Habitat Suitability Modelling of Endangered Medicinal Plant, *Aconitum heterophyllum* in the Western Himalaya

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EGU General Assembly 2025

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Biotechnology and Management Sciences

Outline

- A brief introduction about Himalayan biodiversity and alpine ecosystems
- Overview of climate change impacts in Himalaya
- What is Species Distribution modelling?
- Why *Aconitum heterophyllum* was selected for this study?
- What is niche?
- How will climate change impact the distribution of *Aconitum heterophyllum*?
- What can we do?

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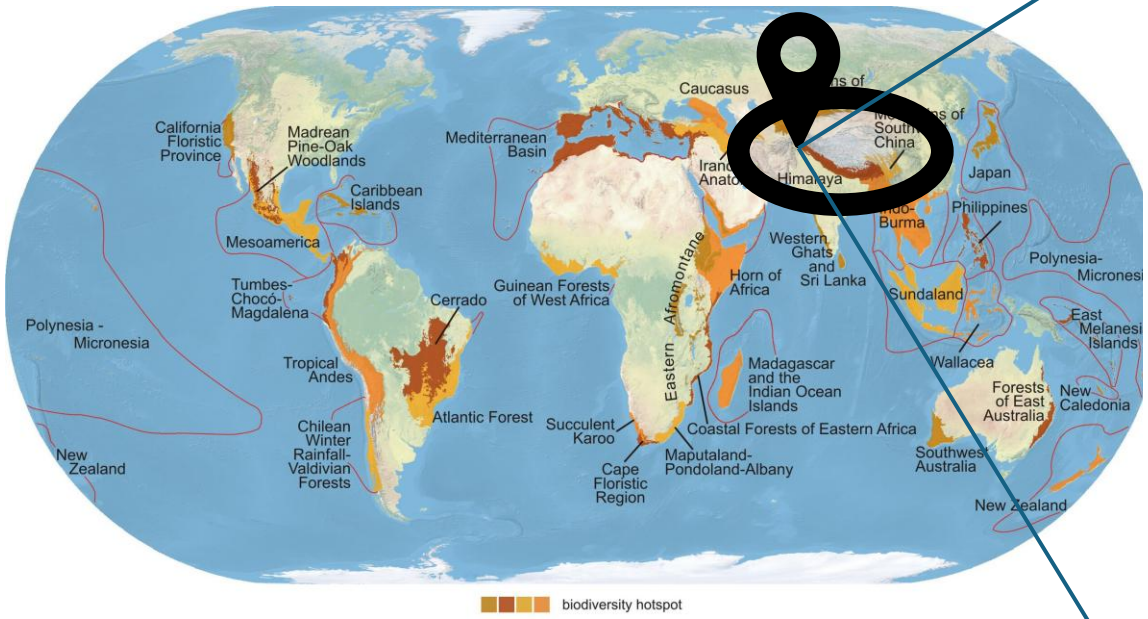
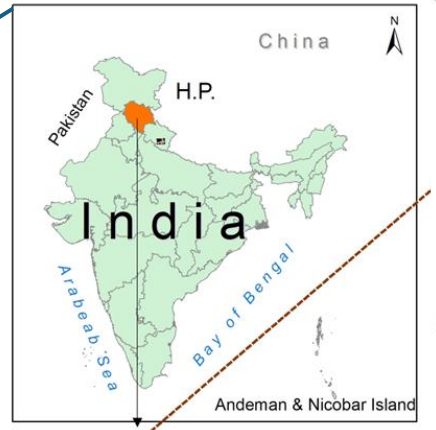
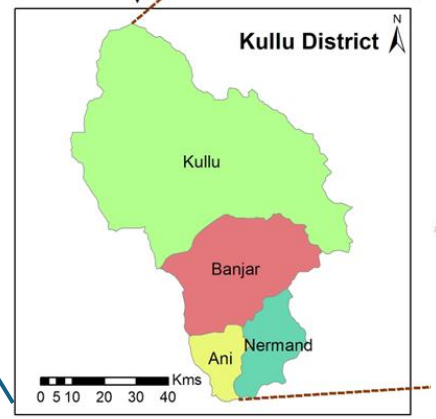
The Himalaya

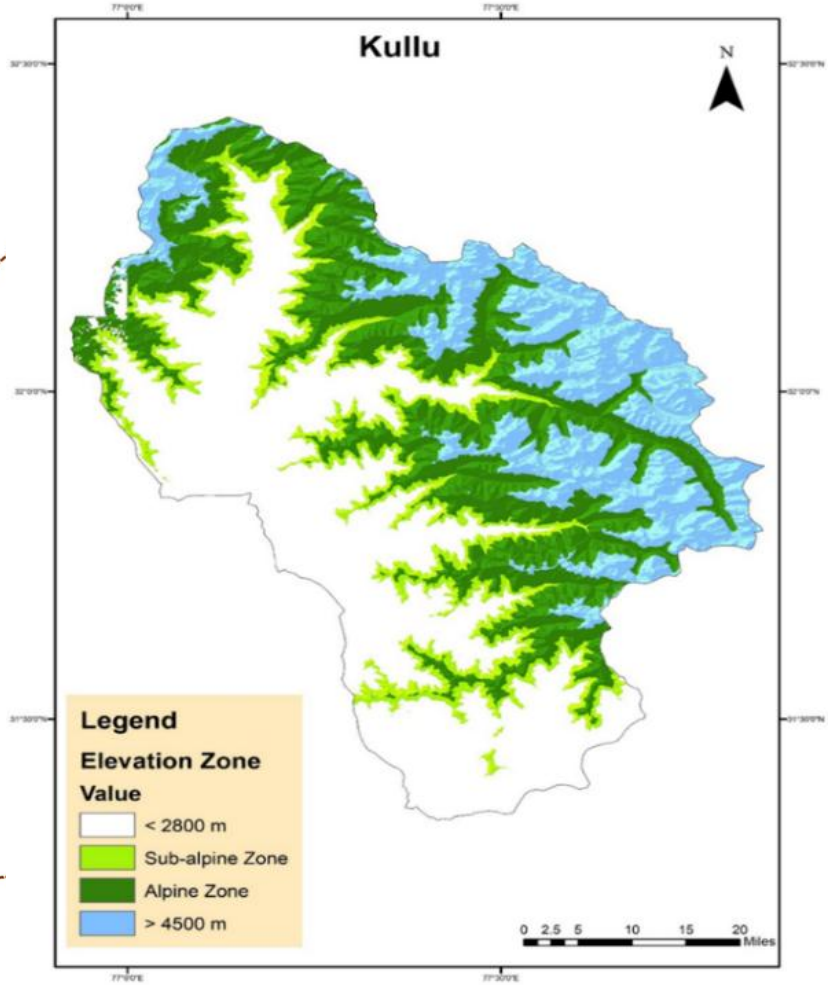
The Himalayan Biodiversity



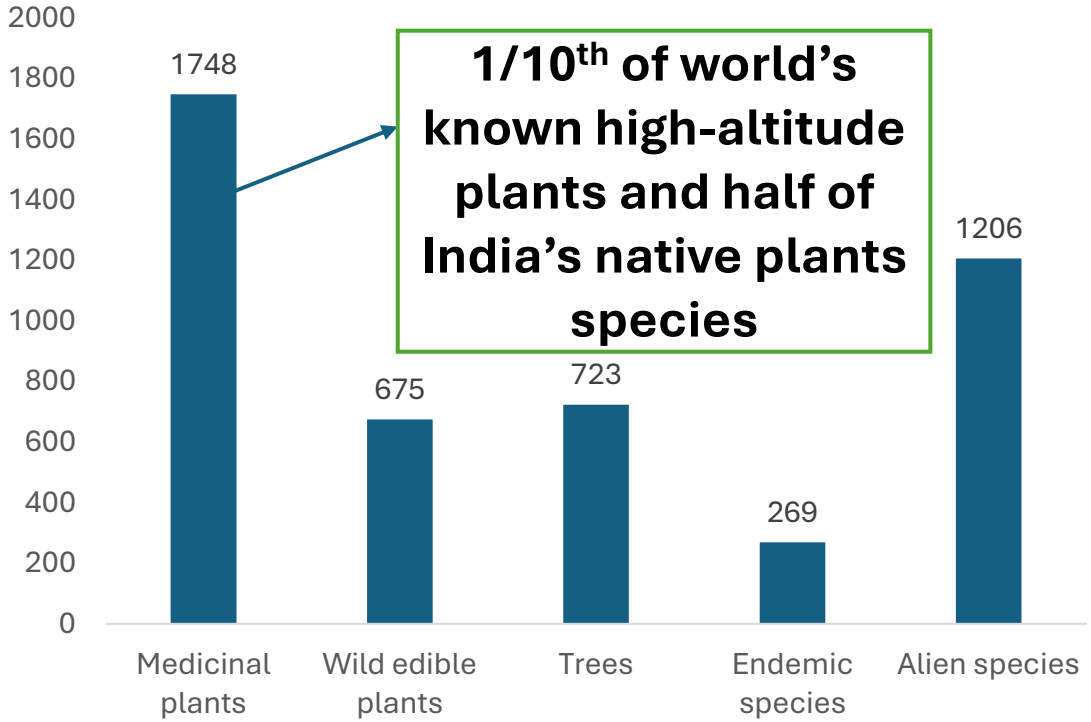
Conservation International (conservation.org) defines 35 biodiversity hotspots — extraordinary places that harbor vast numbers of plant and animal species found nowhere else. All are heavily threatened by habitat loss and degradation, making their conservation crucial to protecting nature for the benefit of all life on Earth.

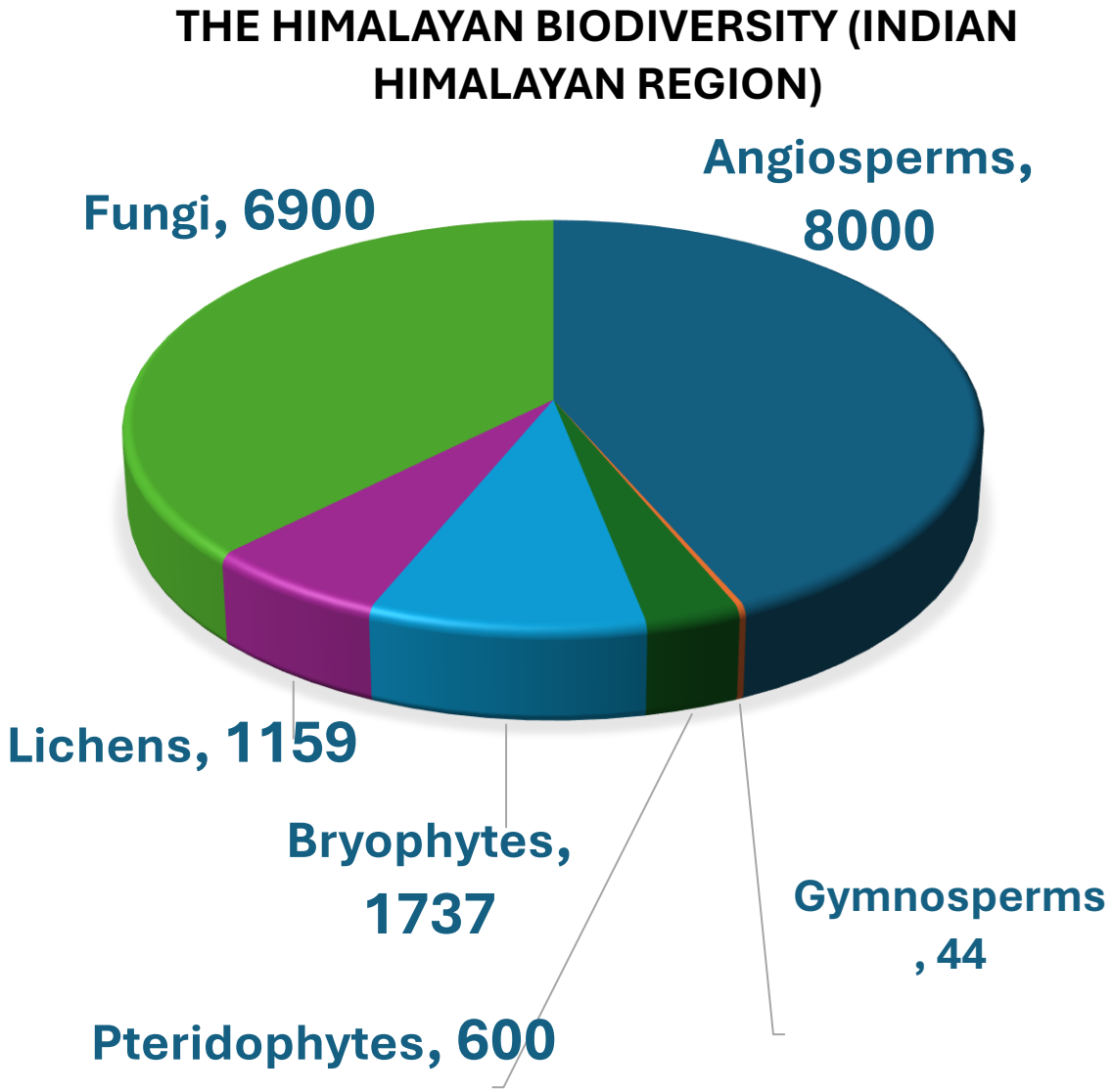






The Himalayan Biodiversity





The **IHR, Nepal and Bhutan** region of Himalayas is inhabited by **10,503 plant species (240 families** and **2322 genera)** out of which, **10,452 species (2302 genera)** belong to **angiosperm** and **51 species (20 genera)** are of **gymnosperms**.

Rawal, R.S., Bhatt, I.D., Chandra Sekar, K., & Nandi, S.K., eds (2013) The Himalayan Biodiversity: Richness, Representativeness, Uniqueness and Life-support Values. Almora, Uttarakhand, India: G.B. Pant Institute of Himalayan Environment and Development(GBPIHED); Padma, 2014; Samant et al., 2007

The Himalayan Biodiversity

Calanthe tricarinata

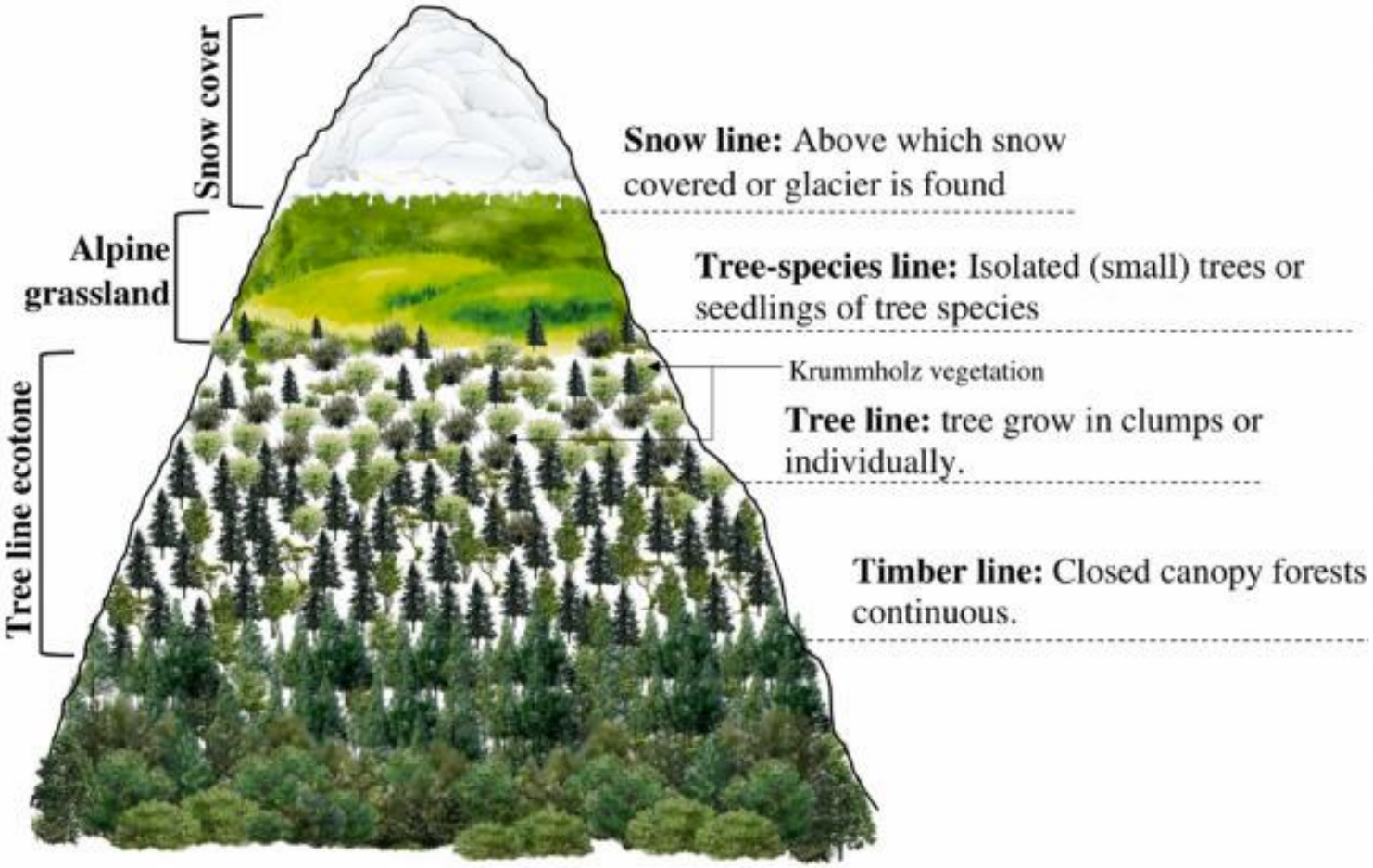
Dactylorhiza spp.

Dominant family:
Orchidaceae (783 species)

Dominant genus :***Carex***
(**124 species**)

Rana & Rawat, 2017

Alpine ecosystems

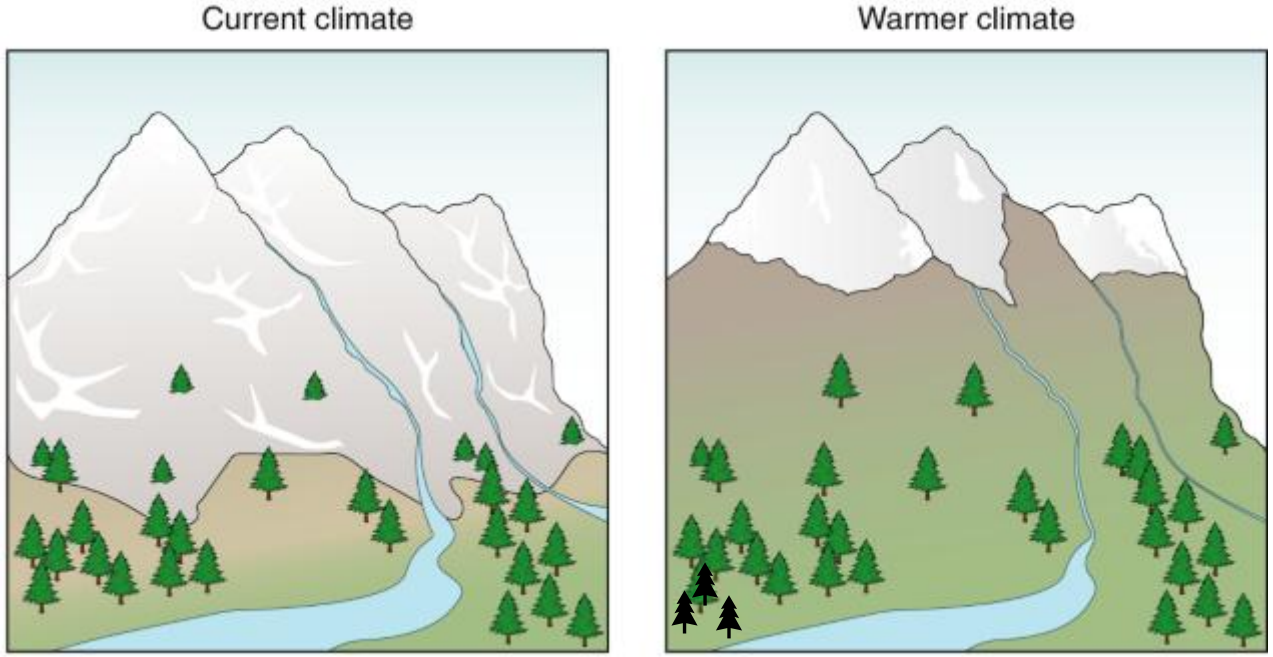


- Alpine ecosystems (sub-alpine, moist and dry alpine scrub)
- Covers an area of 34,40000 km^2 in Indian Himalayas
- Treeless low temperature climate zone between 6-8 ˚C
- Topographically, vegetation varies as dwarf-shrub heath, to dense grass-sedge heath, to snowbank vegetation
- Elevation ranges from 2800-4300m amsl
- 303 species of medicinal plants were found in the subalpine and 108 species were found in the alpine range in Himachal Pradesh
- Around 61% of alpine plants are used in traditional Tibetan medicines

(Grabherr, Gottfried, & Pauli, 2010; Salick et al., 2014); (Grabherr et al., 2010); (Salick et al., 2006; Salick, Fang, & Byg, 2009); Kumar et al., 2024; Samant et al., 2007

How has climate change impacted the Himalayan alpine regions in recent past?

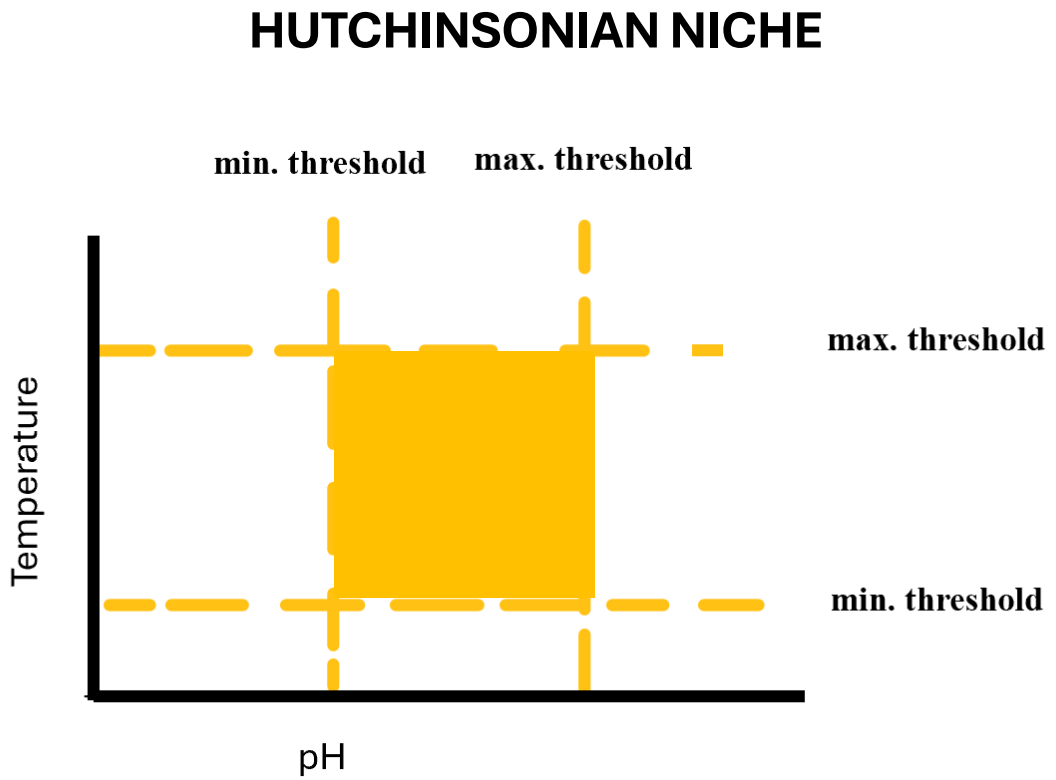
- **Early snowmelt, ablation and diminished snowpack**
- **Expansion of alpine** and **boreal forests northwards and upward shift in tree line** is expected.
- The warmer climate supports the growth of dwarf plant species like lower elevation shrubs
- Expanding grasslands and shrublands at higher elevations



Sushma Panigrahy, D. Anitha, M.M. Kimothi, 2011; Trenberth, 2011; Schickhoff et al., 2015; Korner, 1999; Bharti et al., 2012; Vano et al., 2020

Niche

The ecological space a species occupies

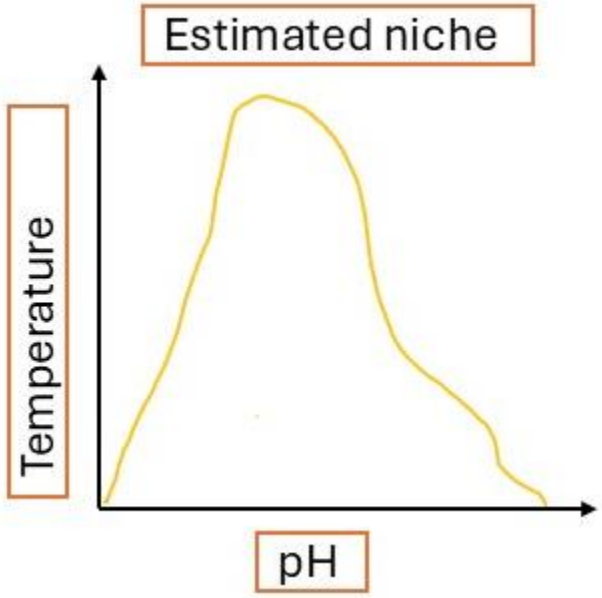


What is Species Distribution Modelling (SDM)?

Species Distribution Models uses species occurrence and environmental conditions to estimate realized niche

Env.

Statistics/Models



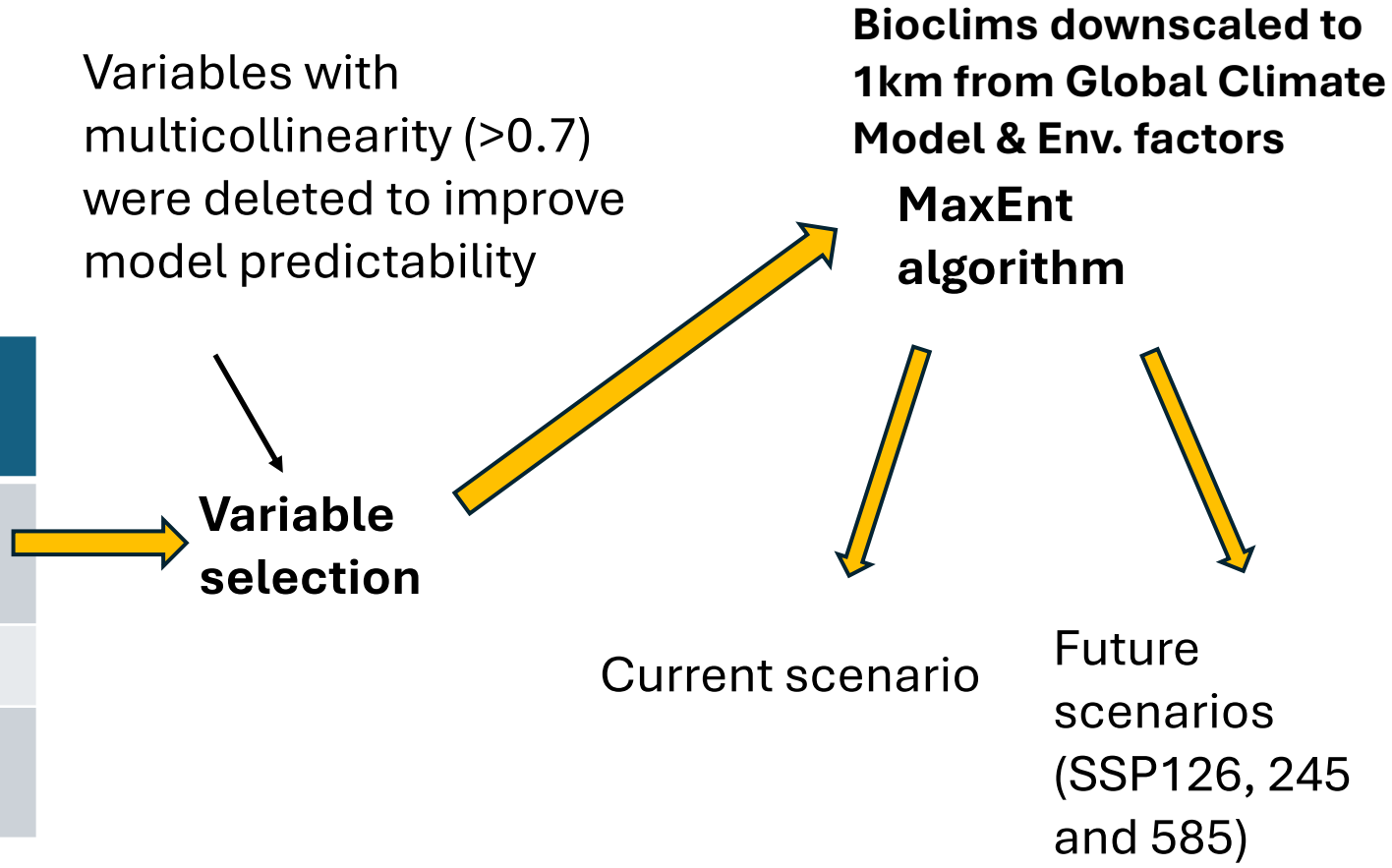
Aconitum heterophyllum

- It is an erect, and tuberous herb of 15-20cm in height.
- The vegetative development starts in May, while flowering and fruiting occur between August and October in the second or third year of growth.
- Flowers are white-violet, with amplexicaules, heteromorphic, spirally arranged dark green leaves with long petioles
- Tubers are whitish-grey in color with tapering ends

How does the model predict?

Predictor variables

Direct variables	Indirect variables
Bioclimatic variables	Elevation
Soil cover	Slope
Land cover	Aspect



Bioclimatic variables

BIO1 = Annual Mean Temperature

BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp)

BIO3 = Isothermality (BIO2/BIO7) (×100)

BIO4 = Temperature Seasonality (standard deviation ×100)

BIO5 = Max Temperature of Warmest Month

BIO6 = Min Temperature of Coldest Month

BIO7 = Temperature Annual Range (BIO5-BIO6)

BIO8 = Mean Temperature of Wettest Quarter

BIO9 = Mean Temperature of Driest Quarter

BIO10 = Mean Temperature of Warmest Quarter

BIO11 = Mean Temperature of Coldest Quarter

BIO12 = Annual Precipitation

BIO13 = Precipitation of Wettest Month

BIO14 = Precipitation of Driest Month

BIO15 = Precipitation Seasonality (Coefficient of Variation)

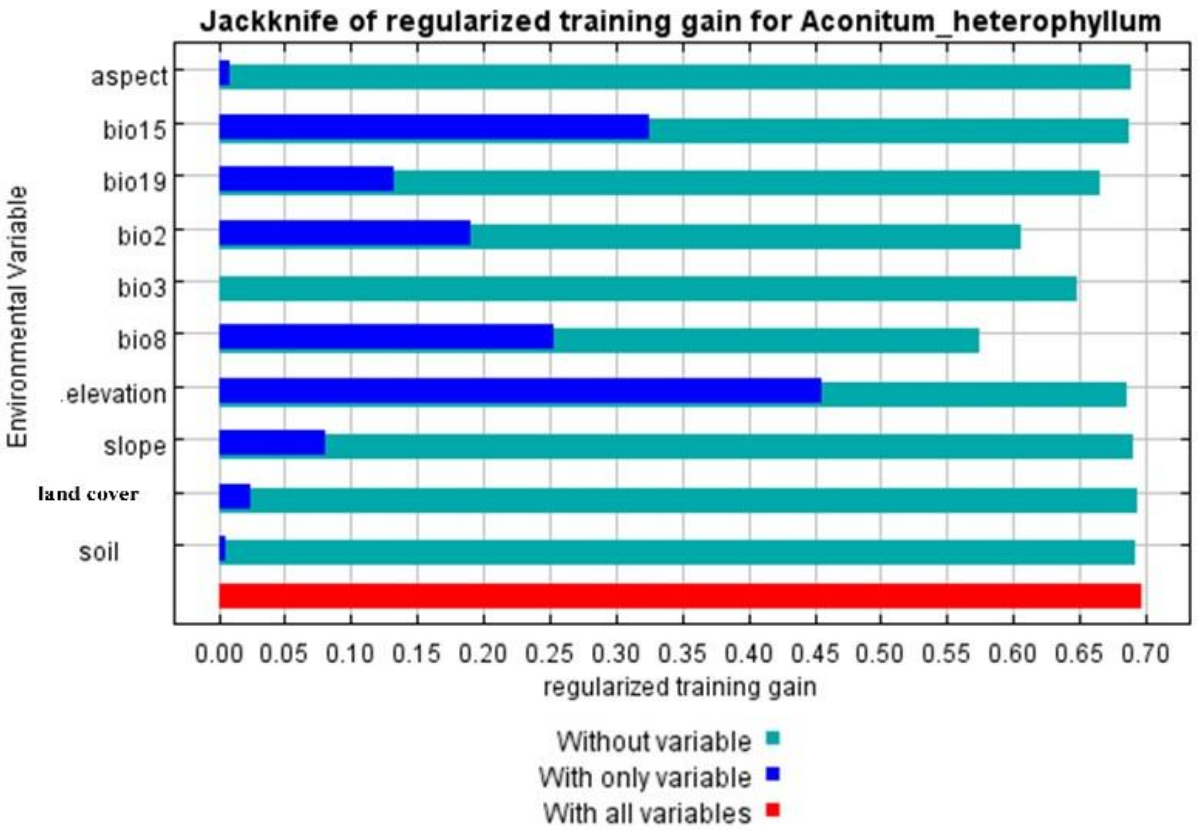
BIO16 = Precipitation of Wettest Quarter

BIO17 = Precipitation of Driest Quarter

BIO18 = Precipitation of Warmest Quarter

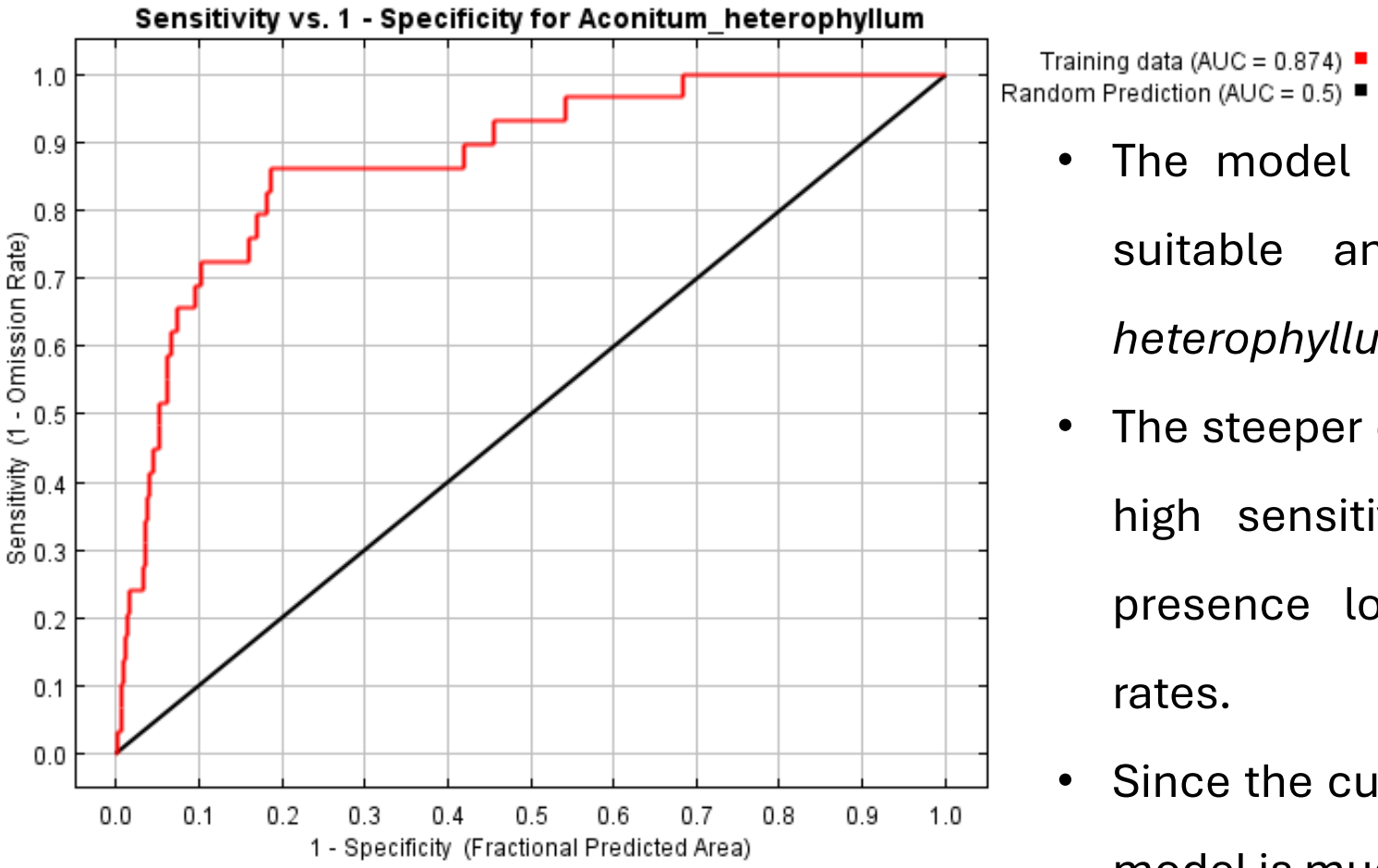
BIO19 = Precipitation of Coldest Quarter

Relative contribution of the predictor environmental variables to the habitat model of *Aconitum heterophyllum*



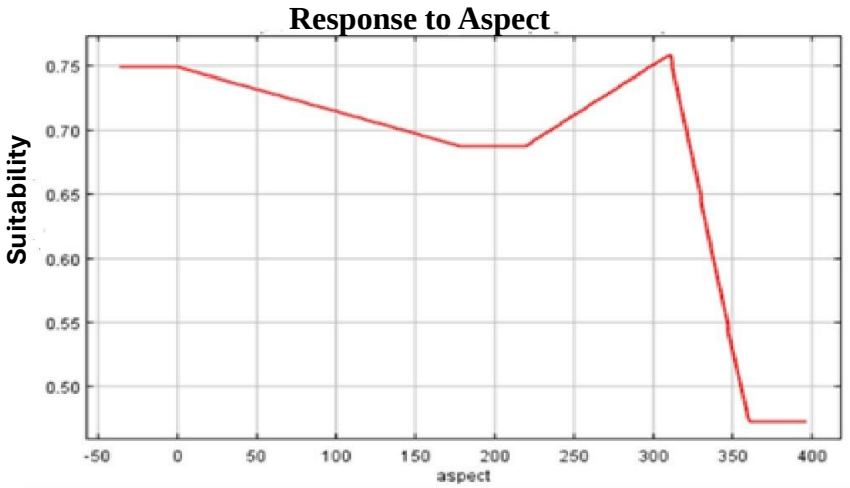
Variable contribution	%
Elevation	**28.19**
Bio15 (Precipitation seasonality)	**16.61**
Bio8 (Mean Temperature of Wettest Quarter)	**16.04**
Bio19 (Precipitation of Coldest Quarter)	**15.12**
Bio2 (Mean Diurnal Range)	**14.32**
Land cover	4.80
Bio3 (Isothermality (BIO2/BIO7) (×100))	3.00
Aspect	1.24
Soil	0.57
Slope	0.04

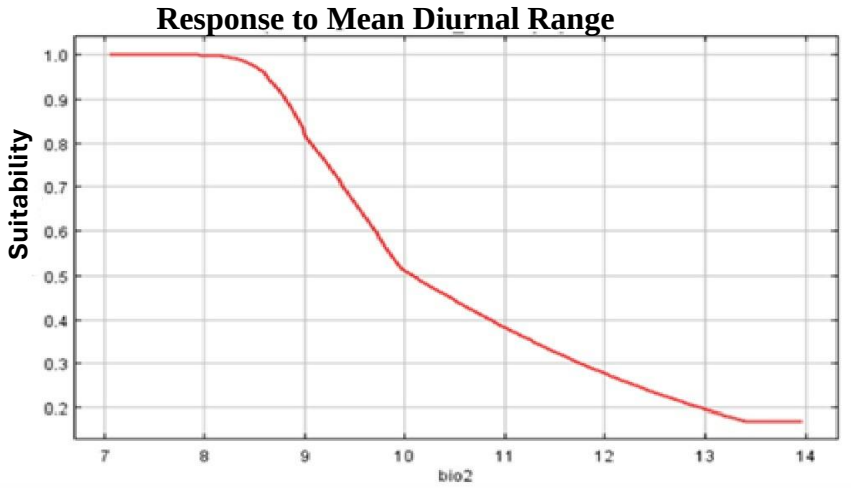
Model accuracy

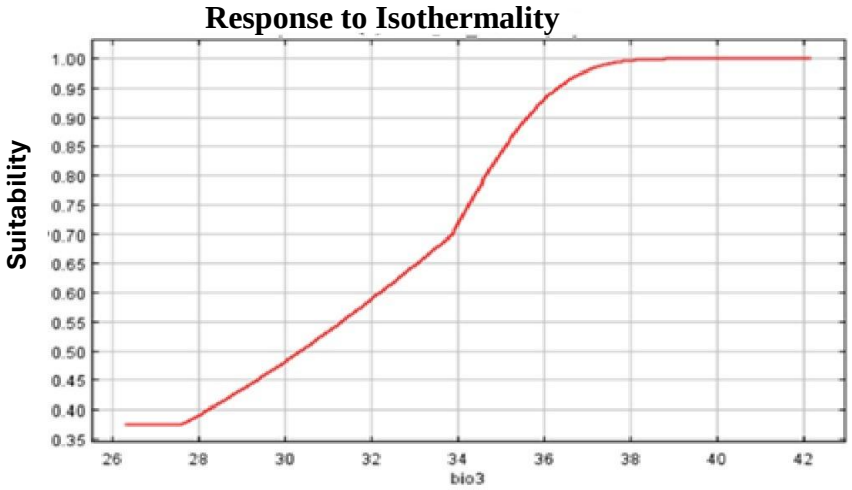


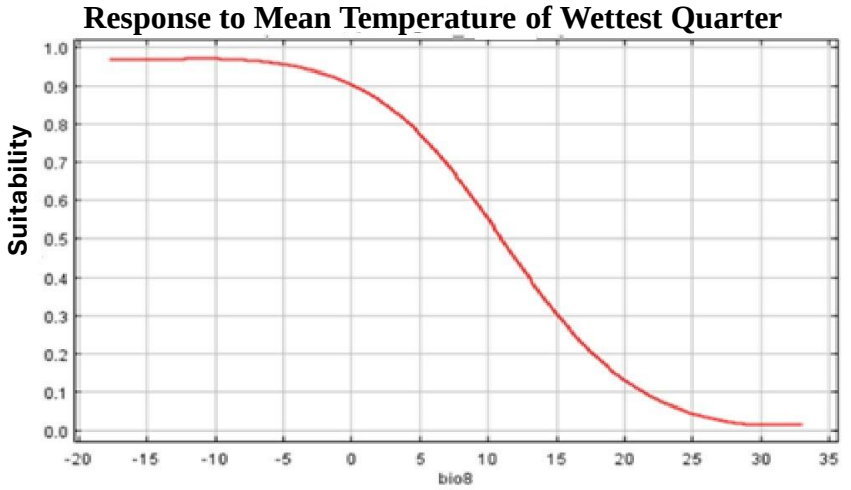
- The model effectively differentiates between suitable and unsuitable habitats for *A. heterophyllum*.
- The steeper curve suggests that the model has high sensitivity (ability to correctly predict presence locations) and low false positive rates.
- Since the curve is well above the diagonal, the model is much better than random prediction.

Response curves for environmental predictors



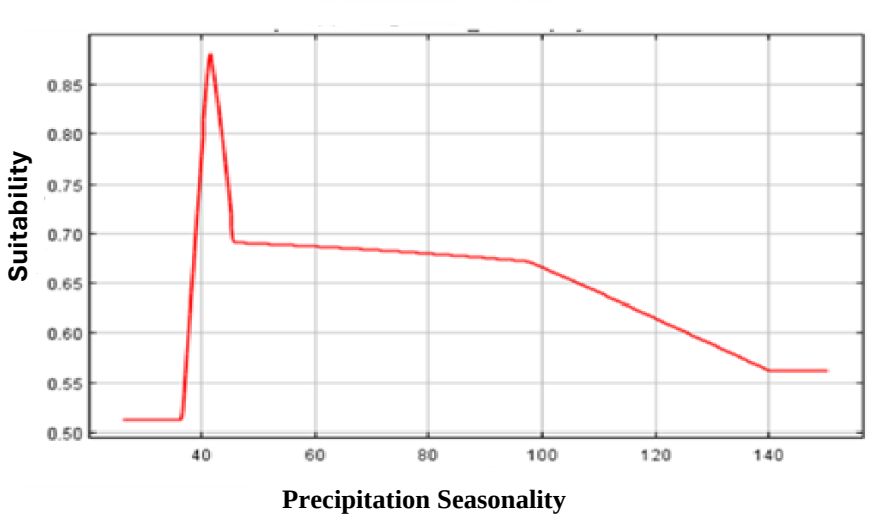


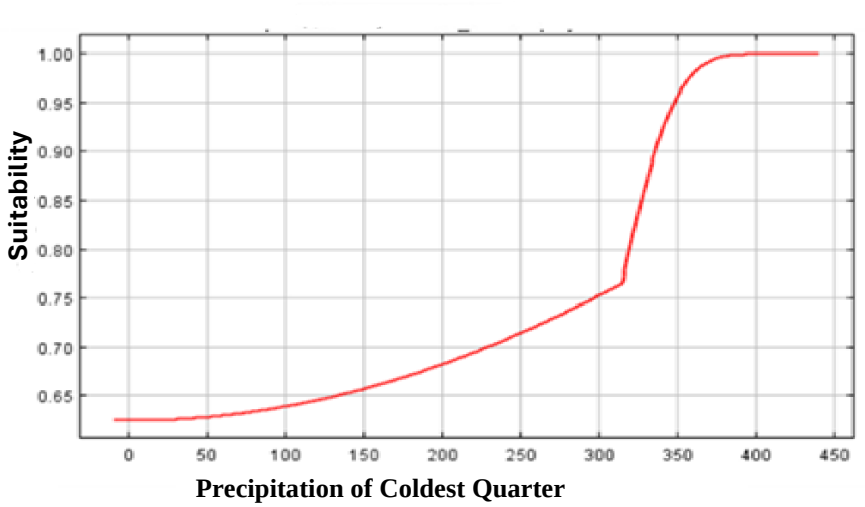


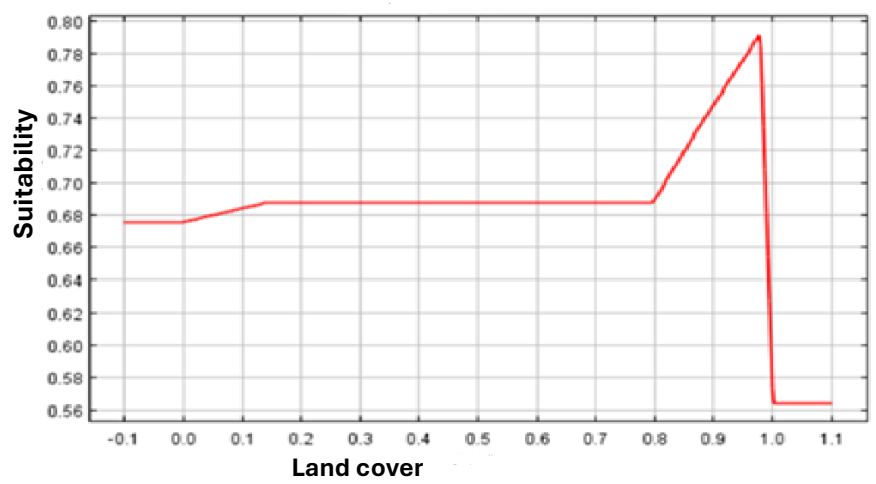


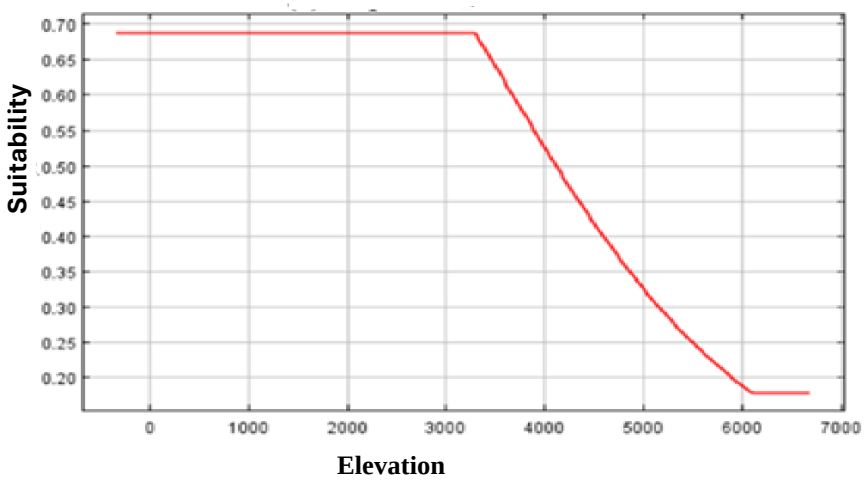
- Prefers **northwest-facing slopes**
- Bio2: **low diurnal temperature ranges** (~7-8°C)
- **Moderate temperature stability** high isothermality (Bio3)
- **Cool, moist conditions** (low BIO8)

Response curves for environmental predictors



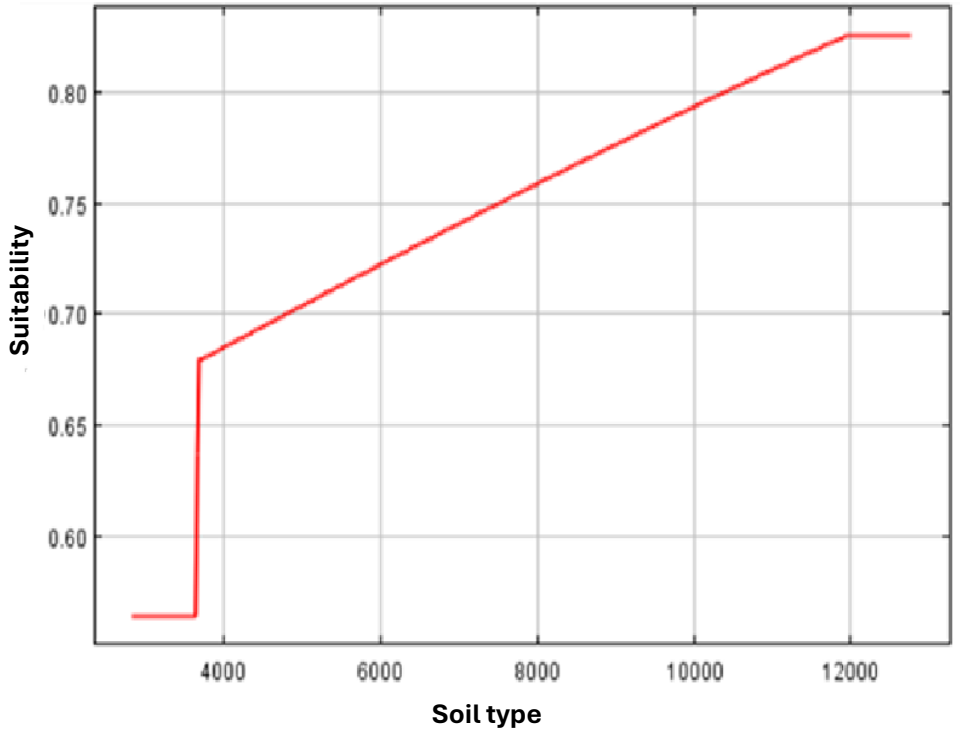


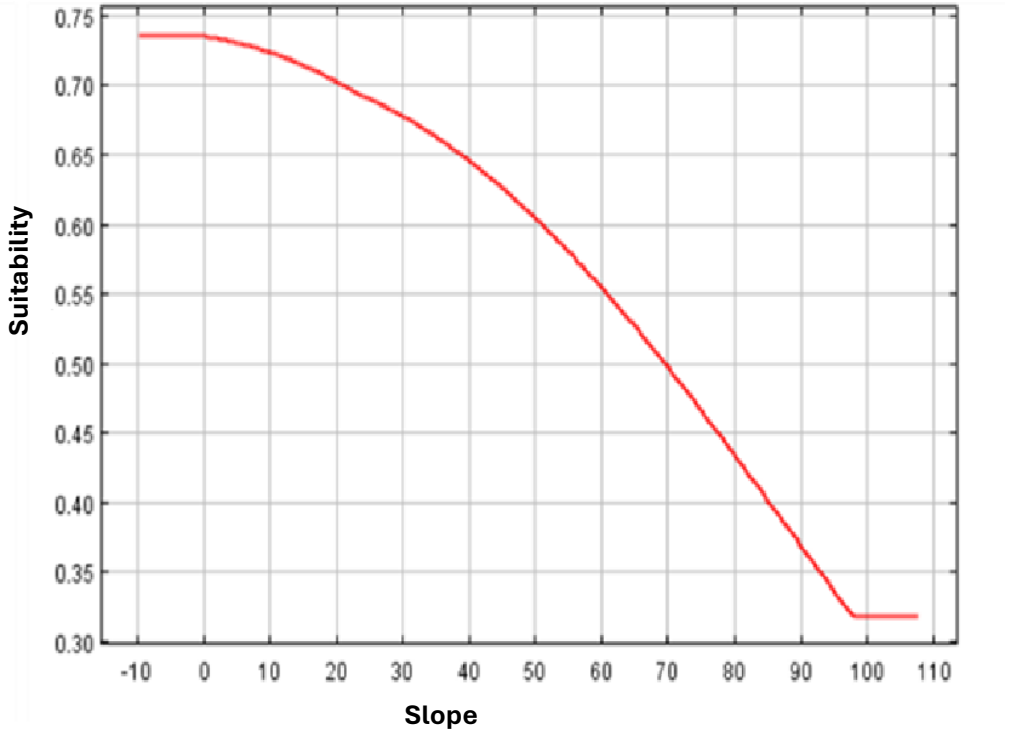




- The species thrives in regions with **moderate precipitation seasonality (Bio15)** and **higher winter precipitation (Bio19).**
- It prefers **specific land cover types** but avoids extreme conditions.
- Elevation is a **key limiting factor**, with the species favoring mid-altitude zones (~ 3200 m) but struggling at higher elevations.

Response curves for environmental predictors





- The species is **highly dependent on specific soil types** (Loamy or clay soils)and shows increasing preference as soil properties change.
- **Gentle slopes (<20°) are ideal**, but habitat suitability declines as slopes become steeper.
- The species likely requires **stable terrain with favorable soil conditions**, avoiding steep and unstable areas.

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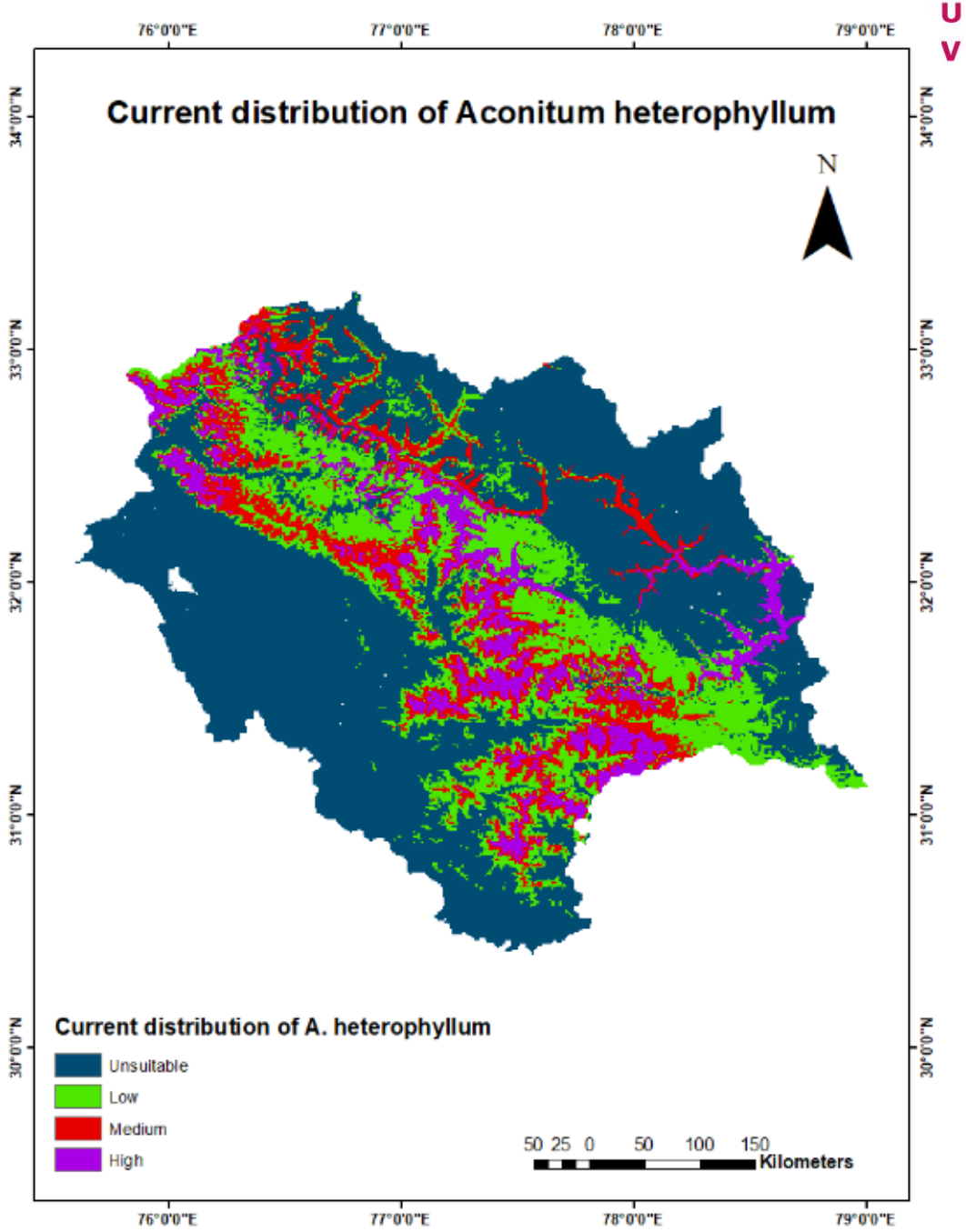
Current habitat suitability of *Aconitum heterophyllum* in Himachal Pradesh

Unsuitable (in km^2)	2571.62
Low(25-50%) (in km^2)	917.00
Medium (50-75%) (in km^2)	552.88
High (>75%) (in km^2)	393.82
Total suitable area (in km^2)	1863.7

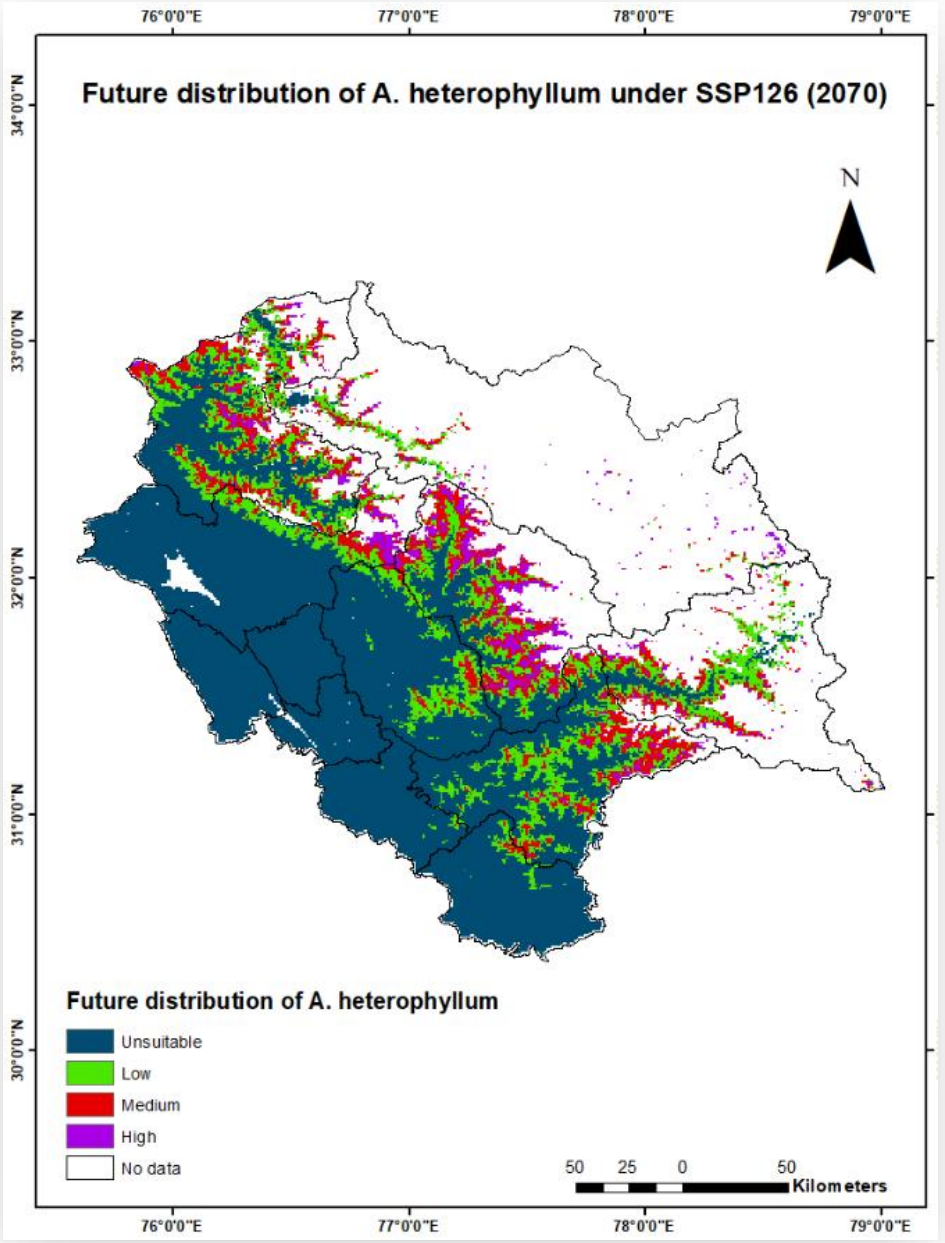
Pixels with value

1 :considered as unsuitable
2 :as low suitability
3 :as medium suitability
4 :as high suitability



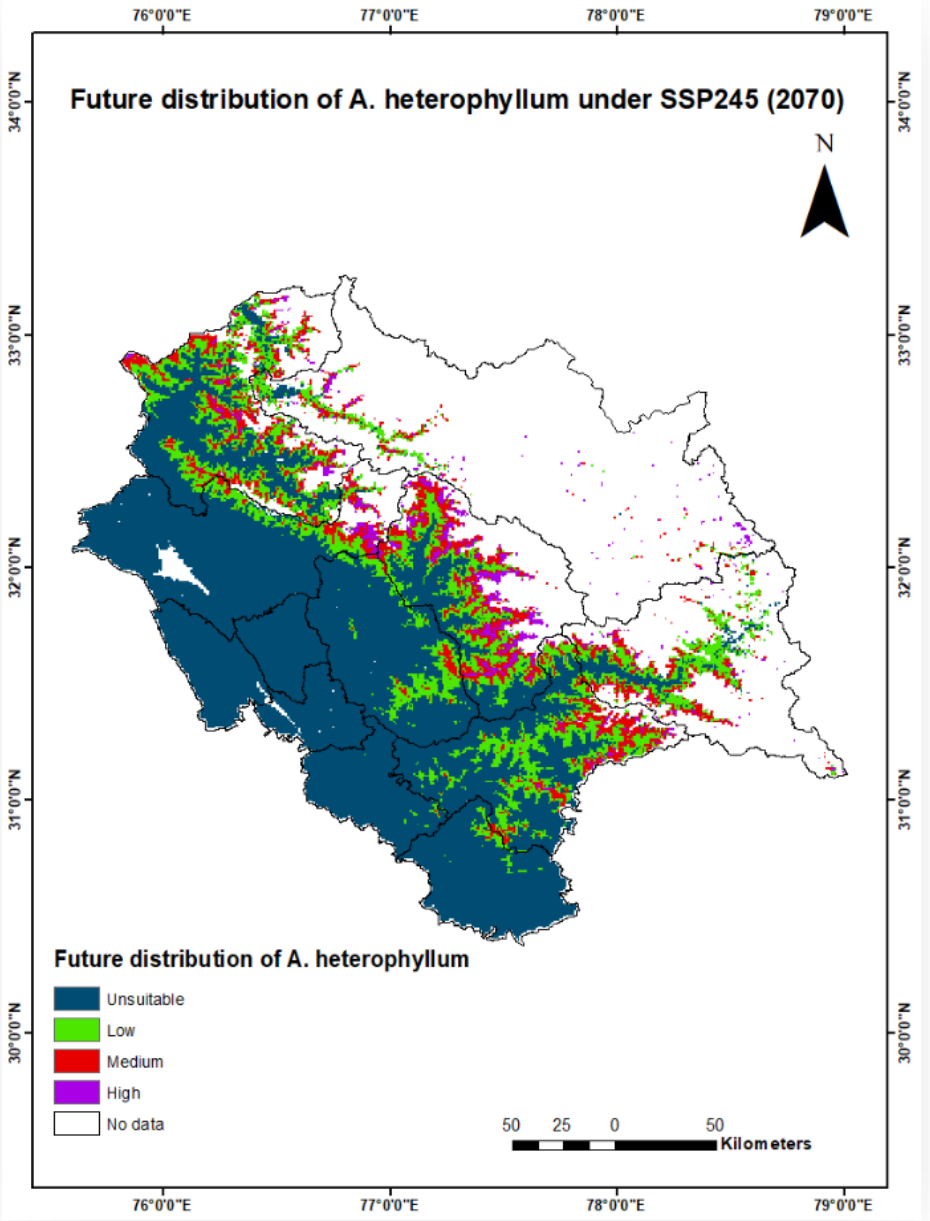
Future distribution in Shared Socioeconomic Scenarios (SSPs)(126)

Area in km^2	Current	SSP126 (2050)	SSP126 (2070)
Unsuitable	2571.62	1889.38	1754.68
Low(25-50%)	917.00	453.48	479.74
Medium (50-75%)	552.88	246.58	301.01
High (>75%)	393.82	73.08	127.15
Total suitable area	1863.7	773.14	907.9



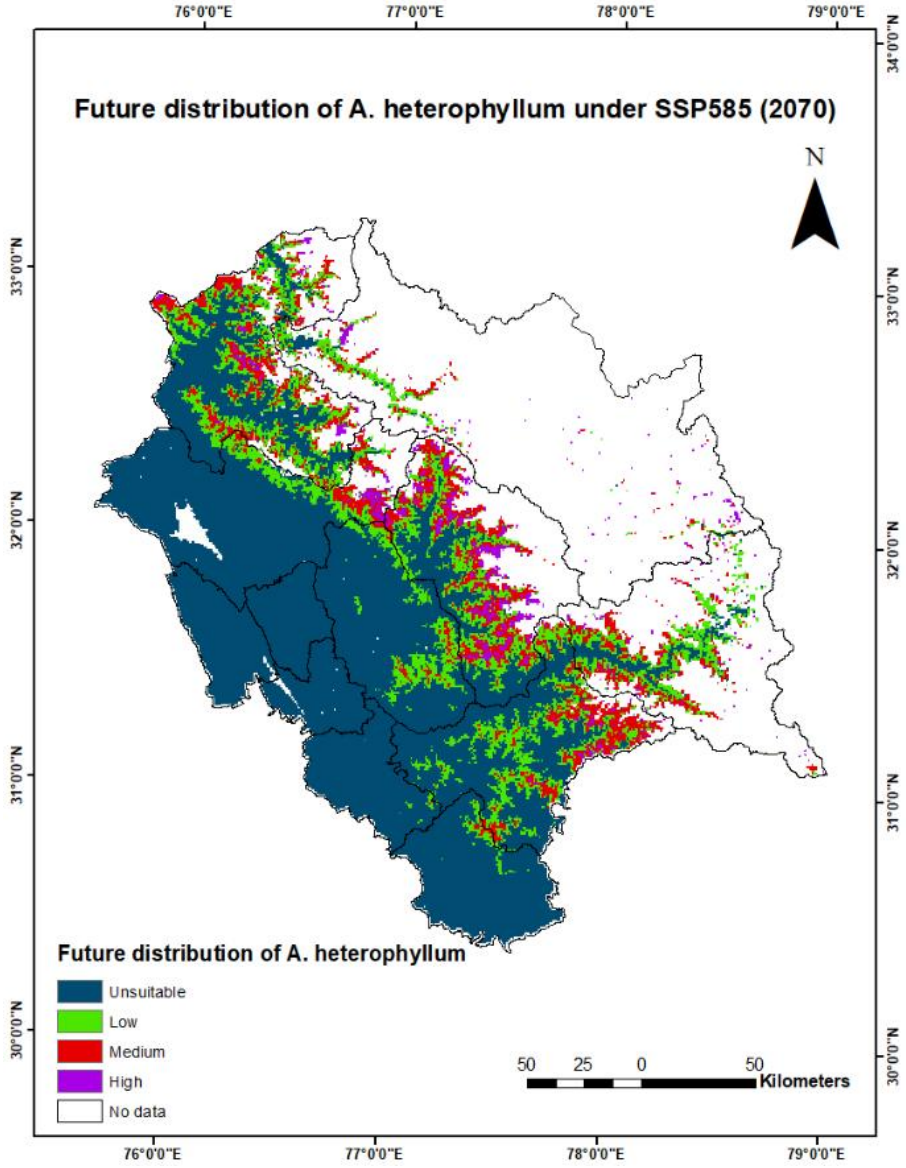
Future distribution in Shared Socioeconomic Scenarios (SSPs)(245)

Area in km^2	Current	SSP245 (2050)	SSP245 (2070)
Unsuitable	2571.62	1806.43	1798.65
Low(25-50%)	917.00	495.37	504.93
Medium (50-75%)	552.88	280.87	269.81
High (>75%)	393.82	79.97	89.12
Total suitable area	1863.7	856.21	863.86



Future distribution in Shared Socioeconomic Scenarios (SSPs)(585)

Area in km^2	Current	SSP585 (2050)	SSP585 (2070)
Unsuitable	2571.62	1370.90	1816.53
Low (25-50%)	917.00	364.29	480.99
Medium (50-75%)	552.88	746.29	283.60
High (>75%)	393.82	181.16	81.58
Total suitable area	1863.7	1,291.74	846.17



Summary

Current Suitable Habitat:

•Characterized by moderate temperatures, moist conditions, clayey or loamy soil, and elevations up to 3200 m asl.

•Key areas: Northwestern, southeastern, and central Himachal Pradesh.

•Environmental factors: Elevation, precipitation, and temperature stability.

•Favorable slopes: Northwest-facing slopes; less suitable: Southwest-facing slopes due to extreme temperatures.

Predictions Under Future Climate Change:

•**SSP126**: 58.4% habitat loss in 2050, 51.3% in 2070.

•**SSP245**: 54.2% habitat loss in 2050, 53.7% in 2070.

•**SSP585**: 30.8% habitat loss in 2050, 54.5% in 2070.

Habitat Shifts:

•Species expected to shift to higher altitudes due to warming and altered precipitation.

•Some current suitable regions will become drier or warmer, reducing habitat availability.

Conclusion and Future Recommendations

Vulnerability & Conservation of *Aconitum heterophyllum*:
•Highly vulnerable to climate change; future models should include soil physico-chemical and evapotranspiration data for refined predictions.
Conservation Priorities:
•Focus on identified areas for their climate stability.
•Adaptation strategies should prioritize habitat corridors, and microclimate protection.

What can we do?

Support Sustainable Harvesting

Raise Awareness

Engage with Policymakers

Protect Natural Habitats

Plant Native Species

Glimpses of alpine landscape of Rohtang Pass, Kullu district in Himachal Pradesh

Thank you for your attention and patience!

Questions?