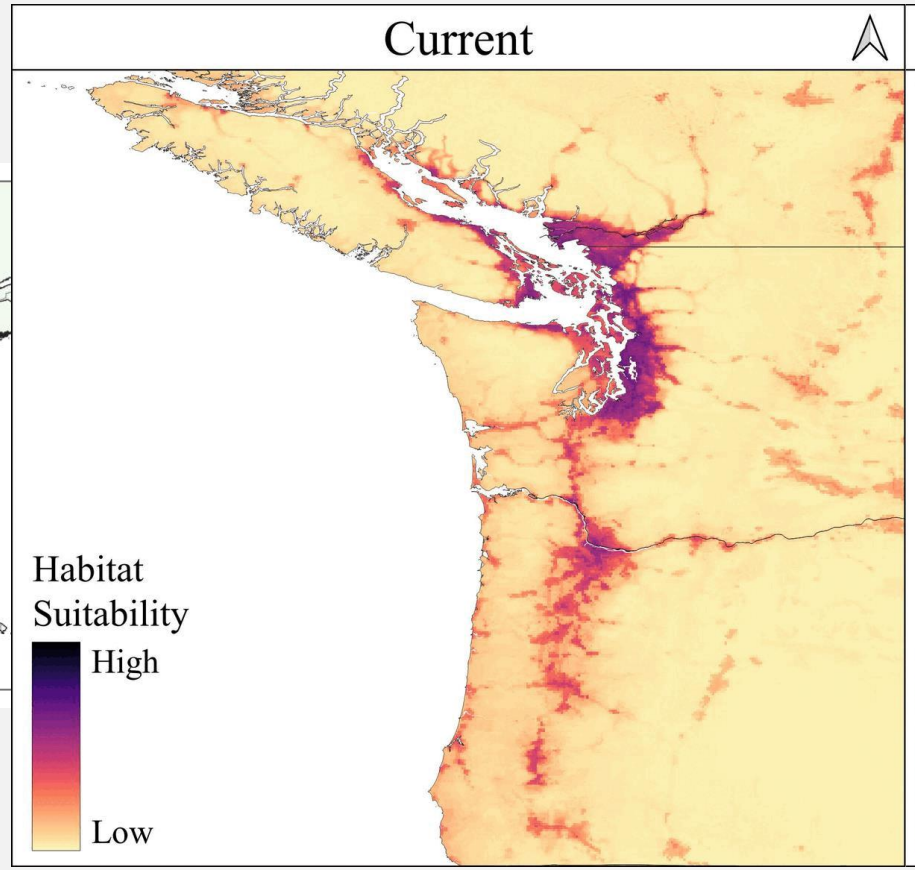

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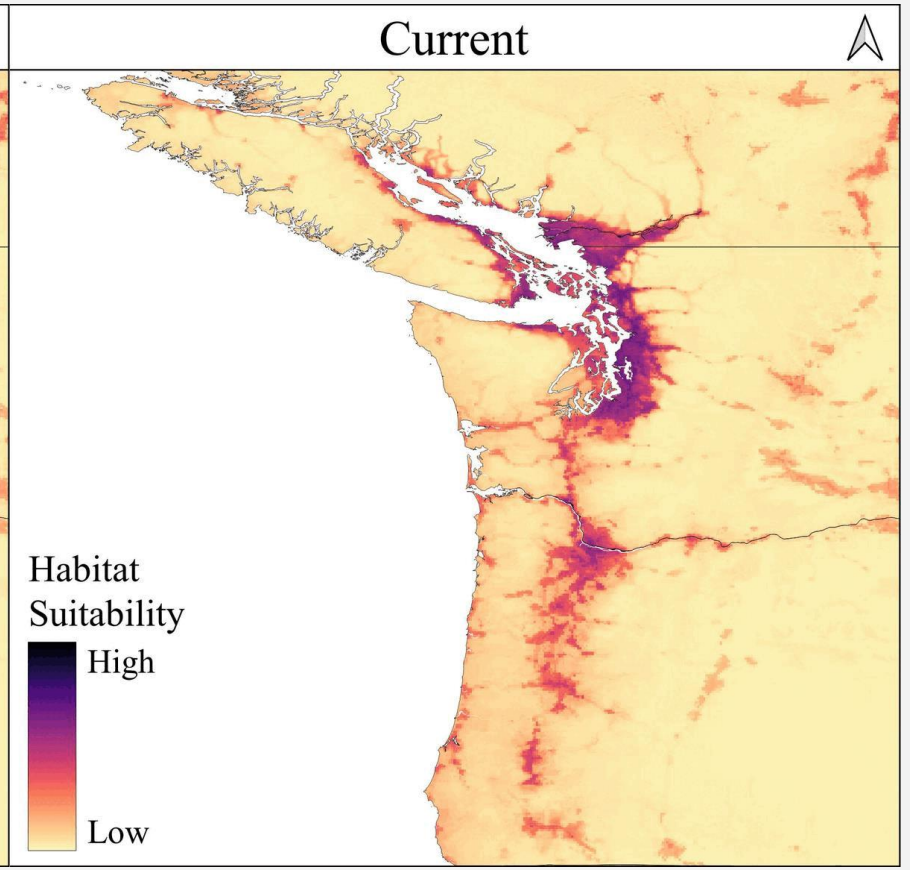

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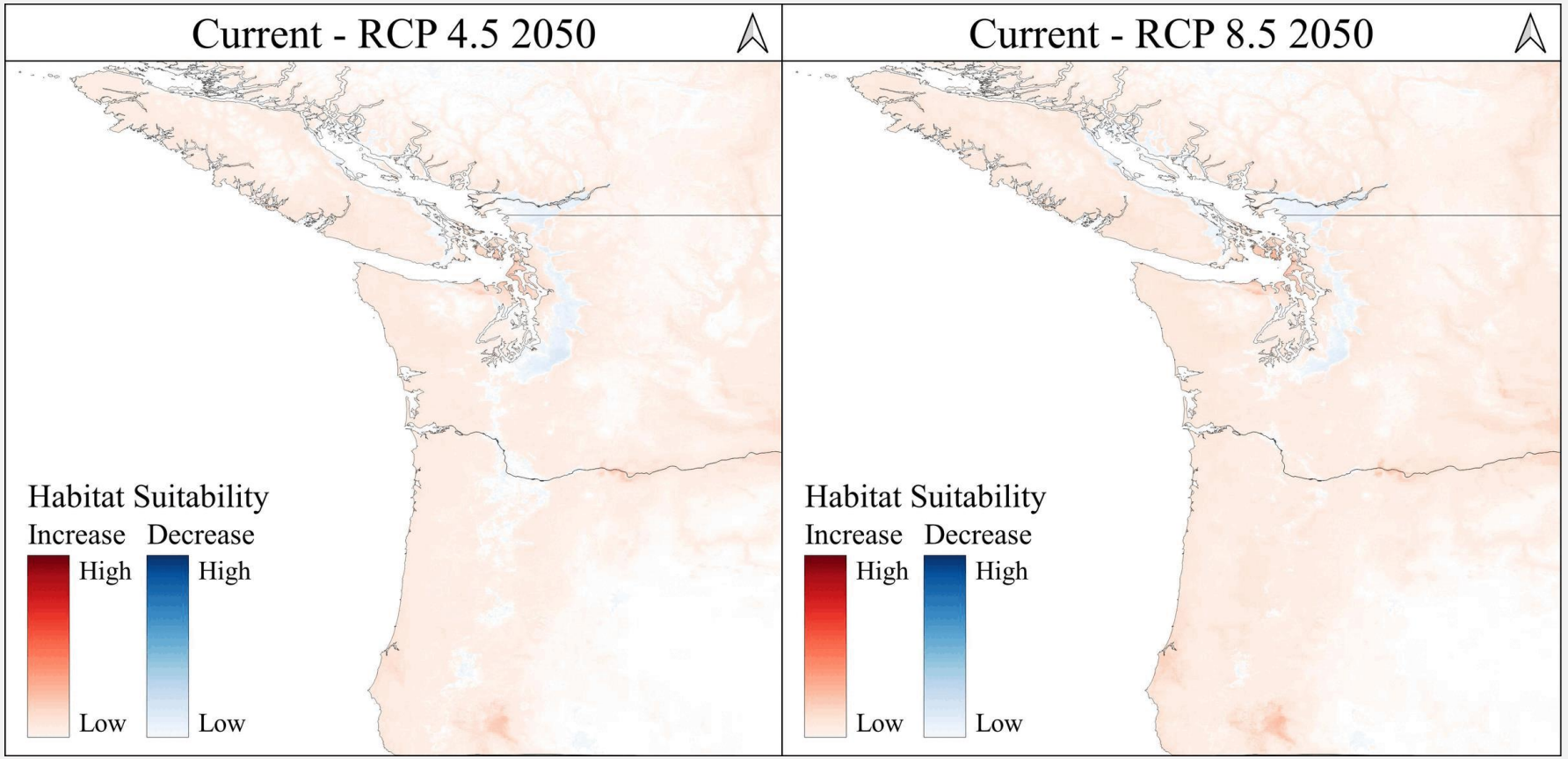

Highest contributing variables

Variable	Response
Number of frost-free days	<350 = limiting
Relative humidity	<65% = limiting
Precipitation as snow	>0mm = limiting

SUMMARY

- Overall, climate change was the most important predictive factor for each species
- Generally, shiny geranium and flowering rush are shifting northward, mouse-ear hawkweed is losing suitability, and water hyacinth is increasing suitability
- Climate change is not impacting the movement of invasive plant species equally and therefore species need to be assessed individually at a regional scale accessible to land managers

APPLICATIONS & CONCLUSIONS

- Habitat suitability maps provide insight into the potential shifting of invasive species due to climate change and other human influences
- Coupled with species risk assessments, land managers can use habitat suitability maps to develop targeted management strategies
- My research provides a working template for the necessary modelling of additional species of concern in the PNW

NEXT STEPS

- Sharing these results locally and publishing in an academic journal
- Continuing habitat suitability modelling for additional species
    - Kudzu, Yellow Floating Heart, Water Lettuce, Brazilian Elodea, Purple Nutsedge
- Exploring how this modelling may be used for invasive species already established in Metro Vancouver

ACKNOWLEDGMENTS


David R. Clements


gobotany.nativeplanttrust.org

QUESTIONS?


strathcona.ca


aquaticbiologists.com