Predicted Responses of Himalayan Alpine Flora to the Anticipated Future Warmer Climate

Preprint · February 2020

Laxmi Raj Joshi
National Trust for Nature Conservation

PREDICTED RESPONSES OF HIMALAYAN ALPINE FLORA TO THE ANTICIPATED FUTURE WARMER CLIMATE

Laxmi Raj Joshi[1], Suresh Kumar Ghimire[1], Jan Salick[2] and Katie M. Konchar[3]

[1]Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal
[2]Missouri Botanical Garden, St. Louis, Missouri, USA
[3]Tallahassee, Florida, USA
Corresponding Email: laxmi_raj100@yahoo.com

1. INTRODUCTION

1. Himalayan alpine ecosystems are biodiversity hotspots and inhabited by a substantial number of rare and endemic taxa important from economic, ecological and evolutionary perspectives in addition to their conservation significance.
2. Alpine ecosystems are particularly vulnerable to climate change than other areas because the main climatic factors shaping plant life in such ecosystems are directly influenced by global warming.
3. Most of the endemic species so far reported from Himalaya have a very narrow range size and shows high habitat specificity (Shrestha & Joshi, 1996). Such range restricted species are more vulnerable to rapid climate change compared to the lowland species.
4. Studying the impacts of climate change on range restricted species has wider implications for preparing/re-defining species and habitat conservation strategies in the Himalaya.
5. The aim of this study is to assess the predicted changes in Himalayan alpine flora with the anticipated future warmer climate led by climate change at the end of 21st Century.

2. METHODS

Field sampling follows the Global Research Initiative in Alpine Environments (GLORIA) multi-summit approach (http://www.gloria.ac.at/; Grabherr *et al.*, 2001).

- Current distribution of vascular plant species at mountain summits representing 4 ecotones (Figure 1and 2)
- Whole summit area surveys
- 1m x 1m permanent plots surveys (16/summit)

Summits in Manang, Nepal are part of larger Himalayan climate change and biodiversity study (Salick *et al.*, 2014).

Statistical analyses:

- Species Distribution Analyses (biogeography and elevation)
- Indicator Species Analyses
- Local Historical Temperature Trend
- Assessment of Impact of Climate Change on Species Elevation Amplitude based on local adiabatic lapse rate and Intergovernmental Panel on Climate Change (IPCC) emission scenarios

Likely impact of climate change on species elevation amplitude =100/adiabatic lapse rate (0.53^{0}C per 100 m rise in elevation) x predicted temperature rise for particular IPCC emission scenario.

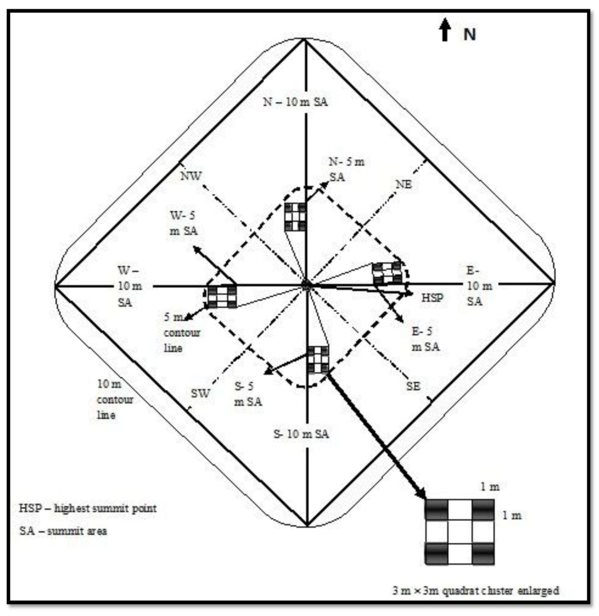

Fig 1. Field sampling technique

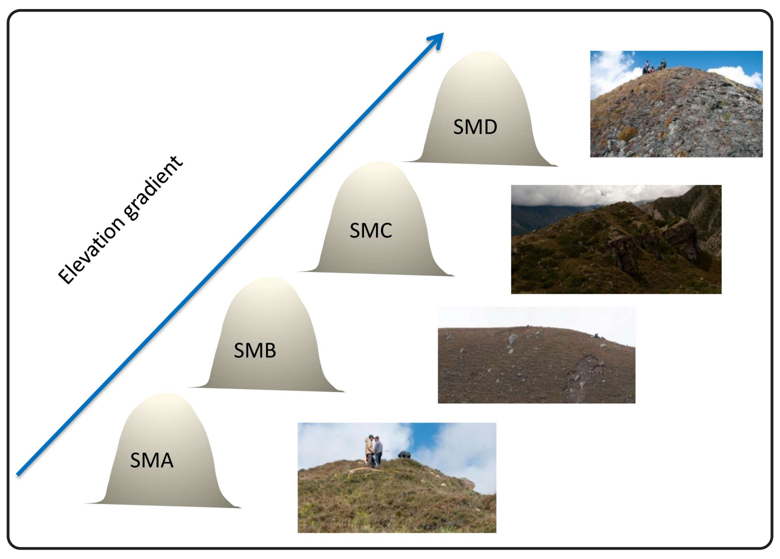

Fig 2. Ecotones sampled along an elevation gradient: SMA- Subalpine-lower alpine (4150 masl); SMB- Lower alpine-middle alpine (4575 masl); SMC- Middle alpine-upper alpine (4835 masl); SMD- Upper alpine-subnival (5005 masl). Photographs representing different summits studied along the gradient

3. RESULTS

a. Biogeographical and elevation pattern of distribution

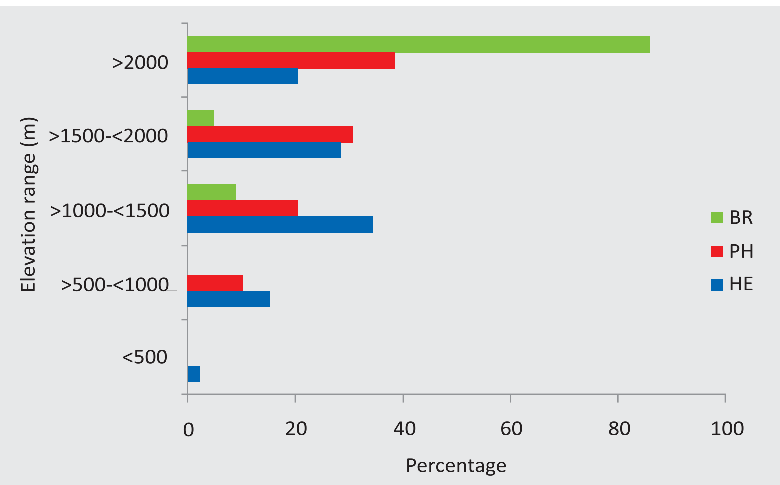

Fig 3. Elevation range of species categorized into different biogeographical groups (HE - Himalaya endemic, PH - pan-Himalayan, BR - broad geographical distribution)

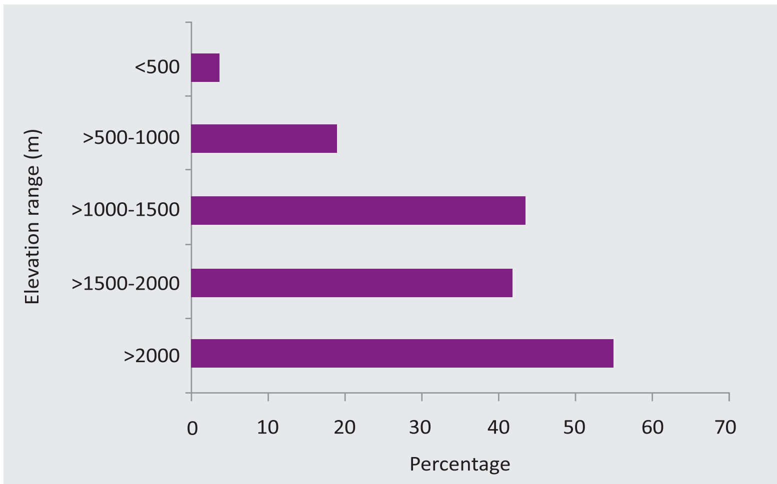

Fig 4. Elevation range for all species calculated as the difference between lower and upper elevation limits

Vascular plants showing increased upper elevation limit (>100 m): 44 species (26% of total investigated species)- probably an evidence of **range shift**

Example: **Invasive species:** *Chenopodium aristatum* (>150 m). Other shrubs, graminoids and forbs: *Artimisia subdigitata* (1575 m), *Cynanthus himalaicus* (1235 m), *Haplosphaera himalayensis* (675 m), *Kobresia williamsii* (835 m), *Poa annua* (650 m), *Potentilla exigua* (500 m) and *Sedum ewersii* (500 m).

Under 1.1-6.4^{0}C projected rise on temperature by the end of 21st century, 23% species having elevation amplitude within the likely impact range of temperature rise (<1250 m) are vulnerable.

Analysis of local historical temperature data (of 30 years) also showed an **increase in annual mean temperature** at the rate of 0.033^{0}C per year ($P = 0.001$; $R^2 = 0.344$).

b. Species indicators to the mountain summits

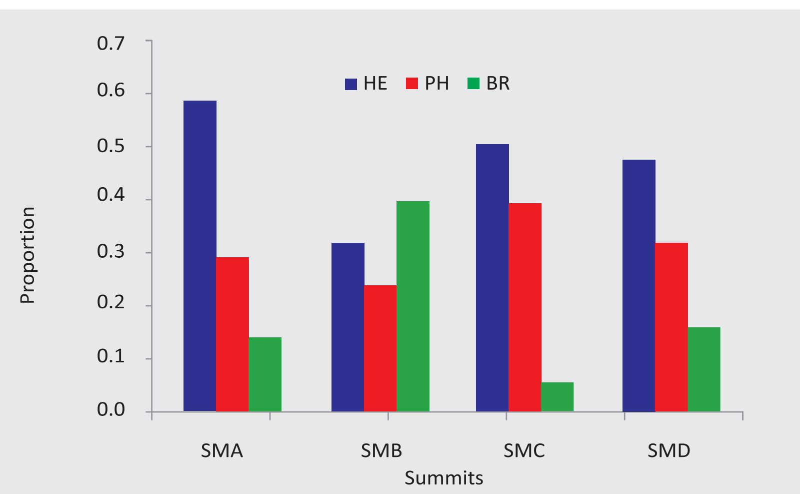

Fig 5. Proportion of indicator species in different summits according to different biogeographical groups. Description of the summits as in figure 2

c. Assessment of Climate Change Impacts

Table 1. Predicted impact of climate change on species elevation ranges

Emission scenario	Rate of average warming[3] (^{0} C)		Likely impacted elevation range (m)	Number of species	Biogeographical affintity
B1[1]	Low	1.1	208	1	All Himalaya endemics
	Intermediate	2.0	378	0	
	High	2.9	548	2	
A1F1[2]	Low	2.4	453	2	Himalaya endemics (79.49%) pan-Himalayan distribution(20.51%)
	Intermediate	4.4	830	11	
	High	6.4	1208	26	

[1]IPCC emission scenario describing a world of very rapid economic growth, a global population that peaks in mid century and rapid introduction of new and efficient technologies
[2]IPCC emission scenario describing a fossil intensive world with the population same as in B1 scenario
[3]Predicted average warming rate at the end of 21st Century (IPCC, 2007)

1

3

2


photo plates:
1. *Taraxacum pseudostenoceras* (Asteraceae), 2. *Aconitum naviculare* var. *leiocarpum* (Ranunculaceae),and
3. *Gentiana algida* (Gentianaceae)- all being Himalaya endemics and highly vulnerable to anticipated climate change

4. CONCLUSIONS

- Study area was dominated by the local endemics (Himalaya endemics) with restricted distribution (narrow elevation amplitude), and the life forms restricted to the cold xeric climates.
- The majority of indicator taxa with restricted geographical distribution also signify the role of endemics on shaping the alpine-nival plant distribution in Himalaya.
- Most of the species likely to adapt through range shift are Himalaya endemics, followed by species with pan-Himalayan distribution with chamaephytic and hemicryptophytic life forms. However, limited habitat availability may hinder the ability of upward march of species and exacerbated species extinction may occur.
- Many of the vulnerable species are the foundation of local livelihoods, and thus future losses of these species means vanishing of local livelihoods, aesthetic norms, values and tradition.
- Scientists and policy makers should urgently make efforts to prepare status database of these species and conservation policies should be formulated accordingly.

LITERATURE CITED

Grabherr, G., Gottfried, M., & Pauli, H. (2001). Long-term monitoring of mountain peaks in the Alps. In: C.A. Burga & A. Kratochwil (Eds.), *Biomonitoring: General and Applied Aspects on Regional and Global Scales.* Dordrecht: Kluwer. pp. 153-177.

IPCC, (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (Eds.), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* United Kingdom and NY, USA: Cambridge University Press, Cambridge. Retrieved from IPCC website: http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html

Salick, J., Ghimire, S.K., Fang, Z.D., Dema, S., & Konchar, K.M. (2014). Himalayan Alpine Vegetation, Climate Change and Mitigation. *Journal of Ethnobiology, 34* (3), 276-293.

Shrestha, T.B., & Joshi, R.M. (1996). Rare, Endemic and Endangered Plants of Nepal. Kathmandu, Nepal: WWF Nepal Program.

ACKNOWLEDGMENTS

Financial support for the field work was provided by National Geographic Society and the US National Institute of Health. Comments on earlier version of the poster was provided by Robbie Hart, Missouri Botanical Garden, USA.