Indian Journal of Ecology (2024) 51(2): 477-483
DOI: https://doi.org/10.55362/IJE/2024/4261

Manuscript Number: 4261
NAAS Rating: 5.38

Ecological Niche Overlap between Himalayan Ibex and Livestock in the Jispa Valley of Trans Himalayan Landscape, Himachal Pradesh, India

R. Dutta[1,2], V. Kumar[3], A. Sharief[3], H. Singh[3], P. Bhatt[4], R. Joshi[5], B.D. Joshi[3*], M. Thakur[3], L.K. Sharma[3] and R. Babu[1]

[1]Southern Regional Centre, Zoological Survey of India, Chennai-600 028, India
[2]University of Madras, Chennai- 600 005, India
[3]Zooological Survey of India, Prani Vigyan Bhawan, Kolkata-700 053, India
[4]Graphic Era Hill University, Dehradun, Uttarakhand-248 002, India
[5]Conservation & Survey Division, Ministry of Environment, Forest and Climate Change, New Delhi -110 003, India
**E-mail: joshidutt01@gmail.com*

Abstract: The issue of livestock grazing poses a significant challenge to the long-term viability of wild ungulates. During the summer season, the Jispa valley of Lahaul and Spiti regions of Himachal experience a significant influx of migratory livestock and coexist and share habitat with the Himalayan Ibex. In the current study, employed the classification of Landsat 8 imagery to determine the land cover land use classes. The image classification achieved an overall accuracy of 82.96% and κ statistic value of 0.81. Species distribution of the Himalayan Ibex and livestock were performed using the Maxent modelling approach, with the utilisation of land cover classes and topographic parameters. The results of the identity test Schoener's D and Warren's I, demonstrate a noteworthy degree of overlap between the Himalayan ibex and livestock. Additionally, the Schoener's D and Warren's I background test indicates that the environmental conditions for Himalayan ibex and livestock are not entirely equivalent. Present study suggests the implementation of effective conservation plan to manage livestock and grazing areas for long-term survival of the wild ungulate species in the study landscape.

Keywords: Himalayan Ibex, Livestock, Image classification, Niche overlap

Globally, competition between wild ungulates and livestock is the most prevalent land utilization activity on a worldwide scale (Robinson et al 2014, Schieltz and Rubenstein 2016). Limitation of available resources used by species of the same trophic level leads to interspecific competition, which negatively affects species fitness. Competition between taxa *viz.* mammals, birds, fish, reptiles, and insecta is one of the most studied research areas (Bagchi et al 2004, Bergstrom and Mensinger 2009, Polo-Cavia et al 2009, Maron et al 2011, Zanni et al 2020). The competition between ungulates can be resource competition, in which species compete for shared space or food and another is interference competition where one species impacted the environment by some adverse effect, which reduces the environmental quality for another species (Birch 1957). Furthermore, the grazing activity of livestock is a serious threat to wild ungulates because the livestock outnumber wild ungulates, and the competition between wild and domesticated ungulates leads to multifaceted negative impacts on the trophic level. For millions of years, ungulates have been essential to maintaining higher trophic levels in ecosystems (Goderie et al 2013, Ripple et al 2015, Roberts et al 2021). The feces of ungulates act as natural fertilizer for the growth of seedlings (Hancock et al 2010, Faust et al 2011). Livestock grazing is also becoming a negative axis for reducing available fodder plants and the crucial habitat of wild ungulates by altering plant composition and structure (McIntyre et al 2017, Ren et al 2021) and trampling and grazing damaged the seedlings (Krzic et al 2006, Wassie et al 2009, Thakur et al 2011). It is evident that conflict between native ungulates and livestock is upsurge in many landscapes (Ren et al 2021). The Himalayan landscape has experienced pastoralism for a few eras. Every summer, enormous herds of sheep, goats, cattle, and equines migrate to the alpine meadows; in order to avoid the harsh cold, they brought back to lower elevations in the middle of autumn (Kittur et al 2010). Pastoralism and other disturbances have the potential to impact the nutritional balance of wildlife. These disturbances can result in increased energy expenditure as wild ungulates move away from the disturbance, potentially leading them to forage in suboptimal habitats instead of areas with higher-quality resources and, wild ungulates may face competition and be excluded from more favourable habitats (Schaller 1977). The significant number of rangelands in the Trans-Himalaya region are currently experiencing overstocking, leading to a notable decline in livestock productivity (Mishra et al 2001). The shifting in habitat use, elevational and dietary niche of wild ungulates is altered by livestock grazing (Namgail et al 2009, Suryawanshi 2009). The wide range of habitats display diversified distribution pattern (Joshi et al 2020). The distribution range of the *Capra sibirica* is in the elevated areas of India, Kazakhstan, Uzbekistan, Afghanistan, Pakistan, Tajikistan, Kyrgyzstan, Mongolia, Russia, and China (Otgonbayar et al 2017). This species is commonly found in the Western Himalayan states of India (Joshi et al 2020). The Himalayan Ibex has been categorised as a "Near Threatened" species by the International Union for Conservation of Nature (IUCN) Red List (Reading et al 2020) and in India, it enjoys protection under Schedule I criteria under the Wildlife (Protection) Act of 1972. The Land cover Land use (LCLU) has a pivotal role in determining the habitats of any given species (Sherbinin 2002). The importance of satellite image classification for land cover categorization, have significant role in addressing societal needs related to managing natural resources, monitoring, and societal growth initiatives (Topaloğlu et al 2016, Khatami et al 2016). Image classification is a methodology that involves the categorization of individual pixels inside an image or raw image obtained from satellites used for remote sensing. The purpose is to provide suitable labels to distinct land cover categories (Abburu and Golla 2015). Furthermore, the impacts of pastoralism on wild ungulates in Trans-Himalaya is an important subject which have been studies from few decades. In this study, specifically investigated the geographical niche overlap that exists between Himalayan Ibex and livestock in the Jispa valley of the Lahaul-Spiti district, located in Himachal Pradesh.

MATERIAL AND METHODS

Study area: The present study area falls under the Jispa valley of Lahaul-Spiti district, Himachal Pradesh. This present study landmass situated in the eastern part of the district and lies from latitudes 32.5556° to 32.7626° N and longitudes 77.0294° to 77.3009° E (Fig. 1). This region is characterised by mountains adorned with snowcaps, gently sloping inclines, and limited vegetation. The region situated under the Trans Himalaya Ladakh Mountains (1A) Indian biogeographic zones and has a total size of 559 square kilometers. Summer and winter are the two prominent seasons of this area. In the summer season the inhabitants grow cash crops mainly peas, cabbage, potatoes and cauliflower, which is the main source of their livelihood. In winter frequent high snowfall occur in this area. Bhaga river intersected this area. Furthermore, this area is the home of many charismatic wild mammals.

Image classification and occurrence point of the Himalayan Ibex and Livestock: The Landsat 8 image was used to classify the LCLU using a supervised machine learning method based on a random forest algorithm (Rodriguez-Galiano et al 2012, Sonobe et al 2014) (Table 1). In this approach, decision trees are constructed individually and then combined in a random manner (Sonobe et al 2017,Thanh Noi and Kappas 2017). The image was categorised into nine distinct types, namely juniper patch, scrub, barren land, sparse vegetation, agriculture land, settlements, water, permafrost, and road. During the field survey, training data was collected from eight LCLU classes, excluding the permafrost class. The accuracy of the classification is determined by overall accuracy, kappa coefficient and F-statistics are utilised to assess the accuracy of the different categorised classes (Congalton 1991, Neetu and Ray 2020). The image classification was performed via the dzetsaka classification tool, which is integrated within the QGIS platform (Karasiak 2019). Furthermore, the collection of the occurrences of the Himalayan Ibex and livestock we employed camera trapping, trail sampling, direct observation and questionnaire survey. Nevertheless, due to the presence of terrain ruggedness, incline slopes, high peaked snowy mountains, and unpredictable weather conditions in the research region, we conducted representative sampling.

Variables preparation and selection: In this present study selection of ecologically pertinent variables and extracted Euclidean distance from each LCLU classes derived from

Table 2. Class accuracy metrices of Landsat 8 classified images using F – statistics

LCLU class	F-statistics
Agriculture	77.19
Sparse vegetation	87.06
Barren	82.93
Scrub	79.17
Juniper patch	74.53
Settlement	83.02
Permafrost	96.55
Water	90.70
Road	77.58

Table 1. Acquisition details for the Landsat 8 imagery

Satellite	Sensor	Path & Row	Acquisition date	Resolution (meter)	Scene ID
Landsat 8	OLI & TIRS	147 & 37	18-09-2022	30	LC81470372022261LGN00

classified Landsat 8 image. Moreover, used Alos Palsar, Digital elevation model (DEM) data and further the topographic variables calculated from this DEM data. Furthermore, generating all the variables resampled them at 30-meter spatial scale. A total of 16 variables were initially prepared for this present study (Table 3). In the process of constructing the final model, we opted to include solely uncorrelated variables based on Pearson correlation coefficients (r) that demonstrated a correlation coefficient exceeding 0.8.

Niche overlap: The ecological niche of the Himalayan Ibex and the livestock analyzed by the Maximum Entropy model (MaxEnt) (Phillips et al 2006). In order to conduct a comparative analysis of the expected distributions of Himalayan Ibex and livestock, we utilised the Environmental Niche Modelling (ENM) approach. Specifically, employed identity test and background test and two metrices Schoener's D and Warren's I indices, which have been recommended for ENM comparisons and were applied using ENMTools 1.1.1 (Warren et al 2021). This metric is widely recognized as a standardized tool for quantifying the relative similarity between observed niches, thereby enabling comparisons akin to percentage overlap (Rödder and Engler 2011, Broennimann et al 2012, Filz and Schmitt 2015). The measurement of potential distribution similarity is achieved by conducting a comparative analysis of corresponding values within individual cells of two grids. This similarity metric ranges linearly from 0, indicating a complete absence of similarity, to 1, signifying that the two grids under examination are entirely identical (Warren et al 2010).

RESULTS AND DISCUSSION

Image classification: The classification of Landsat 8 imagery by random forest algorithm shows overall accuracy of 82.96 and κ statistic 0.81 (Fig. 1), which depicts an overall good classification of this image. Furthermore, the accuracy estimation for classifying each feature class from this image by F- statistics depicts, all classes gain good accuracy when compared by ground-truthing data (Table 2).

Niche overlap result: The MaxEnt analysis yielded an acceptable Area Under the Curve (AUC) value, indicating its efficacy in predicting the spatial distribution of these ungulate species within this landscape. The estimated AUC for the Himalayan Ibex on the training data is 0.86, whereas the AUC for livestock on the training data is 0.92 (Fig. 2). The ecological niche of the Himalayan Ibex and livestock was assessed through the identity tests using two metrices, namely Schoener's D and Warren's I. The results of similarity test Schoener's D is 0.72 and Warren's I is 0.93. However, background tests results of environment similarity test of Schoener's D is 0.17 and Warren's I is 0.28. Therefore, the identity test reveals a significant degree of niche overlap between the wild ungulate and the livestock (Table 4, Fig. 3). The outcomes of the symmetric background tests, indicate that there is not a high resemblance between the ecological niches of the Himalayan Ibex and livestock in terms of environmental areas (Table 4, Fig. 4). The results of the symmetric background test indicate that the p-values for Schoener's D and Warren's I are both less than 0.05. This suggests that the null hypothesis is rejected, indicating a difference in the environmental space.

The livestock movement governed by the shepherd intervention, so their movement is restricted, moreover the livestock outnumbered the Himalayan Ibex, so the wild ungulate moves to this area where livestock not occupied. Bagchi et al (2004) found that Himalayan Ibex and livestock use the similar habitat properties and their diet also not different which indicate high degree of niche overlap. Another study found there are high activity overlap coefficient between Himalayan Ibex and livestock with Δ value of 0.80 (Salvatori et al 2021). Furthermore, Himalayan Ibex and its domesticated sympatric species (sheep and goats) shown the high degree of dietary overlap, which have detrimental effects on wild ungulates (Bagchi and Mishra 2006, Sharma et al 2015, Siraj-ud-Din et al 2016, Salvatori et al 2021). The relatively lower elevated region yields high-quality fodder

Table 3. Variables used for evaluating potential suitable habitat of Himalayan Ibex and livestock in the present study area

	Code	Variables
Land cover land use variables	Agriculture*	Agricultural areas distance
	Barren*	Barren land distance
	Juniper patch*	Juniper patch distance
	Permafrost	Permafrost areas distance
	Road	Road ways distance
	Scrub*	Scrub lands distance
	Settlement	Settlement distance
	Sparse vegetation*	Sparse vegetation areas distance
	Water*	Water lines distance
	NDVI*	Normalized difference vegetation index
Topographic variables	Elevation*	Elevation
	IMI	Integrated moisture Index
	Aspect*	Aspect
	CTI*	Compound Topographic Index
	Heatload	Heat load index
	Ruggedness	Ruggedness

'*' denotes used variables for Ecological Niche modelling

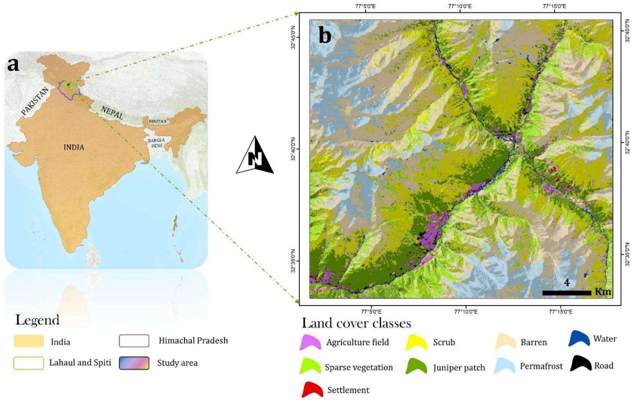

Fig. 1. Present study area location (a) and Landsat 8 classified image of the study area (b)

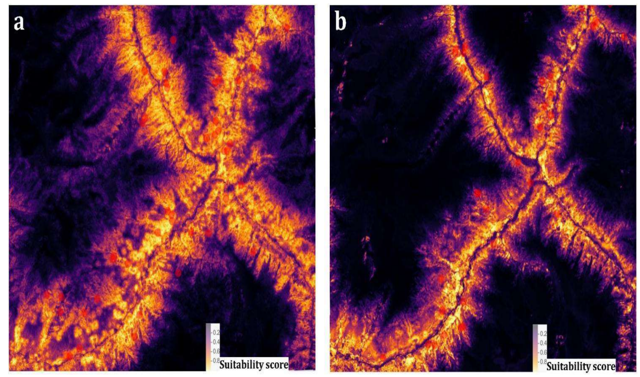

Fig. 2. Predicted suitable habitats of the (a) Himalayan Ibex and (b) livestock in the study area using MaxEnt modelling

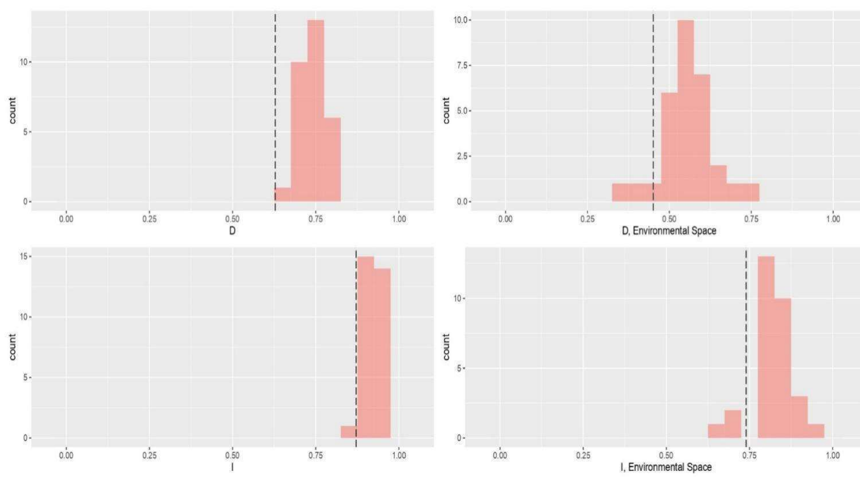

Fig. 2. Predicted suitable habitats of the (a) Himalayan Ibex and (b) livestock in the study area using MaxEnt modelling

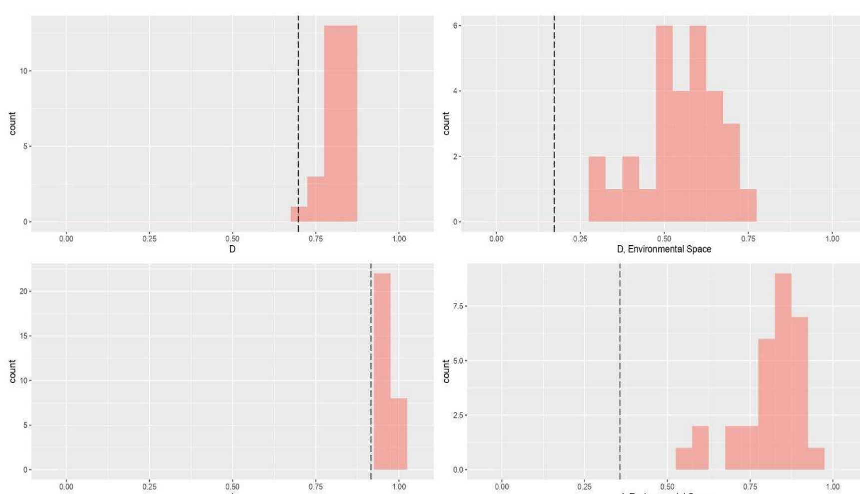

Fig. 4. Outcomes from the background test for the Himalayan Ibex and livestock across the geographic and environmental contexts. Histograms of 30 test simulations employing two distinct metrics, the Schoener's D and the Warren's I. The observed values showed by dotted lines

Table 4. p value of Niche overlap metrices, *viz.*Schoener's D and Warren's I of Identity test and background test

Metrices	D	I	env.D	env.I
Identity test	0.06	0.06	0.13	0.13
Background test	0.03	0.03	0.03	0.03

plant throughout the summer season, primarily utilised by livestock, thereby displacing the Himalayan Ibex from this location to habitats of inferior quality. Differentiation in resource usage facilitating co-existence and similarity in resource selection might cause competition (Voeten and Prins 1999, Bagchi et al 2003, Bagchi and Mishra 2006).The findings indicate that migratory goat and sheep populations in Jispa Valley contribute to spatial niche overlap with Himalayan Ibex, potentially posing a risk for disease transmission and pasture degradation (Khanyari et al 2022). Therefore, it is imperative that conservation management in Jispa Valley prioritises the resolution of the migratory grazing problem. Human – nature relationship is one of the well-known facts in recent world, human development and resource utilisation decline the natural balance, where Global Change Research human role is one of the key factors as a driving force (Holm et al 2013). Furthermore, the livestock grazing also reason of the retaliatory killing of the apex carnivores like snow leopard, wolf because of declination of natural prey like Himalayan Ibex and they hunt on livestock (Snow Leopard Network 2014, Mishra et al 2016, Salvatori et al 2021). Undeniably, livestock grazing plays a significant role in the economic livelihoods of local communities and shepherds. Consequently, it is imperative to closely monitor and manage livestock populations and implement effective pastoralism. These measures undoubtedly contribute to the preservation and maintenance of the natural wildlife population.

ACKNOWLEDGEMENT

The authors express their gratitude to the Principal Chief Wildlife Warden of the Forest Department, Government of Himachal Pradesh, for providing the required authorization and financial support for conducting field surveys. Authors express our gratitude to the Divisional Forest Officers of the Lahaul and Spiti Forest Division for their generous assistance and support during the duration of our fieldwork and Director of the Zoological Survey of India for providing logistical assistance.

AUTHOR CONTRIBUTION

R Dutta, BD Joshi, LK Sharma conceived the idea. R Dutta, H Singh, V Kumar, A Sharief conducted field survey. R Dutta**,** BD Joshi**,** LK Sharma performed the analysis. R Dutta, V Kumar spatial data preparation. R Dutta**,** BD Joshi**,** V Kumar,A Sharief, H Singh, LK Sharma wrote the manuscript. R Dutta**,** BD Joshi**,** V Kumar,H Singh**,** A Sharief, LK Sharma**,** M Thakur and R Babu edited the manuscript. LK Sharma and R Babu provided the logistic support and supervised the study.

REFERENCES

Abburu S and Golla SB 2015. Satellite image classification methods and techniques: A review. *International journal of computer applications* **119**(8): 20-25.

Bagchi S Mishra C and Bhatnagar YV 2004. Conflicts between traditional pastoralism and conservation of Himalayan ibex (*Capra sibirica)* in the Trans-Himalayan mountains. *Animal Conservation* **7**(2): 121-128.

Bagchi S, Goyal SP and Sankar K 2003. Niche relationships of an ungulate assemblage in a dry tropical forest. *Journal of Mammalogy* **84**(3): 981-988.

Bagchi S and Mishra C 2006. Living with large carnivores: predation on livestock by the snow leopard (*Uncia uncia*). *Journal of Zoology* **268**(3): 217-224.

Bergstrom MA and Mensinger AF 2009. Interspecific resource competition between the invasive round goby and three native species: Logperch, slimy sculpin, and spoonhead sculpin. *Transactions of the American Fisheries Society* **138**: 1009-1017.

Birch LC 1957. The meanings of competition. *The American Naturalist* **91**(856): 5-18.

Broennimann O, Fitzpatrick MC, Pearman PB, Petitpierre B, Pellisier L, Yoccoz NG, Thuiller W, Fortin MJ, Randin C, Zimmermann NE, Graham CH and Guisan A 2012. Measuring ecological niche overlap from occurrence and spatial environmental data. *Global Ecology and Biogeography* **21**: 481- 497.

Caro TM 2010. *Conservation by Proxy: Indicator, Umbrella, Keystone, Flagship, and Other Surrogate Species*. Washington, DC: Island Press.

Congalton RG 1991. A review of assessing the accuracy of classifications of remotely sensed data. *Remote sensing of environment* **37**(1): 35-46.

Congalton RG, Oderwald RG and Mead RA 1983. Assessing Landsat classification accuracy using discrete multivariate analysis statistical techniques. *Photogrammetric Engineering and Remote Sensing* **49**(12): 1671-1678.

de Sherbinin A 2002. *Land-use and land-cover change, a CIESIN thematic guide.* Center for International Earth Science Information Network, Columbia University, Palisades, NY.

Faust C, Eichberg C, Storm C and Schwabe A 2011. Post-dispersal impact on seed fate by livestock trampling: A gap of knowledge. *Basic and applied ecology* **12**(3): 215-226.

Fedosenko AK and Blank DA 2001. *Capra sibirica*. *Mammalian species* **2001**(675): 1-13.

Filz KJ and Schmitt T 2015. Niche overlap and host specificity in parasitic Maculinea butterflies (Lepidoptera: Lycaenidae) as a measure for potential extinction risks under climate change. *Organisms Diversity & Evolution* **15**: 555-565.

Foody GM 2002. Status of land cover classification accuracy assessment. *Remote sensing of environment* **80**(1): 185-201.

Goderie R, Helmer W, Kerkdijk-Otten H and Widstrand S 2013. *The Aurochs - Born to be Wild: The Comeback of a European Icon.* Zutphen: Roodbont Publishers.

Gumma MK, Thenkabail PS, Teluguntla P and Whitbread AM 2019. Indo-Ganges river basin land use/land cover (LULC) and irrigated area mapping. In S. I. Khan & T. E. Adams (Eds.), *Indus River Basin* (pp. 203-228). Elsevier, Amsterdam, Netherlands. https://doi.org/10.1016/B978-0-12-812782-7.00010-2

Hancock MH, Summers RW, Amphlett A, Willi J, Servant G and Hamilton A 2010. Using cattle for conservation objectives in a Scots pine *Pinus sylvestris* forest results of two trials. *European Journal of Forest Research* **129**: 299-312.

Harris RB and Miller DJ 1995. Overlap in summer habitats and diets of Tibetan plateau ungulates. *Mammalia* **59**: 197-212.

Holm P, Goodsite ME, Cloetingh S, Agnoletti M, Moldan B, Lang DJ, Leemans R, Moeller JO, Buendía MP, Pohl W and Scholz RW 2013. Collaboration between the natural, social and human sciences in global change research. *Environmental Science & Policy* **28**: 25-35.

Joshi BD, Jabin G, Sharief A, Kumar V, Mukherjee T, Kumar M, Singh A, Singh SK, Chandra K, Sharma LK and Thakur M 2020. Genetic evidence for allopatric speciation of the Siberian ibex Capra sibirica in India. *Endangered Species Research* **42**: 1-5.

Karasiak N 2019. Lennepkade/dzetsaka: Dzetsaka v3.4.4 (Version v3.4.4). Zenodo. http://doi.org/10.5281/zenodo.2647723

Keshtkar H, Voigt W and Alizadeh E 2017. Land-cover classification and analysis of change using machine-learning classifiers and multi-temporal remote sensing imagery. *Arabian Journal of Geosciences* **10**: 1-15.

Khanyari M, Robinson S, Milner-Gulland EJ, Morgan ER, Rana RS and Suryawanshi KR 2022. Pastoralism in the high Himalayas: Understanding changing practices and their implications for parasite transmission between livestock and wildlife. *Pastoralism* **12**(1): 44.

Khatami R, Mountrakis G and Stehman SV 2016. A meta-analysis of remote sensing research on supervised pixel-based land-cover image classification processes: General guidelines for practitioners and future research. *Remote Sensing of Environment* **177**: 89-100.

Kittur S, Sathyakumar S and Rawat GS 2010. Assessment of spatial and habitat use overlap between Himalayan tahr and livestock in Kedarnath Wildlife Sanctuary, India. *European Journal of Wildlife Research* **56**: 195-204.

Krzic M, Newman RF, Trethewey C, Bulmer CE and Chapman BK 2006. Cattle grazing effects on plant species composition and soil compaction on rehabilitated forest landings in central interior British Columbia. *Journal of Soil and Water Conservation* **61** (3): 137-144.

Maron M, Main A, Bowen M, Howes A, Kath J, Pillette C and Mcalpine CA 2011. Relative influence of habitat modification and interspecific competition on woodland bird assemblages in eastern Australia. Emu - Austral *Ornithology* **111**: 40-51.

Mishra C, Prins HHT, van Wieren SE 2001. Overstocking in the Trans-Himalayan rangelands of India. *Environmental Conservation* **28**(3): 279-283.

Mishra C, Redpath SR and Suryawanshi KR 2016. Livestock predation by snow leopards: conflicts and the search for solutions, pp 59-67. In: T. McCarthy, D. Mallon (eds). *Snow Leopards: Biodiversity of the World: Conservation from Genes to Landscapes*. Academic Press, Cambridge, Massachusetts. https://doi.org/10.1016/B978-0-12-802213-9.00005-5

Namgail T, Mishra C, de Jong CB, van Wieren SE and Prins HHT 2009. Effects of herbivore species richness on the niche dynamics and distribution of blue sheep in the trans-Himalaya. *Diversity and Distributions* **15**(6): 940-947.

Neetu and Ray SS 2020. Evaluation of different approaches to the fusion of Sentinel-1 SAR data and Resourcesat 2 LISS III optical data for use in crop classification. *Remote Sensing Letters* **11**(12): 1157-1166.

Nitze I, Schulthess U and Asche H 2012. Comparison of machine learning algorithms random forest, artificial neural network and support vector machine to maximum likelihood for supervised crop type classification. *Proceedings of the 4th GEOBIA, Rio de Janeiro, Brazil*, *79*, 35-40.

Otgonbayar B, Buyandelger S, Amgalanbaatar S and Reading RP 2017. Siberian Ibex (*Caprasibirica*) Neonatal Kid Survival and Morphometric Measurements in Ikh Nart Nature Reserve, Mongolia. *Mongolian Journal of Biological Sciences* **15**(1-2): 23-30.

Phillips SJ, Anderson RP and Schapire RE 2006. Maximum entropy modelling of species geographic distributions. *Ecological modelling* **190**: 231-259.

Polo-Cavia N, López P and Martín J 2009. Interspecific differences in chemosensory responses of freshwater turtles: consequences for competition between native and invasive species. *Biological Invasions* **11**: 431-440.

Reading R, Michel S, Suryawanshi K and Bhatnagar YV 2020. *Capra sibirica* The IUCN Red List of Threatened Species 2020: eT42398A22148720

Ripple WJ, Newsome TM, Wolf C, Dirzo R, Everatt KT, Galetti M, Hayward MW, Kerley GI, Levi T, Lindsey PA and Macdonald DW 2015. Collapse of the world's largest herbivores. *Science advances* **1**(4): p.e1400103.

Roberts NJ, Zhang Y, Convery I, Liang X, Smith D and Jiang G 2021. Cattle Grazing Effects on Vegetation and Wild Ungulates in the Forest Ecosystem of a National Park in Northeastern China. *Frontiers in Ecology and Evolution* **9**: 680367.

Robinson TP, Wint GW, Conchedda G, Van Boeckel TP, Ercoli V, Palamara E, Cinardi G, D'Aietti L, Hay SI and Gilbert M 2014. Mapping the global distribution of livestock. *PloS One* **9**(5): p.e96084.

Rödder D and Engler JO 2011. Quantitative metrics of overlaps in Grinnellian niches, advances and possible drawbacks. *Global Ecology and Biogeography* **20**: 915-927.

Rodriguez-Galiano VF, Chica-Olmo M, Abarca-Hernandez F, Atkinson PM and Jeganathan C 2012. Random Forest classification of Mediterranean land cover using multi-seasonal imagery and multi-seasonal texture. *Remote Sensing of Environment* **121:** 93-107.

Salvatori M, Tenan S, Oberosler V, Augugliaro C, Christe P, Groff C, Krofel M, Zimmermann F and Rovero F 2021. Co-occurrence of snow leopard, wolf and Siberian ibex under livestock encroachment into protected areas across the Mongolian Altai. *Biological Conservation* **261**: p.109294.

Schaller GB 1977. *Mountain monarchs: Wild sheep and goat of the Himalayas*. University of Chicago Press, Chicago, USA.

Schieltz JM and Rubenstein DI 2016. Evidence based review: positive versus negative effects of livestock grazing on wildlife. What do we really know? *Environmental Research Letters* **11**(11): p.113003.

Schoener TW 1974. Resource partitioning in ecological communities. *Science* **185**: 27-39.

Sharma RK, Bhatnagar YV and Mishra C 2015. Does livestock benefit or harm snow leopards? *Biological Conservation* **190**: 8-13.

Siraj-ud-Din M, Minhas RA, Khan M, Ali U, Bibi SS, Ahmed B and Awan MS 2016. Conservation status of Ladakh Urial (Ovis vignei vignei Blyth, 1841) in Gilgit Baltistan. *Pakistan Journal of Zoology* **48**(5): 1353-1365.

Snow Leopard Network 2014. *Snow Leopard Survival Strategy Revised 2014 Version*. Snow Leopard Network, Seattle, Washington, USA

Sonobe R, Tani H, Wang X, Kobayashi N and Shimamura H 2014. Random forest classification of crop type using multi-temporal TerraSAR-X dual-polarimetric data. *Remote Sensing Letters* **5**(2):157-164.

Sonobe R, Yamaya Y, Tani H, Wang X, Kobayashi N and Mochizuki KI 2017. Mapping crop cover using multi-temporal Landsat 8 OLI imagery. *International Journal of Remote Sensing* **38**(15): 4348-4361.

Suryawanshi KR 2009. Why should a grazer browse? Livestock impact on winter resource use by bharal Pseudois nayaur. *Oecologia* **162**(2): 453-462.

Martin TG and McIntyre S 2007. Impacts of livestock grazing and tree clearing on birds of woodland and riparian habitats. *Conservation Biology* **21**(2): 504-514.

McIntyre T, Bester MN, Bornemann H, Tosh CA and De Bruyn PN 2017. Slow to change? Individual fidelity to three-dimensional foraging habitats in southern elephant seals, Mirounga leonine. *Animal Behaviour* **127:** 91-99.

Thakur AK, Singh G, Singh S and Rawat GS 2011. Impact of Pastoral practices on forest cover and regeneration in the outer fringes of Kedarnath wildlife sanctuary, Western Himalaya *Journal of the Indian Society of Remote Sensing* **39**: 127-134.

Thanh Noi P and Kappas M 2017. Comparison of random forest, k-nearest neighbor, and support vector machine classifiers for land cover classification using Sentinel-2 imagery. *Sensors* **18**(1): 18.

Topaloğlu RH, Sertel E and Musaoğlu N 2016. Assessment of classification accuracies of sentinel-2 and landsat-8 data for land cover/use mapping. In: International archives of the photogrammetry, remote sensing & spatial Information Sciences, 41. ISPRS: Prague, Czech Republic, Volume XLI-B8, 1055–1059. https://doi.org/10.5194/isprsarchives-XLI-B8-1055-2016

Received 23 November, 2023; Accepted 28 March, 2024

Voeten MJ and Prins HHT 1999. Resource partitioning between sympatric wild and domestic herbivores in the Tarangire region of Tanzania. *Oecologia* **120**: 287-294.

Warren DL, Glor RE and Turelli M 2010. ENMTools: A toolbox for comparative studies of environmental niche models. *Ecography* **33**: 607-611.

Warren DL, Matzke NJ, Cardillo M, Baumgartner JB, Beaumont LJ, Turelli M, Glor RE, Huron NA, Simões M, Iglesias TL and Piquet JC 2021. ENMTools 1.0: an R package for comparative ecological biogeography. *Ecography* **44**(4): 504-511.

Wassie A, Sterck FJ, Teketay D and Bongers F 2009. Effects of livestock exclusion on tree regeneration in church forests of Ethiopia. *Forest Ecology and Management* **257**(3): 765-772.

Ren Y, Zhu Y, Baldan D, Fu M, Wang B, Li J and Chen A 2021. Optimizing livestock carrying capacity for wild ungulate-livestock coexistence in a Qinghai-Tibet Plateau grassland. *Scientific reports* **11**(1): 3635-3638.

Zanni M, Brivio F, Grignolio S and Apollonio M 2021. Estimation of spatial and temporal overlap in three ungulate species in a Mediterranean environment. *Mammal Research* **66**:149-162.