Landscape connectivity and population density of snow leopards across a multi-use landscape in Western Himalaya

-Ranjana Pal

Aim: Conservation of carnivores such as snow leopard goes beyond protected areas and requires a landscape approach that necessitates integration into human-dominated areas. Such practice requires understanding species responses to anthropogenic pressures and the protection of critical areas and connectivity they provide. The present study examines seasonal, environmental, and anthropogenic drivers of variation in snow leopard (*Panthera uncia*) density and identifies potential areas important for connectivity in the landscape.

Location: Upper Bhagirathi basin (~4600 km^2), Uttarakhand

Method: Using spatial capture-recapture modelling, 4-year seasonal (Summer: May to September; Winter: November to March) camera trapping dataset (October 2015– March 2019) on spatial encounter history data of snow leopards was analyzed to assess the density and the relationship between movement and topography to identify conducive areas for facilitating movement across the landscape.

Results: Snow leopard density was positively associated with elevation and slope, and was higher in protected areas (summer: 1.42±0.02/100km^2; winter 2.15±0.03 vs. summer: 0.4±0.01; winter: 0.6±0.01 for unprotected areas). Precipitous terrain and several prominent mountain peaks were found to be resistant to snow leopard movement. Density-weighted connectivity showed that conducible areas are available between the Gangotri landscape and the adjacent protected areas.

Conclusion: The high density of snow leopards inside protected area, despite the presence of a range of human activities, indicates the importance of protection in sustaining the snow leopards alongside multiple human use practices. Low density outside protected area requires management attention especially the areas identified as potential corridors for snow leopards.

The study provides some crucial insights into carnivore conservation in a human use landscape. Firstly, effective regulation of human behavior and resource use is the key to the survival of carnivores in a multiuse landscape. Secondly, for a successful coexistence model, along with the identification of suitable habitats, conservation practices need to moderate human activities and require integrated management approaches to ensure landscape-scale connectivity. Further, the study provides a framework to collectively quantitate the spatial pattern of abundance, distribution, and connectivity. This approach has broad applicability for policymakers to develop strategic plans for balancing the conservation of species, and other land uses in a multiuse landscape.

Project Title	: Assessment and Monitoring of Climate Change Effects on Wildlife Species and Ecosystems for Developing Adaptation and Mitigation Strategies in the Indian Himalayan Region
Principal Investigator(s)	: Dr. S. Sathyakumar
Researcher(s)	: Ranjana Pal, Project Associate-II
Funding Agency	: DST
Project Duration	: 2014-2020

Generalist Carnivore Red Fox from East to West Himalaya: Religion, Culture and Diet

-Hussain Saifee Reshamwala

Red fox (*Vulpes vulpes*) is the world's most widespread carnivore and is known for its generalist and opportunistic behaviour across its geographic distribution. Although it is one of the most extensively studied carnivore, in the Himalayan landscape there is a dearth of information pertaining to this animal. The feeding ecology is often interesting to ecologist as it governs the behaviour of species. The space-use, mating strategies, denning behaviour and spatio-temporal segregation with others are all dependent on the diet.

Aim: We studied the dietary pattern of red fox in Tawang from the North-Eastern Himalayan landscape and compared it with our previous studies from the North-Western Himalayan landscape.

Study Area: The study area of Tak-Tsang Gompa lies about 40 km from the city of Tawang and the altitude ranges from 1012 to 5676 m. The average annual rainfall is 915 mm.

Methods: All the potential trails were actively searched for fox sightings, signs and scats. A total of 227 scats were collected from of July to September. The scats were washed in running water through a fine sieve of 120 mm and indigestible items were collected for further identification. The prey items were identified on the basis of medullary hair pattern and the diet niche overlap was calculated using the Pianka's index.

Results: The diet of the red fox consists of a wide spectrum of food items and the main prey across the Eastern and Western Himalayan landscape was rodent and lagomorphs. The diet in Tawang showed the highest overlap with Dachigam (0.87) where insects and rodents were the major food items. In Tawang, anthropogenic food subsidies were consumed in very less proportions. Human culture and religion have a great influence on the ecology of red fox across different sites. In Ladakh, it not only influences the diet but also governs the den site selection. The present study helps in understanding the diet of red fox across Eastern and Western Himalayan landscapes.

Keywords: Diet overlap, Scat analysis, Pianka's index, Anthropocene, Food subsidies.

Project Title	: Movement in Space and Time: Ecology of Red Fox in Tawang Upper Valley, Eastern Himalaya, India
Principal Investigator(s)	: Dr. Bilal Habib
Researcher(s)	: Hussain Saifee Reshamwala, Senior Project Associate
Funding Agency	: National Mission on Himalayan Studies (NMHS)
Project Duration	: 2019-2022

Mammalian abundance and factors governing the diversity in mountainous systems: An investigation along varying altitudinal landscapes

-Nidhi Singh & Urjit Bhatt

Aim: Assessing the status of species can serve as a healthy model for monitoring forest ecosystem in the long term. The aim of the study was to assess species richness, Relative Abundance Index (RAI), density, and temporal and spatial overlap of mammalian fauna. Additionally, factors governing the abundance of mammals were also investigated.

Study Area: The study was carried out in PAs of Himachal Pradesh, i.e., Simbalbara National Park (SNP), Pin Valley National Park (PVNP), & Chandratal Wildlife Sanctuary (CWLS).

Methods: Camera traps were deployed in SNP (n=31), PVNP (n=45), and CWLS (n=20) in a grid size of 1 km^2. Species richness was estimated as the total number of species detected during survey. The RAI was calculated as the summed of all detections for each species from all camera traps, divided by the total number of trap nights. Total trap nights required to get a single and first photograph was evaluated. Species accumulation curve for all mammals was pooled across days to evaluate the survey effort. Density of species was estimated using camera-trap distance (CTDS) sampling method. Temporal and spatial overlaps were determined using *kernel density estimation* and *co-occurrence test* respectively.

Results & Discussion: A total of 20 mammalian species were recorded in SNP, and six in each of PVNP and CWLS. RAI was highest for *Rusa unicolor* in SNP, and *Vulpes vulpes* in PVNP and CWLS; and density was highest for *Axis axis* in SNP and *Vulpes vulpes* in PVNP & CWLS. Temporal overlap was highest for *Panthera pardus-Rusa unicolor* (SNP, $delta_1$=0.82), *Panthera uncia-Vulpes vulpes* (PVNP, $delta_1$=0.82), and *Canis lupus-Ochotona roylei* (CWLS, $delta_1$=0.82). Mammalian species showed random spatial distribution, and no co-occurrence pattern was observed. Major potential factors affecting the mammalian abundance in the three landscapes includes intensive grazing, hunting and human interference. The effort is being made to collect seasonal data for the mammalian species in each landscape to compare the data, identify the threats and develop ecological indicators for long term monitoring.

Keywords: Abundance, camera-trap distance sampling, mammalian diversity, Spatio-temporal, trans-Himalayas

Project Title	: Basic study design of biodiversity assessment for Himachal Pradesh
Principal Investigator(s)	: Dr Salvador Lyngdoh
Researcher(s)	: Nidhi Singh & Urjit bhatt
Funding Agency	: JICA
Project Duration	: 2021-2022

Distribution of Herpetofauna along different altitudinal gradients in Himachal Pradesh

-Saurav Chaudhary

Aim: To provide baseline information about the species richness and distribution of the herpetofauna along different altitudes in Himachal Pradesh.

Study Area: The study was conducted in and around three protected areas based on their elevation gradient covering the lower elevation (350-750m) in Simbalbara Wildlife Sanctuary, mid-elevation (1500-3654m) in Churdhar Wildlife Sanctuary and higher elevation (3450-6000m) in Pin Valley National Park.

Methodology: Stratified random sampling approach using both nocturnal and diurnal Visual encounter survey (VES) (Time constrained) was used for assessing the distribution of the herpetofauna in the study area. Opportunistic encounters for reptiles were also recorded. Information about the encounter rate and abundance of species at each elevation gradient was also calculated and relative abundance of species at each elevation gradient was also calculated. Site specific species accumulation curves were generated to show community richness and effectiveness of sampling efforts.

Results & Conclusions: The survey resulted in the presence of 43 species of Herpetofauna belonging to 15 families which included 29 species of reptiles and 14 species of amphibians. 25.58% of the encountered species are endemic to the western Himalayan region. There is a monotonous decline in species number with an increase in elevation. The coefficient of biogeographic resemblance between lower and mid-elevation is mere 0.09. Trans-Himalayan region is species-poor but most distinctive in its herpetofauna. Species accumulation curve reached asymptote in lower elevation but mid elevation and upper stretches remain to be sampled.

Keywords: Species richness, Amphibians, Reptiles, Encounter rate, Himalayas.

Project Title	:	Basic study design of Biodiversity Assessment for Himachal Pradesh
Principal Investigator(s)	:	PI: Dr. Salvador Lyngdoh Co-PI: Dr. Abhijit Das
Researcher(s)	:	Saurav Chaudhary- Junior Project Fellow (Herpetological Diversity)
Funding Agency	:	JICA
Project Duration	:	2021-2022

Forest types as drivers of variance in spider (Araneae) communities in Lahaul, Himachal Pradesh

-Irina Das Sarkar

Aim: The paper aims to assess the role of vegetation structures as drivers of community variations in spider assemblages in temperate forests of Himachal Pradesh, to establish the importance of forest composition in determining arthropod community variations across habitat gradients. Much of the diversity of terrestrial species in temperate ecosystems is associated with physiognomy of forest habitats, highlighting the necessity of understanding species-habitat associations.

Location: The study was conducted in 3 different forest types (Poplar, Birch, Juniper) in the trans-Himalayan region of Lahaul, Himachal Pradesh.

Method: Spiders were collected in the month of August 2021 using standardized protocols of direct hand collection, as well as vegetation beating and sweep netting from systematic sampling quadrats across the forest types. Identification of specimens (genus level) was done through taxonomic keys and literature, followed by assessment of diversity profiles with ecological indices. Community assemblage structures across study sites were observed through ordination method based on abundance values of species composition.

Result: The study resulted in a pooled diversity of 31 genera from 16 families, with Birch forests reflecting highest diversity, followed by Poplar, and Juniper. Spider assemblages were affected by forest vegetation, wherein the forest type with a more foliage-intensive undergrowth (Poplar) was represented by structured web-builders and the forest with little to no ground vegetation (Juniper) housed more ground runner and ambush hunters. Birch represented a more heterogeneous habitat housing both web-builders (*Dictyna sp.*) and ground hunters (*Cheiracanthium sp.)*.

Conclusion: This distinctive structuring of communities across the study sites establishes forest types as a primary driver of assemblage variances in predatory arthropod communities. The study has implications in forest management strategies that could help in regional conservation of cryptic taxa and geo-climatically restrained high-altitude species in the context of climate change.

Key words: community drivers, high-altitude Arachnids, temperate forest, trans-Himalaya

Project Title	: Taxonomic and ecological studies on arachnids in Trans and Western Himalaya, India.
Principal Investigator(s)	: Dr. V. P. Uniyal
Researcher(s)	: Irina Das Sarkar, Junior Research Fellow
Funding Agency	: MoEFCC, GoI.
Project Duration	: 2020-2023

Change in community and metabolic footprint of soil nematode along the elevation gradient of Gangotri National Park, Uttarakhand

-Priyanka Kashyap

Aim: To understand the dynamics of soil nematode communities association and associated variables along an elevation gradient in high-altitude regions of Western Himalaya.

Location –Gangotri National Park

Methods – The diversity and distribution pattern of soil nematodes were investigated at four elevation ranges of 500m class along altitudinal gradient (3000-5000m). Stratified random sampling has been done along the elevation. Nematodes were extracted using Cobb's sieving and decantation method and identified up to the genus level. Nematode genera were allotted to trophic groups, colonizer-persister groups and microfaunal ecological indices were calculated. Multidimensional Scaling was performed to investigate the position of soil nematode community in ordination space along the elevation gradient.

Results – The nematode community comprised 58 genera. Out of 58 nematode genera, 37 genera significantly differed ($p<0.05$) among various elevation classes. It was found that elevation significantly affects the nematodes trophic group, diversity composition, and the nematode indices. The maturity indices of soil nematode communities vary from low to high from disturbed to undisturbed soil ecosystems. The present study showed comparatively high disturbance among the highest elevation class with alpine scrubs than the lower elevation class with sub-alpine forest based on maturity indices. Carbon footprint of the whole nematode assemblage declined along the elevation. Nematode faunal profile based on EI-SI, an indicator of ecosystem functioning falls under quadrant D i.e. low nutrient and low disturbance.

Conclusion – Overall substantial differences in the nematode composition, abundance, trophic structure, and contribution to belowground carbon cycling were observed with change in elevation. Lower elevation range are comparatively nutrient richer than alpine region along elevation which may be due to the adverse conditions at higher elevation directly and indirectly affecting the abiotic and biotic condition and restricted resource entry in the region. These findings could be utilized as a useful tool in the long-term monitoring and to understand the region's soil health.

Key Words – Nematode diversity, Community structure, Metabolic footprint, Indian Himalaya.

Project Title	: Assessment and Monitoring of Climate Change Effects on Wildlife Species and Ecosystems for Developing Adaptation and Mitigation Strategies in the Indian Himalayan Region
Principal Investigator(s)	: Dr. V.P. Uniyal and Dr. Anjum Rizvi
Researcher(s)	: Priyanka Kashyap
Funding Agency	: DST
Project Duration	: 2014-2020

Influence of snowmelt on structural and functional attributes of herbaceous vegetation along elevation gradient

-Rahul Kumar

Aim: The present study attempts to investigate the influence of snowmelt water on the composition and phenology of herbaceous vegetation in ecotonal region.

Location: The study was conducted in and around Tungnath region, which is located in the fringe of Kedarnath Wildlife Sanctuary.

Methods: Four summits were selected and each summit was divided into three altitudinal zones namely Timberline (3200-3300m), Treeline (3300-3400) and Alpine (3400-3500m). At each zone, a 50x50m plot was identified and based on snowmelt timing, divided into Early Snowmelt (ESM) and Late Snowmelt (LSM) microsites with 3 permanent quadrats (1x1m) established in each microsite.

Results: A total of 107 species recorded in established plots, of which 91% species were perennials, 86% hemicryptophytes and 70% native to Himalaya. The species richness and diversity were significantly higher ($p<0.05$, $p<0.02$ respectively) in ESM than in LSM. The main effect of altitude was on diversity ($p<0.001$) while snowmelt affected density ($p<0.003$), species richness ($p<0.001$) and diversity ($p<0.003$) significantly. Interactive effect of altitude and snowmelt was significant for species richness and diversity ($p<0.01$). Phenophase initiation was noticed earlier in ESM than LSM in majority of species, while the duration was longer in ESM than LSM. The maximum species were in vegetative phase (74.4 and 75.6%) in June and July, while reproductive phase and fruiting and seed maturation phase peaked in August (72.1%) in all zones. Thirteen species showed two distinct periods for budding, flowering and fruiting in either ESM, LSM or both microsites.

Conclusion: The results conclude that the interactive effects of snowmelt with altitudes and microhabitats largely influences species richness and density of herbaceous vegetation. This, in future, may lead to increase in species diversity across altitude in the ecotonal region. Furthermore, early snowmelt largely influences the phenology of species, with most of plants showing early phenophase initiation with advances in snowmelt timing.

Keywords : Climate change, Ecotone, Phenophase, Growth cycle, Snowmelt.

Project Title	: Influence of microclimatic variables on herbaceous plant communities in treeline ecotone in the Himalaya
Principal Investigator(s)	: Dr. B S Adhikari
Researcher(s)	: Research Scholar
Funding Agency	: National Mission on Himalayan Studies (NMHS)
Project Duration	: 2016-2021

Monitoring Forest structure and Dynamics in relation to climate change through LTEO programme in the Western Himalayan Landscape

-Himani Singh Khati

Aim: The aim of the project is to provide a baseline data on forest dynamics to achieve the fundamental research premise for LTEO network across the country.

Location: The study area span from foothills to timberline region of Uttarakhand state in Western Himalaya.

Method: The standard protocols CTFS-SIGEO, RAINFOR and Forest Dynamics Plot Network will be followed in LTEO project. The plots (1 ha each) will be censured once in five years for the generation of baseline data on forest dynamics and annually for dominant species for recording mortality, recruitment etc. The plot will be sub-gridded into 10×10m quadrats. All woody plants ≥1 cm DBH (at 1.37 m above the ground) will be measured, tagged and mapped to the nearest 10cm. Similar number of litter traps (1×1m) will be laid systematically within each plot. The biomass of standing dead trees, fallen trees and stumps will be estimated by following the standard methods. Trap contents are oven-dried at 65 °C, and then sorted into leaves, reproductive parts (flowers, seeds, and fruits) fine woody material etc. and these fractions will be weighed for each trap. For soil physic-chemical properties, analysis will be done as per the protocols. The ground measured variables will be linked through remote sensing techniques for better understanding of the forest dynamics at landscape-to-regional scale estimates.

Results and conclusion: A transect (50-60km wide and 230-250km long) has been identified considering the various climatic zones viz., sub-tropical (450m) to sub-alpine (3300m). Long-term permanent plots (50×200m) have been identified in major climatic zones (4-5 plots within each zone) starting from tropical moist deciduous (*Shorea robusta*), sub-tropical (*Pinus roxburghii*), temperate (*Quercus leucotrichophora, Q. floribunda* and *Abies pindrow*) and sub-alpine (*Q. semecarpifolia, A. spectabilis* and *Betula utilis*). The outputs of this study could be used to review relevant environmental policies and management - particularly related to future projections of community structure, diversity and forest biomass under various climate change scenarios over a long time period.

Keywords: Elevation gradient, Climate change, Long-Term Monitoring, Vegetation ecology, Western Himalaya

Project Title	: Forest Dynamics Research in the Long-Term Ecological Observatories (LTEO) programme
Principal Investigator(s)	: Dr. B S Adhikari
Researcher(s)	: Junior Project Fellow
Funding Agency	: MoEF&CC through IISc, Bangalore
Project Duration	: 2020-2024

Native species on the move: competition with an aggressive territorial invader for life and space in Himalayan stream networks

-Aashna Sharma

Aim: Himalayan riverscapes are pervaded with the invasive-exotic brown trout *Salmo trutta*, posing serious threats to co-occurring native, the snow trout *Schizothorax richardsonii*. Urgent prioritization of stream networks is thus necessitated to conserve the lotic taxa under invasion. With the concept of 'riverscapes' long pending to be acknowledged in the 'landscape-centric' legislative framework of Himalayan nations, this study is specifically targeted to support policy decisions by identifying critical invasion refugia.

Location: Snow trout populations were contrasted in stream networks of Asiganga (Bhagirathi basin), Tirthan and Parwati (Beas basin). The choice of watersheds was made based on the allopatric and sympatric association of snow trout with the exotic-invasive brown trout, apart from the damming interventions.

Methods: Using intensive surveys (241 km) adaptive plasticity of natives were assessed with weight-length relationships, condition factors, gonado-somatic indices and length-at-maturity. Additionally, age and growth comparisons were made using Gompertz growth trajectories and maturity ogives. Geostatistical stream network models were built to decipher movement directionalities of the species using moving average constructions. The spatial predictions were universally kriged.

Results: The sympatric snow trout adapted to a 'fast' life history with maturation at a smaller length (177.9mm) and age (1.2y), greater fecundity (5492±1291.08), smaller egg diameter (1.347±0.417) and faster growth ($k=0.40yr^{-1}$) to cope invasion pressures. The sympatrics in dammed stream networks were under higher invasion stress. The spatial models indicate invasion-induced relegations of natives from the river mainstem into headwaters, with large sections of mainstem occupied by invasives. The small percentage of potential habitat left for natives in the mainstem is further threatened, where a 100% overlap of native and invasive trout distributions is predicted.

Conclusion: The approach of basin-scale dendritic prioritization provides management solutions to tackle brown trout invasion threats in Himalaya. The study informs decisions on delineation of headwaters as invasion refugia for native fish, with their assisted recovery in river mainstems through targeted management of invasives.

Keywords: geostatistics, invasion refugia, dendritic prioritization, life-history, growth

Project Title	: Assessment and Monitoring of Climate Change Effects on Wildlife Species and Ecosystems for Developing Adaptation and Mitigation Strategies in the Indian Himalayan Region
Principal Investigator(s)	: Dr. K. Sivakumar and Dr. J. A. Johnson (Thematic PI Aquatic component)
Researcher(s)	: Dr. Aashna Sharma (Senior Project Fellow) and Dr. Vineet K. Dubey (Project Scientist)
Funding Agency	: DST
Project Duration	: 2014-2020

Investigating fish assemblages along altitudinal gradients in selected Protected areas of Himachal Pradesh

-Meghma Ghosh

Keywords: Himalaya, ichthyofaua, diversity, elevation, conservation

Aim: The Himalayan freshwater habitats that are an abode to several life forms are undergoing irreversible damages with respect to its biodiversity and ecosystem stability. This study thus aims at undertaking a detailed assessment of ichthyofaunal diversity in selected protected areas and correlating them with their site-specific physico-chemical variables so as to ensure its scientific conservation and management.

Study area: The ichthyofaunal diversity was recorded along varied altitudinal gradients in selected PA's of Himachal Pradesh including Simbalbara NP, Churdhar WLS, Pin Valley NP and Chandertaal WLS.

Methods: A total of 69 sites were sampled in the overall study area by means of cast (10mins/point), drag (15 mins/point) and kick (30 mins/ point) netting techniques An interval of 1km was maintained between study sites based on accessibility. The specimens were then carefully collected, photographed and preserved as required. Physico-chemical parameters were assessed per site by using a multi-parameter probe. After species identifiction, variation in ichthyofaunal diversity patterns along altitudinal gradient was assessed. Redundancy analysis was further performed to understand the fish assemblage patterns based on their site-specific ecological variables.

Result: 24 fish species belonging to 11 different families were collected from the overall study area. A single fish species was recorded from Chandertal (4300m) followed by 2 species from Pin (3500m), 4 species from Churdhar (2000m) and 21 species from Simbalbara (500m). This result clearly depicts a decreasing trend in ichthyofaunal diversity with respect to increasing altitudinal gradient. The redundancy analysis demonstrates the determining role of temperature in distribution of fish species especially for that of species like *Triplophysa.*

Conclusion: The current study brings into attention three vital native species viz. *Tor putitora*, *Schizothorax richardsonii* and *Naziritor chelynoides* which have found their way to the IUCN list of threatened species. Additionally, the presence of three exotic species namely *Samo trutta*, *Cyprinus carpio* and *Oncorhynchus mykiss* seem alarming. Our study efforts shall thus be continued with the aim to monitor and protect the fish biodiversity before the damage turns out to be irreversible.

Project Title	: Basic study design of biodiversity assessment for Himachal Pradesh
Principal Investigator(s)	: Dr. J.A. Johnson & Dr. Salvador Lyngdoh
Researcher(s)	: Meghma Ghosh, Project Associate- I
Funding Agency	: JICA
Project Duration	: 2021-2022

Assessment and monitoring of climate change effects on wildlife species and ecosystems in the Indian Himalayan Region: Progress and Way Forward

-Vineet K. Dubey

Aim: Research on climate-related vulnerabilities of wild fauna and microflora in the Indian Himalayan Region (IHR) was initiated as a task force under the National Mission for Sustaining the Himalayan Ecosystem (NMSHE), run by the Wildlife Institute of India. This work details on research outputs during the NMSHE Phase-I and way forward for the upcoming Phase-II.

Location: Extensive monitoring and research work was primarily focused on three major river Basins, Bhagirathi (~7,000km^2, Uttarakhand), Beas (~3,000km^2, Himachal Pradesh), and Teesta (~5,000km^2, Sikkim).

Methods: Grid-based sampling approach was used by dividing the three basins into 16x16km grid cells, further sub-divided into 4x4km cells for intensive monitoring of different taxa, covering an elevation gradient of 357-5500m. Open Top Chamber (OTC) based long-term experimental setups were established to chart long-term spatio-temporal activity patterns of soil microbial and microfaunal communities. Taxa-specific field methodologies were used to generate long-term field data on major thematic groups *viz.* terrestrial, aquatic, spatial and human ecology. Robust climate envelope models were generated for selected indicator taxa *viz*. ichthyofauna (snow trout and brown trout), herpetofauna (Himalayan pit viper) and mammals (snow leopard), based on different predictive algorithms.

Results: The OTC experiments indicated warming effects on microbial extracellular enzyme activities, with a reduced diversity and maturity index of soil nematodes. Distinct elevational movements and phenological responses to seasonal variations were evident in insects, fish, herpetofauna, birds and mammals. Considering the intensity of different emission scenarios and time periods, snow trout was predicted with a high-altitude squeeze, expanding its range across leading edges with major contraction across trailing edges below 1000m. The current potential habitat for snow leopard was estimated to be 37,034km^2 across IHR. The Himalayan pit viper (*Gloydius himalayanus*) was predicted with increased distributional range in lower elevations for future scenarios.

Conclusion: The outputs generated in NMSHE Phase-I will aid policy-decisions for climate mitigation and set platforms for paced up advancement of research in Phase-II.

Keywords: range shifts, niche models, refugia, conservation, predictive algorithms

Project Title	: Assessment and Monitoring of Climate Change Effects on Wildlife Species and Ecosystems for Developing Adaptation and Mitigation Strategies in the Indian Himalayan Region
Principal Investigator(s)	: Dr. S. Sathyakumar (Nodal Scientist), Dr. K. Sivakumar and Dr. J. A. Johnson (Thematic PI Aquatic component)
Researcher(s)	: Dr. Vineet K. Dubey (Team NMSHE:Project Scientists, Project Associates, Project Fellows, H-JRFs, Project Assistants)
Funding Agency	: DST
Project Duration	: 2014-2020

Modelling potential impacts of climate change on the distribution of Woolly Wolf (*Canis lupus chanco)*

-Hussain Saifee Reshamwala

The Central Asian wolves form a cohort within wolf-dog clade known as Woolly wolf (*Canis lupus chanco*). These wolves are poorly studied and their current extant and distribution remain unknown. Apex predators already existing at higher elevations like Woolly wolf can be severely affected because of the absence of suitable refuge. Concomitantly, in the era of Anthropocene, the change in land-use land-cover is rapidly increasing. Even the most adaptable species occurring in human-dominated landscapes may fail to cope under the combined impact of both climate change and human pressure.

Aim: In this study we predicted the change in the woolly wolf distribution under different anthropogenic factors, climate change, and land-use land-cover change scenarios.

Methods: We collected 3776 presence locations of woolly wolf from published literature across the countries of Afghanistan, Pakistan, Kyrgyzstan, India, Nepal, Bhutan, China and Mongolia. We also included data from our telemetry study on woolly wolf (n = 3223). Out of the total collected locations we filtered location to remove spatial autocorrelation. We then compiled 116 predictor variables for species distribution modelling, which included anthropogenic factors, climatic, vegetation and topographic features to perform MaxEnt modeling.

Results: Woolly wolf showed affinity towards areas with low to moderate warm temperatures and higher precipitations. It showed a negative relation with forests and farmlands. Our future projections showed an expansion of wolf distribution and habitat suitability under the combined effects of future climate and LULC change.

Conclusions: Our results show that Myanmar and Russia had introduction of high and medium suitable area for woolly wolf in future scenarios. Uzbekistan and Kazakhstan showed consistent loss in high suitable area while Mongolia and Bhutan had the highest gain in suitable area. Based on such projections, conscious management decisions need to be taken regarding the conservation of this species in a country-specific manner. Hotspot areas where future conflict with humans could arise due to increased livestock numbers resulting in depredation should be considered priority areas for management.

Keywords: Future prediction, Habitat suitability, Predator, Species distribution model, Global warming

Project Title	: Response to Anthropocene and Climate Change: Movement Ecology of Selected Mammal Species across the Indian Himalayan Region
Principal Investigator(s)	: Dr. Bilal Habib
Researcher(s)	: Hussain Saifee Reshamwala, Senior Project Associate
Funding Agency	: National Mission on Himalayan Studies (NMHS)
Project Duration	: 2020-2023

Spatial and trophic interactions between Himalayan ibex and livestock in the alpine pastures of Pin Valley, Himachal Pradesh

-Kalzang Targe

Aim: Understanding the resource use patterns and interactions of Himalayan ibex (*Capra sibirica hemalayanus*) and domestic migratory livestock (goat and sheep) in the cold desert alpine pastures of Pin Valley.

Location: Pin Valley National Park is located in Himachal Pradesh's Lahaul and Spiti district in the Trans-Himalayan region.

Methods: The intensive study was carried out in grazed and ungrazed pastures. Following the quadrat method vegetation quantification was done and analyzed for richness, density and diversity using PAST 4.03. The vegetation communities were identified through TWINSPAN using PC-ORD4. The feeding habits of livestock and Ibex were observed using direct and indirect feeding signs. Various maps (aspect, slope, elevation and vegetation communities) were developed using ArcMap-10.3. Ungulates pellets were collected from both grazed and ungrazed pastures for micro-histology and forage quality assessment. Diet analysis was carried out using the R packages "spaa" and "electivity" in the R-4.0.5 version.

Results & Conclusion: The species richness and diversity were high in ungrazed pastures based on quadrat sampling (#576, 1x1m). Ten major vegetation communities were discernible, among them *Oryzopsis, Carex-Artemisia* and *Cicer-Aconogonum* were dominant. Pianka's index showed Ibex and livestock had the least diet overlap (0.2), whereas, goat and sheep had the most (0.9). Levin's index revealed Ibex had a wider trophic niche in ungrazed pastures. The micro-histology results revealed the use of monocots was highest (67%) in winter and lowest (35%) in summer. Whereas dicots use was highest (42%) in summer and lowest (17%) in winter. The N, P, K ratio was high in summer and low in winter. Kernel density estimation revealed that Ibex utilization of grazed pastures in summer was very low as compared to ungrazed pastures in the presence of migratory livestock. Whereas in winter when migratory herders vacate that place ibex use was more or less similar in both grazed and ungrazed pastures. Therefore, there is a need to have a proper implementation of the policies on livestock grazing in and around Protected Areas.

Keywords: Diet overlap, Communities, Livestock grazing, Trans-Himalaya, Vegetation.

Project Title	: Ecological response of flora and fauna to climate change in the trans-Himalaya landscape with special reference to vulnerability and adaptations
Principal Investigator(s)	: Dr. B.S. Adhikari Scientist-G and Dr. Salvador Lyngdoh Scientist-D
Researcher(s)	: Kalzang Targe (Ph.D. Scholar)
Funding Agency	: UNDP NATCOM-3rd
Project Duration	: 28-August,2018 to 31-December,2021