भारतीय वन्यजीव संस्थान
Wildlife Institute of India

2nd HIMALAYAN RESEARCH SEMINAR

September 1, 2017

Programme & Abstracts

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

2ND HIMALAYAN RESEARCH SEMINAR

1st September 2017

PROGRAMME

Seminar Chairperson: Dr. Shrikant Chandola, Former PCCF & HoFF, Uttarakhand

INAUGURAL SESSION

0915 – 0920 h	Welcome	**Dr. Bitapi Sinha,** Research Coordinator, WII
0920 – 0930 h	Opening Remarks	**Dr. G.S. Rawat,** *Dean,* WII

TECHNICAL SESSION – I

DIVERSITY AND DISTRIBUTION

Chair : Dr. S. Sathyakumar, Scientist-G

Co-Chair(s) : 1. Dr. K. Sivakumar, Scientist-F

2. Dr. R. Suresh Kumar, Scientist-E

0930-0945	Seasonal variation in mammalian assemblages in different climatic zones of Bhagirathi Basin, Uttarakhand ***Ranjana Pal,*** Project Fellow
0945-1000	Importance of riverine system for conservation management: preliminary insights on small carnivores from Great Himalayan National Park ***Meghna Bandopadhyay,*** Junior Research Fellow
1000-1015	Discerning patterns of river bird distribution using species-traits and environmental variables ***Ankita Sinha,*** Junior Research Fellow
1015-1030	Abundance and distribution of breeding waterbirds in Changthang Cold Desert Sanctuary, Ladakh (India) ***Neeraj Mahar,*** Junior Research Fellow

1030-1045	Diversity, distribution and microclimatic regime of amphibians in Bhagirathi Basin, Uttarakhand
	Naitik Patel, Project Fellow
1045-1100	Diversity and distribution of Dragonflies and Damselflies (Insecta: Odonata) along an elevation gradient in the Bhagirathi River Basin
	Shuvendu Das, Junior Research Fellow
1100-1115	Elevational and latitudinal diversity patterns of trees along the Himalaya
	Suresh Rana, Senior Research Fellow
1115-1135	**Discussion & Remarks by Chair and Co-Chairs**
1135-1150	**Tea**

TECHNICAL SESSION – II

HABITAT ECOLOGY

Chair : Dr. S. A. Hussain, Scientist-G

Co-Chair(s) : 1. Dr. Bivash Pandav, Scientist-F

2. Dr. Gautam Talukdar, Scientist-D

1150-1205	Ecological interaction between native and non-native trouts in a tributary of Beas, Himachal Pradesh
	Aashna Sharma, Project Fellow
1205-1220	Habitat use of ecological indicator fish species inhabiting in the streams of Askot Landscape, Western Himalaya
	Vandana Rajput, Project Biologist
1220-1235	Soil microbial community composition and function across alpine habitats of Gangotri National Park, Uttarakhand
	Pamella Bhattacharya, Senior Project Fellow
1235-1250	Population estimation and resource utilization of Rhesus macaques in Chandrabani, Dehradun
	Sayli Sawant**,** Project Fellow
1250-1305	In search of the greener side: Habitat utilization of mountain ungulates with respect to livestock grazing in Askot Landscape, Uttarakhand
	Ankita Bhattacharya**,** Project Biologist
1305-1320	**Discussion & Remarks by Chair and Co-Chairs**
1320-1415	**Lunch**

TECHNICAL SESSION – III

LANDSCAPE ECOLOGY & CLIMATE CHANGE

Chair : Shri Qamar Qureshi, Scientist-G

Co-Chair(s) : 1. Dr. B.S. Adhikari, Scientist-F

2. Dr. Abhijit Das, Scientist-C

1415-1430	Multi-scale assessment of landscape productivity and its drivers in the Uttarakhand Himalayan Region ***Sujata Upgupta***, Project Scientist
1430-1445	Alpine plant communities and impact of snow-melt water on phenology at Tungnath, Western Himalaya **Sachin MH,** Junior Research Fellow
1445-1500	Habitat characterization of Himalayan brown bear for landscape genetics in Jammu and Kashmir ***Shahid Dar*****,** Project Fellow
1500-1515	Potential impact of climate change on life history traits of native and non-native trouts in Tirthan valley, Himachal Pradesh **Dr. *Vineet Dubey,*** Project Associate
1515-1530	**Discussion & Remarks by Chair and Co-Chairs**
1530-1545	**Tea**

TECHNICAL SESSION – IV

HUMAN DIMENSION & ECOSYSTEM SERVICES

Chair: Dr. Ruchi Badola, Scientist-G

Co-Chair(s) : 1. Dr. Gopi, G. V., Scientist-E

2. Dr. Anju Baroth, Scientist-C

1545-1600	It's a catch 22 situation! ***Amrita Laha***, Project Biologist
1600-1615	Human wellbeing and livelihood resilience in face of climate change in the Bhagirathi basin of Uttarakhand **Dr. *Soumya Dasgupta***, Project Associate
1615-1630	Key ecosystem services and strategies to ensure their continued flow: A case study from Dhauladhar mountaine range, Western Himalaya. **Dr. *Anjali Uniyal,*** Research Associate

1630-1645	Assessment of agriculture vulnerability in the Himalayan region: A case study from Pithoragarh district, Uttarakhand **Dr. *Nehru Prabhakaran***, Research Associate
1645-1700	Addressing human-wildlife conflicts in the Indian Himalayan region through action research and participatory approach **Dr. *Dipanjan Naha*,** Project Associate
1700-1715	**Discussion & Remarks by Chair and Co-Chairs**

TECHNICAL SESSION – V

MONITORING STRATEGIES

Chair : Dr. V.P. Uniyal, Scientist- F

Co-Chair(s) : 1. Dr. Bilal Habib, Scientist-E

2. Shri Salvador Lyngdoh, Scientist-C

1715-1730	Monitoring initiatives for micro-flora in Gangotri National Park, Uttarakhand **Dr. *Ishwari Datt Rai,*** Project Scientist
1730-1745	Strategies and approach for long-term ecological monitoring in Sikkim Himalaya. **Dr. *Rishi Kumar*,** Project Associate
1745-1755	**Discussion & Remarks by Chair and Co-Chairs**
1755-1810	**Concluding Remarks by the Seminar Chairperson**
1810-1815	Vote of Thanks ***Dr. Bitapi Sinha*,** Scientist-G

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Seasonal Variation in mammal assemblages in different climatic zones of Bhagirathi basin, Uttarakhand

-Ranjana Pal

Aim: Abiotic factors play an important role in community ecology by delimiting a pool of species that could plausibly occupy a specific habitat hence also conditioning the biotic interactions. In this study, the response of non-volant mammals to changes in climatic factors was investigated.

Location: The study was conducted along an elevation gradient of Bhagirathi Basin (500 to 5200m) in Uttarakhand.

Method: The area was divided into different climatic zones based on bio-climatic variables (n= 4) and elevation classes (n=10) using cluster analysis. Species richness and relative abundance (mean # photo-capture/ 100 days) of mammals were estimated for summer (April to August) and winter (November to February) using camera traps (n= 290, 3057 trap days) from October 2015 to June 2017.

Results: Four different climatic zones- Low-Hot-Wet (LHW), Mid-Warm-Wet (MWW), High-Cold-Moist (HCM) and Very high-Very Cold-Dry (VVCD) were classified. In summer, observed species richness was highest in HCM and lowest in VVCD. In winter, highest species richness was estimated in both MWW and HCM and lowest in VVCD. In summer, relative abundance was high for red fox (30.30±10.84, N=506) followed by blue sheep (10.97 ± 7.19, N=114), and snow leopard (2 ± 0.83, N=24) in VVCD and in HCM it was high for red fox (25.10 ± 7.09, N=471), sambar 5.39 ± 2.89, N=128) and musk deer (2.06 ± 1.39, N=81). In winter, high relative abundance in VVCD was recorded for red fox ((26.37 ± 6.39, N=679), wolf (6.54 ± 1.83, N=151) and blue sheep (3.85 ± 1.83, N=75), and in HCM it was high for red fox (51.66±12.86, N=3320), snow leopard (5.97±1.20, N=288) and sambar (3.99±1.99, N=142).

Conclusion: Refining of climatic zones using fine scale field data on temperature and humidity is proposed. Species of a warmer climate such as rhesus macaque, leopard cat, sambar, and leopard showed a trend of using high elevation and colder climate during summer. Hence, in future, warming conditions may enhance chances of co-occurrence among these low elevation species with typical high altitude species such as blue sheep and snow leopard.

Keywords: Abiotic factors, Cluster analysis, Elevation gradient, Camera trapping, Species richness, Relative abundance

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.B. Mathur (Principal Investigator), Dr. S. Sathyakumar (Nodal Scientist) and 11 Co-Investigators
Researcher(s)	: Ranjana Pal (Project Fellow), Shashank Arya (Project Fellow), Shagun Thakur (Project Assistant) and Tapajit Bhattacharya (Project Scientist)
Funding Agency	: Department of Science and Technology
Project Duration	: 2014-2019

Importance of riverine system for conservation management: Preliminary insights on small carnivores from Great Himalayan National Park

-Meghna Bandyopadhyay

Aim: Riverine area serves a gradient of various resources like food, water, shelter, etc. and thus plays crucial role for the existence and survival of a species or group of species, in addition to being corridor. Unlike large carnivores, small carnivores have lesser home range size and so their activities are restricted to much smaller area. It is more likely that any small scale changes in habitat composition may affect the small carnivore communities at early stage. The aim of the study is to find the ecological factors responsible for the occupancy and intensity of use of sites by small carnivores with reference to riverine area. The content of the current presentation relates to the preliminary survey carried out in the study area and the results thereof.

Study Area: Study was carried out in Sainj (90 km^2) and Tirthan (61 km^2) (1500-3500m) valleys located within the Great Himalayan National Park Conservation Area, Himachal Pradesh.

Methods: A reconnaissance survey (March to June, 2017) was done for carnivore sign on available trails and accessibility (without replicate). Based on which 66 camera traps were deployed in 1x1 grids. The incidence data of small carnivores was used to estimate the number of species observed per grid and photo capture rate per 100 trap night (leopard cat, yellow throated marten, Himalayan palm civet and red fox).

Results: A total of 162 grids of 1x1 km^2 were sampled to record carnivore signs out of which only 79 grids had evidence of carnivores (all), total effort walked was 184 km. 61% (17nos.) and 55% (21no.s) of the camera trap sites within and beyond 500m from river showed small carnivore captures. Average photo capture rate (per 100 trap night) for all small carnivores for both the spatial units are 18(SE=3) and 21(SE=3) respectively, but is not significantly different (p value=0.6).

Conclusion: Small carnivores showed variation in the intensity of use with preference for specific sites. Their association with riverine areas can be defined with improved sampling intensity and identifying the responsible ecological factors.

Keywords: Small carnivore, riverine area, conservation

Project Title	: National Mission on Himalayan Studies
Principal Investigator(s)	: Dr. K. Ramesh (Principal Investigator) and Dr. S. Sathyakumar (Co-Investigator)
Researcher(s)	: Meghna Bandyopadhyay (Himalayan Junior Research Fellow)
Funding Agency	: Ministry of Environment, Forest and Climate Change, Government of India
Project Duration	: 2016 – 2019

Discerning patterns of river bird distribution using species-traits and environmental variables

-Ankita Sinha

Aim: Species traits represent functional relationships with environmental selective forces. The study aimed at exploring river bird distribution patterns and regional species assemblages by explicitly considering environmental constraints imposed at different ecological scales using species traits.

Study area: Bhagirathi basin, the headstream of the Upper Ganges in the state of Uttarakhand (Western Himalaya).

Methods : Field data was collected through extensive surveys between elevational range 330 m and 3100 m asl The fourth-corner and RLQ methods were employed as these provide a direct way to test and estimate trait–environment relationships. Assessing trait responses to environmental gradients requires the simultaneous analysis of linking three data matrix tables: a table L with abundance or presence–absence values for species at a series of sites, a table R with variables describing the environmental conditions of the sites, and a table Q containing traits (e.g., morphological or behavioural attributes) of the species. The fourth corner method tests for individual-trait-environment relationships.

Results: Including traits alongside habitat data explains more variability in the distribution of the studied species. RLQ analysis explained 95% variance in the first four axes whereas CCA explained 75%. The RLQ biplot also showed clear segregation among the riverine obligate and non-obligate species. Traits that best explained the distribution of river birds across multiple ecological scales in the Himalayan rivers were elevation, body size and obligate riverine nature. Interestingly, body size showed a decreasing trend with increasing elevation.

Conclusion:The above approach helps in understanding how tightly linked habitat features work at different hierarchical levels in creating local species pool. This framework is also helpful in predicting trends how species composition in communities might change in response to modification of environmental filters at a variety of scales from micro-habitat to landscapes.

Project Title	: National Mission on Himalayan Studies (NMHS-Fellowship)
Principal Investigator(s)	: Dr. K. Ramesh
Researcher(s)	: Ankita Sinha (Himalayan Junior Research Fellow)
Funding Agency	: Ministry of Environment, Forest and Climate Change, Government of India
Project Duration	: 2016 – 2019

Abundance and Distribution of breeding waterbirds in Changthang Cold Desert Sanctuary, Ladakh (India)

-Neeraj Mahar

Aim: Population estimates are of fundamental importance in applied ecology and frequently used in conservation planning. In the present study, we examined the population status and trend of breeding waterbirds with special reference to Black-necked Crane (BNC) (Grus nigricollis) in trans Himalayan wetlands.

Study areas: The study was conducted in Changthang Cold Desert Sanctuary (CDS) having an area of 4000 sq. km located in Ladakh.

Methods: We applied total count method using photo counts in different vantage points with the help of prosumer camera (65X Zoom). A total of 274 points were surveyed at 25 wetlands between May-October, 2016 across different seasons (spring, summer and autumn). Concurrently, recruitment and breeding success of 19 BNC pairs were assessed by regular monitoring.

Results: We recorded 26 species of waterbirds belonging to 10 families, of which 12 species were breeding in CDS. Among the 25 wetlands examined for birds species diversity, the Statsapuk Tso wetland was recorded the most diverse (H'=1.91). Bar-headed goose (Anser indicus) (mean = 929 ±255.66 SE) followed by Ruddy shelduck (Todorna ferruginea) (mean = 875.67 ±319.37 SE) and Brown headed gull (Chroicocephalus brunnicephalus) (mean = 383.33 ±93.13 SE) were the most abundant species. The large flocks of waterbirds were recorded mostly during autumn owing to post-breeding and pre-migration time. Two new breeding sites and one new foraging site of BNC were recorded during this study. Since 1985, 31% decline in the breeding success of BNC was observed in CDS. Decline was also observed in the population of BHG (0.9%), RSD (6.6%) and BrHG (3.8%).

Conclusion: This study suggests that Statsapuk Tso is diverse in terms of waterbirds. A decline in breeding success of BNC was recorded which was attributed to predation by free ranging dogs and nesting failure due to floods.

Keywords: Black-necked Crane; Bar-headed Goose; Trans-Himalayan wetlands; breeding success; recruitment

Project Title	: Distribution pattern, habitat use and movement of breeding waterbirds with special reference to Black-necked Cranes and Bar-headed Geese using satellite telemetry in Changthang Cold Desert Wildlife Sanctuary, Ladakh and Gharana Wetland Conservation Reserve, Jammu & Kashmir.
Principal Investigator(s)	: Dr. S. A. Hussain, Dr. Bilal Habib (Wildlife Institute of India) and Jigmet Takpa, Tahir Shawl, Pankaj Raina (Department of Wildlife Protection, J & K)
Researcher(s)	: Neeraj Mahar (Senior Research Fellow)
Funding Agency	: Department of Wildlife Protection, Government of Jammu & Kashmir
Project Duration	: 2012 – 2018

Diversity, distribution, and microclimatic regime of stream amphibians in Bhagirathi Basin, Uttarakhand

-Naitik Patel

Aim: To identify species richness and diversity of stream amphibians in Bhagirathi basin. To understand the thermal and moisture requirements of the amphibian species in Bhagirathi river basin.

Location: Bhagirathi river basin, Uttarakhand.

Methods: We conducted nocturnal visual encounter survey (time constrained) along with opportunistic observation(n=108). Morphometric data of all captured (n~200) specimens were also recorded using vernier caliper and pesola digital weighting machine. Body and surface temperature °C and relative humidity % were collected (n=350) for amphibians usin infrared hygro thermometer. Environmental parameter such as air temperature; air flow; wind speed; dew point; wet point; relative humidity; barometric pressure and water temperature is collected using extech EN150 handheld weather meter (n=68).

Species richness, alpha diversity for each plot, and beta diversity along with quadrate richness were estimated. Correlation between body temperature and surface temperature was calculated using Pearson correlation. Principal component analysis was carried out to test the identity of a supposedly new species involving morphometric measurements (n=54). The distribution pattern of six frogs was analyzed with respect to different microclimatic features.

Results: 12 species of amphibians were recorded during the survey including one new record. Estimated species richness is 12 ±0.246988(Chao 2 estimates). Mean species diversity is 2.12 ±0.01(SD). Species richness decreases with the elevation. *Nanorana vicina* occurred in lower barometric pressure zone and their presence is independent of stream flow. *Amolops formosus* occurred in mid barometric pressure zone. *Duttaphrynus melanostictus* and *Amolops jaunsari* occurred in high barometric pressure zone. The body temperature of amphibians is positively correlated with surface temperature (R^2 = 0.92). Temperature range for *Amolops formosus* 13.6°C to 20.8°C; *Amolops jaunsari* 17.1 °C to 24.3°C ; *Duttaphrynus stomaticus* 19.2 °C to 24.9°C ; *Duttaphrynus melanostictus* 15°C to 24.2 °C; Mycrohyla ornata 20.5 °C to 25.1 °C. Six abnormalities and malformations were observed in amphibians during the sampling. Abnormality included eye opacity (*Nanorana vicina*); and malformation included Skin web (*Duttaphrynus himalayanus*); Polyphalangy (*Amolops formosus*); Digital loss (*Duttaphrynus stomaticus*); Ectromelia (*Nanorana minica*).

Conclusion: The species were grouped distinctly based upon their microclimatic regime. Being limited by its specificity to stream habitat and narrow temperature regime genus *Amolops* is more vulnerable to environmental changes. Morphometric analysis shows new record of *Amolops* is distinct from its relative species and awaits validation through molecular analysis.

Keywords: Species richness, *Amolops* , Mountain stream, Body temperature, Malformation.

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. Abhijit Das
Researcher(s)	: Naitik Patel (Project Fellow)
Funding Agency	: Department of Science and Technology
Project Duration	: 2014 – 2019

Diversity and distribution of Dragonflies and Damselflies (Insecta: Odonata) along an elevation gradient in the Bhagirathi River Basin

-Shuvendu Das

Aim: The study aimed as certain the influence of altitude, seasonality, vegetation types, environmental parameters, aquatic composition and anthropogenic factors that likely affect Odonata assemblages.

Location: The study was conducted in Bhagirathi River Basin (BRB), Uttarakhand.

Methods: Stratified random sampling was carried out in at least 10 plots at each 250m elevation interval within a range of 500m-4000m during day time. Presence of anthropogenic disturbances such as cutting, lopping and livestock grazing was also noted around the sampling location. The recorded individuals were sorted into morpho-species. Mean encounter rate (transect and species) were calculated for all sampling plots (n=220) and indicator value for habitat specific families and species occurrences with atmospheric lifted index were calculated.

Results and Conclusion: Preliminary assessment led to listing of 85 species of Odonates belonging to 45 genera and 12 families. During the transect sampling, total 64 species were recorded and 22 species were recorded during opportunistic sampling. Preliminary findings show a decreasing diversity with increasing altitude. Based on morphometric analysis and historical data 7 species were recorded for the first time from Uttarakhand. Few genus and restricted altitudinal family or species are identified as indicator species to track environmental changes such as family Coenagrionidae and Libellulidae for mid to lower basin, family Cordulegastridae and Aeshinidae for mid to high altitude water bodies.

In future, negative impact of habitat degradation and impacts of changes in microclimatic factors on distribution and diversity of Odonates will be investigated. The applicability of Odonates as surrogate to monitor climatic or human-caused changes in habitats will be studied.

Keywords: Bhagirathi River Basin, Odonates, Systematic sampling, Atmospheric Lifted Index, Indicator Species.

Project Title	:	Diversity and distribution of Odonata assemblages along altitudinal gradient in the selected river basins of Bhagirathi and Teesta in relation to environmental parameters
Principal Investigator(s)	:	Dr. V.P. Uniyal
Researcher(s)	:	Shuvendu Das (Himalayan Junior Research Fellow)
Funding Agency	:	National Mission on Himalayan Studies (NMHS)
Project Duration	:	2016 – 2019

Elevational and latitudinal diversity patterns of trees along the Himalaya

-Suresh Kumar Rana

Aim: To summarise the distribution and richness patterns of Himalayan trees along elevational and latitudinal gradients from east to northwest Himalaya.

Location: The Himalaya.

Methods: We examined 31 floras on species occurrence and their elevational distributions across six Indian Himalayan states, Nepal and Bhutan. Further, presence of all species was cross checked in the Indian plains floras and species with underestimated lower ranges in Himalayan floras were updated for their elevational ranges. We conducted field sampling of trees in 50 quadrats of size 0.1ha after every 500m elevation along a single gradient in North Bengal and Sikkim in eastern and Jammu & Kashmir in western Himalaya.

Results: A total of 1382 species of trees including 1173 natives and 209 aliens have been recorded in the Himalaya. Species richness declines about fivefold from eastern to western Himalaya. Along the elevational gradient trees show a peak between 500m and 1000m in the east and a mild monotonic decline with elevation in west from both range interpolation as well as field sampling methods. Species with tropical affinities shows a low-elevation peak, whereas species with temperate affinities show a mid-elevation peak in Himalaya. Beta diversity along elevation shows maximum turnover of species at 1500-2000m zone indicating that transition zone between tropical and temperate species is higher than the richness peak in trees. Climatic variables across Himalaya show fivefold higher annual precipitation with much lesser temperature seasonality in east than in the northwest Himalaya. Richness is highly correlated with precipitation (r= 0.8). Average tree densities are higher along elevation in east whereas girth sizes are higher in the west. However, tree densities and girth shows no peculiar trend along the elevational gradient.

Conclusion: The latitudinal and climatic differences may have resulted this gradient with sharp decline in tree species richness from more tropical east to temperate northwest Himalaya. Different species richness patterns along elevational gradients in east and west Himalaya provide opportunities to test the role of dispersal and climate in shaping such patterns.

Keywords: Elevational gradient, Himalaya, mid-elevational peak, trees, latitudinal gradient

Project Title	: National Mission on Himalayan Studies (NMHS-Fellowship)
Principal Investigator(s)	: Dr. G. S. Rawat
Researcher(s)	: Suresh Kumar Rana (Himalayan Senior Research Fellow)
Funding Agency	: Ministry of Environment Forest and Climate Change, Government of India
Project Duration	: 2016 – 2019

Ecological interaction between native and non-native trouts in a tributary of Beas, Himachal Pradesh

-Aashna Sharma

Aim: Higher altitude freshwater zones are perfect sites to study the ecology of unique cold water fish communities that are simple in composition. Successfully established populations of non-native brown trout in higher altitude of Himalaya raised concerns for the conservation of native species over the past years, however, interactions between native and non-native species has not been fully understood. This study therefore aimed to elucidate interactive existence of native and non-native trouts at various life history stages in connection with climate change.

Location: The Tirthan River is one of the major tributaries of River Beas traversing a stretch of 130 km in the Great Himalayan National Park. This study was conducted in the main channel as well as in streams (N=24) and tributaries (N=2) Tirthan.

Methods: Point samplings for fish were done at every 500m interval in the higher order streams (6th and higher) and at every 200m for lower order streams (5th and lower). A total of 109 points have been sampled from confluence to origin of rivers/streams, ranging from 989 to 3677msl, of which 69 points confirmed with presence of fish. A total of 25 physical and chemical habitat variables were recorded at each point. Cast, drag and kick nets were used for sampling. Spectrophotometer was used for hydrological analysis. Data were analyzed in R ver.3.4.1.using *"vegan", "gclus"* and *"ape"* packages for clustering and redundancy analysis.

Results: A total of 1808 young and 178 adult fishes were captured and analysed for their distribution and habitat use. Redundancy Analysis (RDA) for species and environmental covariates resulted in total 61% variance and 25% of constrained variance with higher eigen values for RDA1 and RDA2. Ward's minimum variance clustering of hellinger transformed data revealed sites agglomerating into four reasonable distinct subgroups with respect to species abundances. Immature individuals of non-native and native trouts used similar habitat conditions, but they differed in using habitats at adult stage. Non-native trouts showed abundance in main stream of higher stream order while natives mostly restricted themselves to the lower order streams.

Conclusion: Native trouts prefer lower order streams of higher altitude unlike the non-natives which prevail mostly in higher order main streams. As changing climate would affect the lower order streams to a greater extent, sustaining their populations would be tough for the natives as temperatures increase.

Keywords: Nursery sites, climate change, stream orders, Tirthan

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 Principal Investigators Aquatic Component)
Researcher(s)	: Aashna Sharma (Project Fellow) and Dr. Vineet. K. Dubey (Project Associate)
Funding Agency	: Department of Science and Technology
Project Duration	: 2014-2019

Habitat use of Ecological Indicator fish species inhabiting in streams of Askot Landscape, Western Himalaya

-Vandana Rajput

Aim: Streams are the living systems which provide vital services to humankind. This fragile system is facing severe threats from anthropogenic activities leading to loss of ecological integrity. Fishes are the best known group of vertebrates, which indicate health of an aquatic ecosystem. In order to monitor the aquatic ecosystem integrity, understanding of habitat use by indicator species is essential. Therefore, the present study was indent to assess the habitat requirement of two indicator fish species identified in the Askot Landscape.

Location: Askot landscape of eastern Kumaon region lies in the Pithoragarh district of Uttarakhand at the tri-junction of the borders of Nepal, India and Tibet with three rivers-Gori, Kali and Dhauli, flow through this landscape.

Methods: The study was conducted in tributaries of Gori and Kali during 2015-2016. Habitat use by fishes evaluated in selected habitat based on underwater observation using aquascope and underwater mask. At each observation, depth, flow and substrate near the fish were recorded using depth measuring rod, hand held flow meter and visual observation respectively. Followed by habitat availability (flow, depth, substrate) were measured at every 1×1 m grid in the same habitat. All measured variables were organized into six categories. Based on the relative availability of habitat and use, habitat suitability curve was calculated for *Schizothorax richardsonii* and *Naziritor chelynoides*.

Result: The dominant habitats for *Schizothorax richardsonii* utilized depth between 30 and 60cm, Flow between 0 and 0.093m/s and it found associated with boulders. In the case of *Naziritor chelynoides* uses the same substrate and flow as of *Schizothorax richardsonii*, but used greater depth (<60 cm).

Conclusion: Both the fish species show co-existence in terms of habitat use, except depth usage. The ecological information gathered through this study would be useful for assessing condition of aquatic habitat and monitoring.

Keywords: Habitat use, indicator, Askot landscape

Project Title	: Biodiversity Conservation and Rural Livelihood Improvement Project
Principal Investigator(s)	: Dr. J. A. Johnson and Ajay Srivastava
Researcher(s)	: Vandana Rajput (Project Assistant)
Funding Agency	: World Bank
Project Duration	: 2012-2018

Soil microbial community composition and function across alpine habitats of Gangotri National Park, Uttarakhand

-Pamela Bhattacharya

Aim: The Himalayan alpine ecosystems are young, fragile and most vulnerable to global climate change impacts. In this study we aim to investigate climate-warming impacts on soil organic carbon (SOC) stock of alpine and sub-alpine habitats of Indian Himalayan Region (IHR) through soil microbial (bacterial and fungal) community composition and function.

Study Location: This study was conducted across major alpine and sub-alpine habitats in Gangotri National Park (GNP), Uttarakhand, (IHR).

Methods: We used a combination of soil sampling, experimental warming and laboratory analysis involving metagenomics, biochemical enzyme assays and soil characterization to understand the response of microbial communities. We collected soil samples from a wide range of alpine and subalpine habitats (3000 to 4000 m) during two seasons. In the laboratory we conducted soil physico-chemical characterization, biochemical estimation of SOC degrading enzymes activities of β-glucosidase and phenol oxidase at variable temperatures. Further, we extracted environmental DNA, amplified, cloned and sequenced 16s rDNA for bacterial community diversity analysis. We set up six Open Top Chambers (OTCs) in both subalpine and alpine habitats for long term monitoring of microbial community composition and activity changes under experimental warming.

Results: Laboratory analysis indicated increase in potential activity of both enzymes till 30 °C, however β-glucosidase exhibited greater temperature sensitivity in pre-winter than monsoon in both habitats. 16S rDNA sequencing from these habitats identified *Proteobacteria, Cyanobacteria, Gemmatimonas, Actinobacteria, Acidobacteria spp* and few unidentified species. Short-term experimental warming in three OTCs significantly increased the activities of both enzymes in first growing season. This provides baseline information on soil bacterial community composition and SOC degrading activity for future long-term climate change monitoring.

Summary: The results indicate that SOC stock in these habitats may experience more degradation due to temperature increase in the short term with enhanced temperature sensitivity during pre–winter than monsoon. However more sampling and analysis is required to confirm the trends. To understand warming induced changes in soil microbial community composition, next generation sequencing followed with functional group classification would be critical.

Keywords: Bacteria and fungi, climate change, Indian Himalayan Region, open top chambers, SOC degrading enzyme activity.

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.B Mathur, Dr. G.S Rawat and Dr. G. Talukdar
Researcher(s)	: Pamela Bhattacharya (Senior Project Fellow)
Funding Agency	: Department of Science and Technology
Project Duration	: 2015-2019

Population estimation and resource utilization of Rhesus macaques in Chandrabani, Dehradun

-Sayli Suresh Sawant

Introduction: Rhesus macaque (*Macaca mulata*) is widespread across northern and central parts of the country, except north Kashmir, Desert and west central India (Fooden, 2000) and behaviorally adapted to live amidst humans. The aim of the study is to understand the ranging and foraging patterns of rhesus macaques in human altered habitats.

Study Area: This study was conducted within 2 km radius of Wildlife Institute of India, Campus, Chandrabani, Dehradun.

Methodology: Chandrabani, Dehradun was divided into 1 hectare grids (N=1600). A reconnaissance survey was carried out for all the grids wherein information on variables like type of houses, forests, macaque presence, temples, garbage dumps was collected. The grids were grouped into three clusters: forest, agriculture and built up area using k-means cluster analysis. Sampling quadrats of 10 x 10 m for trees, 4 x 4 m for shrubs and 1 x 1m for herbs was used to assess the plant diversity in the area. Line transects of 1 km were walked in two seasons to estimate the abundance of macaques in the area. Based on the information about presence of macaques grid counts were done in the respective grids, where number of macaques in each grid was recorded. Simultaneously, roost sites were inspected and macaques in each roost were counted. Instantaneous scan and focal sampling were carried out for five troops to understand the time activity budget and movement patterns. A visual inspection of health of macaques was done on the basis of body condition and alopecia.

Results: Macaque presence was highest in agriculture (N=277) followed by built up area (N=252) and forest (N=74). We located 227 garbage dumps in the study site, out of which macaque presence was observed on 89 dumps. The time activity budget revealed that macaques visited garbage dumps regularly. They foraged on 13 trees, 18 shrubs and 19 herbs. Most abundant species *Shorea robusta* was intensively used for cover, roost and foraging by the macaques. Body condition of sub-adults was normal than adults. External wounds were higher in females than males and immature individuals. Alopecia was found to be prominent in females than others.

Future plans: We plan for reproductive control of macaque population by immunocontraception and other non-invasive techniques.

Keywords: activity budget, immunocontraception, non-invasive

Project Title	: National Mission on Himalayan Studies-Human Wildlife Conflict
Principal Investigator(s)	: Dr. S. Sathyakumar and Qamar Qureshi
Researcher(s)	: Sayli Suresh Sawant (Project Fellow)
Funding Agency	: Ministry of Forests and Climate Change, India
Project Duration	: 3 years

In search of the greener side: Habitat utilization of mountain ungulates with respect to livestock grazing in Askot Landscape, Uttarakhand

-Ankita Bhattacharya

In recent years, an integrated landscape vision for ecological and livelihood outcomes has come forth. In this regard, management of vast rangelands for sustaining a distinct kind of habitat for a unique biodiversity as well as social communities has been given importance. Rangelands in Himalaya support some of the globally threatened, rare and endemic species. They also support an economy influx from traditional pastoralism practices. However, whether grazing pressure exists in the landscape or not, to the extent of excessive competition with wild ungulates, is a matter of consideration. Our study aims to find out the habitat utilization of mountain ungulates with reference to livestock grazing and topographic covariates.

The study was done in the Johaar valley of Askot Landscape in Uttarakhand. The valley encompasses an area of ~953 sq.km. The intensive study area was ~700 sq. km. where 9 micro watersheds were sampled for habitat use pattern of mountain ungulates and livestock.

Sampling for both direct and indirect evidences was done in 38 patches for livestock and mountain ungulates. Topographic covariates and habitat patch sizes were generated from spatial data. Analysis was done for Blue Sheep, Himalayan Tahr and livestock using Design I of Manly's resource selection function.

Blue Sheep mostly preferred birch fir (Selection ratio = 2.34 ± 0.3), upper temperate grassy slope (Selection ratio = 2.25 ± 1.001), alpine meadow (Selection ratio = 1.81 ± 0.12) and rhododendron (Selection ratio = 1.71 ± 0.77) habitat types. For Himalayan tahr, moru–oak mixed (Selection ratio = 62.65 ± 25.17), upper temperate grassy slope (Selection ratio = 52.20 ± 5.39) and kharsu-oak (Selection ratio = 41.77 ± 9.99) were the most preferred habitat types. Habitat types generally utilized by livestock more than their proportional availability were rhododendron (Selection ratio = 4.3 ± 0.12), upper temperate grassy slope (Selection ratio = 4.25 ± 0.14), birch fir (Selection ratio = 2.47 ± 0.029) and alpine meadow (Selection ratio = 2.26 ± 0.012).

Resource selection studies can be used in evaluation of the effect of domestic animals on wild animal forage and to characterize habitat quality for selected species of conservation importance.

Keywords: Resource selection, Pastoralism, Blue sheep, Himalayan Tahr, Rangeland management

Project Title	: Biodiversity Conservation and Rural Livelihood Improvement Project
Principal Investigator(s)	: Dr. Bilal Habib
Researcher(s)	: Ankita Bhattacharya (Project Assistant)
Funding Agency	: World Bank
Project Duration	: 2012 – 2018

Multi-Scale Assessment of Landscape Productivity and its Drivers in the Uttarakhand Himalayan Region

-Sujata Upgupta

Biotic and abiotic interactions are conspicuously reflected in the pattern and dynamics of landscape structure and configuration. Quantification of landscape changes over spatial and temporal scales enables effective monitoring and management. Therefore changes in the landscape productivity and the factors determining the change need to be monitored continuously. The objective of this study is to model the relationship between landscape productivity with a set of exploratory variables at multiple scales and to identify the primary drivers of change.

The analyses were carried out for Uttarakhand, which is a predominantly Himalayan state located in the northern part of India. Using the Normalized Difference Vegetation Index (NDVI) data from 2000 to 2015, the predominant forces regulating the distribution as well as changes in landscape productivity at various spatial scales (16 km, 4 km and 1 km grid cells) were identified. A combination of geo-spatial analysis and regression modeling techniques was employed to evaluate the pattern and to identify the drives of changes.

The annual average maximum NDVI of Uttarakhand showed marginal decline from 0.68 in 2000 to 0.63 in 2015. However, there are spatial variations in the landscape productive across different scales. Majority of the landscape (63%) has experienced noticeable increase in productivity, indicating that declines are sharper in some areas only. The modeling outcomes revealed that spatial scale played a vital role in discerning the variation of driving factors. At the 16 km scale (n=251) the changes in landscape productivity were driven primarily by precipitation while seasonal extremes of temperature and precipitation were dominant at the 4 km (n=3478) and 1 km scales (n = 53148). Human footprint was found to be one of the primary drivers behind the decline in landscape productivity at all the scales.

Climatic variations reinforced by human disturbance are accelerating the negative effects on the landscape productivity and different factors operate at different scales. The findings of the study elucidate the role of spatial scale in detecting landscape patterns and processes indicating the need to adopt a multi scale approach in the formulation of effective strategies for resource management and nature conservation.

Keywords: spatial analysis, NDVI, GLM, Western Himalayas, climate change

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. B. Mathur and Dr. S. Sathyakumar
Researcher(s)	: Sujata Upgupta (Project Scientist)
Funding Agency	: Department of Science and Technology, Ministry of Environment Forest and Climate Change
Project Duration	: 2014 - 2019

Alpine plant communities and impact of snow-melt water on phenology at Tungnath, Western Himalaya

-Sachin M.H.

Aim: The global climate change will advance the timing of snowmelt and the onset of plant growth and flowering and fruiting in subalpine and alpine ecosystems, which might further affect plant community composition and structure. Therefore, we aim to study the impacts of snow cover characteristics and the timing of snowmelt on the plant phenology, and species abundance in the short term and species composition in the long term.

Location: The study was performed at Tungnath region, Chamoli District, Uttarakhand between 3000-3600m asl. The vegetation in the subalpine region mostly comprised of broadleaved sclerophyllous forests of *Abies pindrow*, *Quercus semecarpifolia, A. spectabilis* and krummholtz vegetation by *Rhododendron campanulatum*, whereas alpine meadows were dominated by various communities of herbs and grasses.

Methods: Based on physiognomic characteristics 5 communities' viz., *Trachydium, Polygonum*, Danthonia, Mixed *Danthonia and* Mixed herbaceous communities were identified. Twenty, random 1x1m quadrats were laid to record the abundance of individual species and cover percent of tussock forming species which help to understand community structure. The aboveground biomass from each site (3 replicates) was clipped in September, 2016 and analyzed. Soil samples were collected from each site randomly down to 20cm (0-10 and 10-20cm) depth and physico-chemical analysis is in progress. Snow manipulation experiments to study the impacts advanced and delayed snowmelt timing on plant phenology following 'Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie – BBCH' scale (Hess et al., 1997).

Results: Among plant communities the density was high in *Trachydium* (526.3 individuals m^{-2}) followed by mixed herbaceous (471.6 individuals m^{-2}) communities and species richness was highest in mixed *Danthonia* (35) and lowest in *Trachydium* (24) communities. The diversity was highest in *Danthonia* (3.45) and mixed *Danthonia* (3.13) communities. The aboveground biomass was highest in *Polygonum* community (138g m^{-2}). Soil moisture was similar in all communities and ranged from 44.2-50.4% and 41.2-45.4% at 0-10 and 10-20cm, respectively. Phenological observations on *ca.* 65-70 herbaceous plant species had recorded so far from both plant communities and elevation gradient plots.

Keywords: Phenophase, BBCH scale, Snow melting, Open Top Chamber

Project Title	: Influence of microclimatic variables on herbaceous plant communities in treeline ecotone in the Western Himalaya.
Principal Investigator(s)	: Dr. B.S. Adhikari
Researcher(s)	: Sachin M.H. (Junior Research Fellow)
Funding Agency	: Ministry of Environment , Forest and Climate Change, Government of India
Project Duration	: 2016 – 2019

Habitat characterization of Himalayan brown bear for using subsequently in landscape genetic analysis in Jammu and Kashmir

-Shahid Ahmad Dar

Aim: Landscape genetics is an approach for understanding how geographical and environmental features structure genetic variation at both the population and individual levels. Hence quantifying drivers which determine suitable habitats are crucial to assess the functional genetic connectivity between the suitable habitats. Therefore, the present study is aimed at assessing the distribution of potential habitats of brown bear and determining the underlying environmental drivers in Jammu and Kashmir

Location:The study area (Jammu and Kashmir) was divided into five blocks (North Kashmir, South Kashmir, Kishtwar, Drass and Kargil regions). We conductedfield survey in different protected (Hirpora Wildlife Sanctuary, Kazinag National Park, Overa-aru Wildlife Sanctuary and Kishtwar Wildlife Sanctuary)and outside protected areas of Jammu and Kashmir, India.

Methodology & Analysis: During the field expedition surveys, natural trails, ridges and *nullahs* were sampled (234.1km^2) and information on evidences either direct or indirect (scat, tracks) of brown bear were recorded. We collected 267 occurrence records of brown bear.The maximum entropy (MaxEnt) algorithm was used to predict the potential distribution of brown bear habitat. Only presence data together with 12 environmental input variables were used in the model.

Results: The encounter rate was highest in Drass region (1.20 signs/km) whereas it was lowest in South Kashmir (0.53 signs/km). The maxent distribution model was evaluated by calculating the area under curve (AUC) and it is 0.90±0.01 which reveals the better model predictability. Among the selected environmental variables, 5 variables explained the most variation (77.8%) for occurrences for brown bear in Jammu and Kashmir which include precipitation of coldest quarter, mean diurnal range, NDVI of June, seasonal temperature and Isothermality. Of the 221852 km^2 of the State, 10% (22185.2 km^2) area emerged as highly suitable habitat for brown bear in Jammu and Kashmir.

Conclusion: The overall maximum entropy areas as predicted by MaxEnt algorithm reveals only 10 per cent area of the state is suitable from Brown bear. These spatially identified areas will be used to assess the extent of functional genetic connectivity in this landscape.

Project Title	: Population genetic structure, gene flow in brown bear (*Ursus arctos isabellinus*) in India (Jammu & Kashmir, Himachal Pradesh and Uttarakhand) and assess extent of gene flow between populations of India and Pakistan: Conservation and forensic implications
Principal Investigator(s)	: Dr. S. Sathyakumar and Dr. S. P. Goyal
Researcher(s)	: Shahid A. Dar (Project Ecologist), Dr. Sujeet Kumar Singh (Project Biologist) and Vinay Kumar (Technical Assistant)
Funding Agency	: Department of Science and Technology
Project Duration	: 2015 - 2017

Potential impact of climate change on life history traits of native and non-native trouts in Tirthan valley, Himachal Pradesh

-Dr. Vineet K. Dubey

Aim: Life histories of cold water fishes in higher altitudes are governed by the local environmental settings that are known to be highly vulnerable to climate change. Exploring the key life history traits that are prone to change due to minor alteration of environmental factors would aid our understanding about the impact of climate change on fish in the Himalaya. In this context, this study was conducted to understand the interaction and vulnerability of different life history traits of native (*Schizothorax richardsonii*) and non-native (*Salmo trutta fario*) fish in western Himalaya.

Location: This study was conducted in the River Tirthan, is one of the major tributaries of River Beas, which rises from Chakri glacier (4880m) and confluences with Beas at Larji (900m) in the Great Himalayan National Park.

Methods: Fish samples were collected between April to July 2017, using cast, drag and kick nets covering 130 km of river stretch including tributaries and streams of Tirthan River. Length-weight relationship and condition factor were calculated using the Le Cren equation. The mean length at first maturity (L50) was estimated using samples collected during the reproductive periods. Fecundity of fish was quantified from the Gonad Somatic Index (GSI) and gonad development status. The GSI was calculated from the equation: GSI=(Wg/Wb)× 100, where Wg is the gonad weight (gram) and Wb is the body weight (gram).

Results: The analysis of the relationship between the total weight and length of both the native and non-native trouts showed that they were at negative allometric growth ($b < 3$). The sexual maturity of *Salmo trutta fario* gradually increased from Stage I to V during May to July and in the case of *Schizothorax richardsonii* the maturity was seen during the post June when the water temperature ranged between 9.5 to 23°C. The cumulative frequency curve of individuals that reached maturity stage III had indicated that nearly 50% (L50) female native trouts matured at 21.64 cm, whereas 50% of nonnative trouts matured at 17.60 cm, which were then compared to other trout populations in the Himalayan Rivers. Therefore, it is assumed that the fast growing populations of non-native trouts are threat to natives due to competitions for space.

Conclusion: The study is a tentative step towards our understanding of linkage between reproductive biology and key environmental cues governing spawning periods and maturity which will be more strengthened by long term future monitoring.

Keywords: Spawning season, Maturity, Himalaya, Environmental change

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 Principal Investigators Aquatic Component)
Researcher(s)	: Dr. Vineet K. Dubey (Project Associate) and Aashna Sharma (Project Fellow)
Funding Agency	: Department of Science and Technology
Project Duration	: 2014-2019

Its a catch 22 situation!

-Amrita Laha

The present times command a critical distinction between sustainable natural resource dependencies and resource exploitation. Biodiversity Conservation and Rural Livelihood Improvement Project was conceptualized to maintain some of the biodiversity rich landscapes of the country by investigating the interplay of social and ecological dynamics. It is an imperative query to understand how the biodiversity richness of some hotspots is maintained and assess its thresh-hold of sustainability.

Askot landscape in Uttarakhand, is one such biodiversity hotspot that is undergoing social, cultural political and economic alterations. Through this sociological study we aim to understand the interplay between socioeconomics of communities and their natural resource dependency in a steadily modernizing society.

Askot Musk Deer Sanctuary and its adjoining areas spread across 4496.5 km^2 and composed of a mosaic of land use constitute Askot landscape. It is the north eastern fringe of the State of Uttarakhand and shares international borders with Nepal and the autonomous region of Tibet.

Questionnaire survey (690 interviews) using a semi-structured questionnaire schedule, enquiring about socio-demographic and natural resource dependency was conducted across the landscape in sampled villages along the elevational gradient. Observations were corroborated with historical facts and anecdotal information documented during interviews and subsequently substantiated statistically.

Settlements here are part of urbanizing conglomerations by the river and motorable road (600-1500m), located at mid-elevation (1500-2500 m) and migratory for six months (above 3000). Consumption of natural resources (fuel-wood and fodder) is maximum at the mid-elevation and nominal in the lower and upper reaches of the valley. Subsequently people with relatively higher economic status have lesser natural resource consumption. We inquire if they have a higher environmental impact.

Approximately 60% of households in the landscape rely on wage labour and more than 50% on income from *ophiocordysep sinensis*. Income from *ophiocordysep sinensis* has led to unprecedented cash influx associated social changes. Around 30% of the total populations of sampled households live away from home and agricultural land abandonment is on the rise. Is this good news for biodiversity conservation? Does improved socio-economic status have anything to do with environmental stewardship?

Project Title	: Biodiversity Conservation and Rural Livelihood Improvement Project
Principal Investigator(s)	: Dr. S.A.Husaain and Dr. Ruchi Badola
Researcher(s)	: Amrita Laha (Project Assistant)
Funding Agency	: The World Bank
Project Duration	: 2012 - 2018

Human wellbeing and livelihood resilience in face of climate change in the Bhagirathi basin of Uttarakhand

-Soumya Dasgupta

Aim: Climate change has implications for conservation of biodiversity and well-being of the human communities, dependent on varied resources and range of ecosystem services provided by the Himalayan ecosystem. This research aims to answer key questions such as: (a) what are the critical biodiversity resources and ecosystem services that sustain local communities in the Indian Himalayas; (b) how ecosystem changes are going to impact upon human communities in terms of reduction of resources, and degradation of ecosystem services in the future; and (c) what are the socio-cultural dimensions linked to natural resource and ecosystem.

Location: This study was carried out in the villages of Bhagirathi Basin in Uttarkashi and Tehri garhwal districts of Uttarakhand.

Methods: A total of 1096 villages were identified from 2014 census India dataset and a Two step cluster analysis was done to classify the villages in different clusters according to altitude, population, village area, disaster severity and remoteness index. A total of 11 sub clusters were found under three clusters and a total of 33 villages representing all the clusters were selected for household level survey. Semi structured questionnaire was formed following the household economy approach and stratified random sampling was carried out to select households for detailed survey. 307 households of 13 villages of Uttarkashi and 279 households of 12 villages of Tehri Garhwal district were surveyed.

Results: Access and utilization of different provisioning ecosystem services such as agriculture, forest and water were assessed and on the basis of economic status and ability to sustain livelihood under the changing scenario, village and household level vulnerability was calculated. Average of the variety of agricultural product and their production in an individual household was higher in Uttarkashi district than the Tehri Garhwal district. Changes in rainfall pattern and human-animal conflict were found as the major reasons for change in agricultural pattern. Use of fuel wood and LPG is negatively correlated with each other and found to be dependent on the household economy.

Conclusion: Findings from the village and household level vulnerability study will help to formulate a long term monitoring strategy of fragile but important ecosystems and vulnerability of local community in the Bhagirathi basin.

Keywords: Climate change, Indian Himalayan Region, Bhagirathi Basin, Ecosystem services, Vulnerability

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. Ruchi Badola and Dr. Asha Rajvanshi
Researcher(s)	: Soumya Dasgupta (Project Associate)
Funding Agency	: DST - NMSHE
Project Duration	: 2014-2019

Key Ecosystem Services and Strategies to Ensure Their Continued Flow: a Case Study from Dhauladhar Mountain Range, Western Himalaya

-Anjali Uniyal

Aim: Assessment of ecosystem services (ESS) and their flow helps in conservation planning and sustainable development. Simple lifestyle of rural communities in the Himalayan region has helped in the sustained flow of ESS, especially water, for the downstream communities. However, increasing demand for bioresources could affect the flow of ESS from the region. Therefore, present study aims to assess the key ESS from a West Himalayan watershed, participatory management and upstream - downstream linkages to develop strategies for sustained flow of services in the long run.

Study area: Bohl spring water recharge zone (BSWRZ, *ca*. 286 ha, 31°13'51.1" to 32° 08' 31.8" N & 77° 55' 33.2" to 76° 32' 59.4" E) that lies in the Dhauladhar mountain range (Himachal Pradesh) has been selected for the pilot study. This spring shed fulfills the need of drinking water to downstream Palampur town. Three hamlets of agro-pastoral *Gaddi* community are located in the lower recharge zone.

Methods: Focus group discussions, participant observations and structured interviews were conducted with stakeholders in BSWRZ to assess their socio-economic status, dependency and management of natural resources.

Preliminary findings: Forest, grassland and agro-ecosystem have been identified in the study area, which provides different services at local and regional level. Key provisioning services of the forests are fuel wood (12.7kgday^{-1} household^{-1} to 36.86kg day^{-1} household^{-1}), leaf fodder (45.27kgday^{-1} household^{-1}), grass fodder (22.88kgday^{-1} household^{-1}) and drinking water (~Rs. 56.66month^{-1}household^{-1}) and main regulating service is the discharge of spring water. Key management issues identified in the area include spread of Eupatorium and crop raiding by wild animals. Conflict of interest among different socio-economic groups over payment of fine and flow of PES in the management plan is also evident.

Conclusion: Valuation of ESS in the study area, socio-economic upliftment & ecological awareness of villagers is essential for the long-term conservation & management of ecosystems and valuation of PES. This needs an integrated working approach among all the stakeholders.

Keywords: Spring-shed, Himalaya, resource, ecosystem, PES

Project Title	: Conservation and sustainable management of land and natural resources
Principal Investigator(s)	: Dr. Gopal Sigh Rawat
Researcher(s)	: Dr. Anjali Uniyal (Himalayan Research Associate)
Funding Agency	: Govind Ballabh Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD), Ministry of Environment, Forest and Climate Change, Government of India
Project Duration	: 2016- 2019

Assessment of agriculture vulnerability in the Himalayan region: A case study from Pithoragarh district, Uttarakhand

-Nehru Prabakaran

Aim: Traditional farming communities of Indian Himalayan Region (IHR) have preserved numerous native crops that are suitable for the marginal lands and harsh climatic conditions. This rich farming tradition and crop diversity of IHR is under enormous pressure due to: preference for modern high yielding crops, degradation of traditional knowledge, climate change and outmigration of rural communities to urban areas. In our project we study the influence of aforementioned factors on the crop diversity and traditional agriculture practices in the Pithoragarh district of Uttarakhand, Western Himalayas.

Location: The study was conducted in three administrative blocks of Pithoragarh district which is bordered on the east by Nepal and north by Tibetan Autonomous Region of China. The agriculture here is mostly rain-fed and is driven by subsistence than economy.

Methods: Household survey (n=136) was conducted across 36 villages of the study district to understand the trends in agriculture, crop diversity, socio-economy of farmers, village status in terms of basic amenities (eg. mode of transportation, school, healthcare, distance from market etc.,) and the major threats to mountain agriculture. Each basic amenity variable (n=8) was assigned a score to quantitatively evaluate the village status (maximum score = 13).

Results: The land under cultivation is rapidly declining in the study area – 30% decline within last decade – and agriculture is currently practiced on 54% of the total cultivable land. Decline in crop diversity and cropping area is less for villages with high (10-13) and less (1-5) basic amenity scores compared to villages with medium score (6-9). Cultivation of indigenous crops belong to the millet group (eg. foxtail millet, hog millet, pearl millet) has declined drastically and the crop diversity is negatively influenced by cash cropping (Potato and French bean). Wildlife damage, climate change and manpower shortage – due to human outmigration – were the most influencing factors contributing to the decline in agriculture.

Conclusion: The current rate of decline in crop diversity and area under cultivation is influenced by multiple factors (eg. cash cropping, climate change, wildlife conflict, migration etc.,) and thus demands a multi-disciplinary approach to evolve solutions that can aid in sustaining the mountain agriculture.

Keywords: Traditional agriculture, indigenous crops, cash crops, climate change, migration

Project Title	: Conservation of indigenous crop varieties and vulnerability assessment of agro-ecosystem in Pithoragarh district, Uttarakhand
Principal Investigator(s)	: Dr. G. S. Rawat
Researcher(s)	: Dr. Nehru Prabakaran (Himalayan Research Associate)
Funding Agency	: Ministry of Environment, Forest and Climate Change, Government of India
Project Duration	: 2016 - 2019

Addressing Human-wildlife Conflicts in the Indian Himalayan Region through Action Research and Participatory Approach

-Dipanjan Naha

Aim: Human-wildlife conflict is a major management issue in the Indian Himalayan Region (IHR) where large expanse of human habitations and agricultural land areas are either interspersed with fragmented wildlife habitats or located in close proximity to protected areas that are home to many wildlife species involved in crop/livestock depredations and attack on humans. Quantification and reduction of wildlife conflicts in the IHR through participatory action research is absolute necessity for long-term conservation and management of wildlife as well as to maintain the natural and social integrity of the Himalayan ecosystem.

Objective: During 2016-17, WII has initiated action-oriented research project in three Himalayan states *viz.,* Jammu & Kashmir, Uttarakhand and West Bengal (northern region). The objectives are to: (i) identify vulnerable areas for regular monitoring and implementation of mitigation efforts through risk assessment in the IHR; (ii) understand ranging pattern of selected wildlife species that are involved in livestock/crop depredation in the IHR and biological factors responsible for the conflict; and (iii) develop and implement adaptive management strategies in some of the identified vulnerable areas through community engagement. The focal species are snow leopard, brown bear, common leopard, black bear, wild pig and rhesus macaque. Results regarding rhesus macaque are being addressed through a separate presentation.

Methodology: Secondary data on conflict records have been compiled between 2000-2016 from the state wildlife departments of J&K, Uttarakhand and West Bengal. Extensive surveys have been undertaken in Ladakh, Darjeeling, Kalimpong and Jalpaiguri districts of West Bengal and Pauri district of Uttarakhand to document plausible reasons, patterns of conflict and socio-economic condition, perception of local communities towards wildlife. Based on these surveys, conflict risk maps have been prepared on the GIS domain for Pauri Garhwal in Uttarakhand and North Bengal.

Conclusion: Snow leopard contributed to 89% of livestock loss followed by Tibetan wolf (10.8%) and brown bear (0.11%) in Leh region of Ladakh between 2010-2016. The average number of human injuries and deaths to leopard attacks in Pauri (Uttarakhand) was 11 (SE 1.13) and 3 (SE 0.6) between 2000-2016 whereas in North Bengal it was estimated to be 70 (SE 9.2) and 1.6 (SE 0.3) respectively between 2004-2016. Average number of human injuries and deaths per year due to black bear attacks were estimated to be 11 (SE 2.4) in Pauri region between 2012 till date. The central and northern regions of Pauri Garhwal and areas around Protected Areas in Central and south-western Dooars (West Bengal) were identified as “high human-leopard conflict risk prone areas”. We propose to pilot mitigation measures in few of the selected hotspots in the IHR in the near future.

Keywords: conservation, hotspot, risk map, management

Project Title	: Human-Wildlife Conflict Resolution Mechanism in the Indian Himalayan Region: Risk assessment, prediction and management through research and community engagement
Principal Investigator(s)	: Dr. G.S. Rawat and Dr. S. Sathyakumar
Researcher(s)	: Dipanjan Naha (Project Associate)
Funding Agency	: NMHS and Ministry of Environment, Forest and Climate Change, Government of India
Project Duration	: 2016-2019

Monitoring initiatives for microflora in Gangotri National Park, Uttarakhand

-Ishwari Datt Rai

Aim: To determine impacts of climate change on microfloral communities through long term monitoring and experiments.

Location: The study area lies inside Gangotri National Park (GNP), Uttarakhand.

Methods: Systematic sampling of lichens was done across the habitat types. Two retreating glaciers, Nelang and Gangotri, were selected for systematic sampling of lichen community with regular distance from the snout to study patterns of lichen community with glacier shrink. Experiment based long term monitoring of soil microflora was initiated in November 2016. In order to simulate the warming effects on microflora, 6 Open Top Chambers (OTC) equipped with soil and air temperature probes were installed in the subalpine-alpine habitats. Thalli of soil lichens inside the OTCs were identified and marked for further monitoring of growth and biochemical compounds synthesized in warming conditions towards the completion of the study. Lichen species were also marked inside and outside the OTCs for changes in growth (Lichenometry) and secondary metabolites. Impact of simulated warming on soil bacterial community composition and function is being assessed with seasonal soil sampling from OTCs and controlled plots. Litter traps containing leaf litter were placed inside and outside the OTC in the subalpine zone and decomposition rate and nutrient status in natural and warming conditions will be analysed in following years.

Results/Trends: Over 1200 samples of lichens were collected from the greater and trans-Himalayan landscape of Bhagirathi basin and about 100 species were identified so far. Many interesting species, collected from trans-Himalayan areas up to >5000m are yet to be identified. Two lichen species, *Rhizocarpon geographicum* and *Xanthoria elegans* were identified as focal species for Lichenometry studies. Considerable difference in the growth of the plant species inside the OTCs was observed in the first growing season.

Conclusion: Open Top Chamber based experimental setup are ideal for assessing responses of soil microflora and plant community in the short span of time in alpine environment. Further, continuous monitoring will provide deep understanding about the responses of microflora towards warming to predict their responses in future scenarios of climate change.

Keywords: Experimental Study, Lichen, Lichenometry, Open Top Chambers

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.B. Mathur (Principal Investigator), Dr. G.S. Rawat and Dr. Gautam Talukdar (Co-Investigators)
Researcher(s)	: Dr. Ishwari Datt Rai (Project Scientist), Pamela Bhattacharya (Project Fellow) and Anjali Uniyal (Project Assistant)
Funding Agency	: Department of Science and Technology, Government of India
Project Duration	: 2014-2019

Strategies and approach for long-term ecological monitoring in Sikkim Himalaya

-Rishi Kumar

Aim: Anthropogenic pressures and other drivers including climate change are affecting biodiversity and human well-being. In order to evolve appropriate adaptation strategies and predict future trends in biodiversity and ecosystem services, it is important to establish baselines on the state of ecosystems and long term monitoring system. This project aims to generate baseline data on key environmental parameters along altitudinal and anthropogenic pressure gradients and develop a comprehensive system of long term monitoring for Sikkim Himalaya.

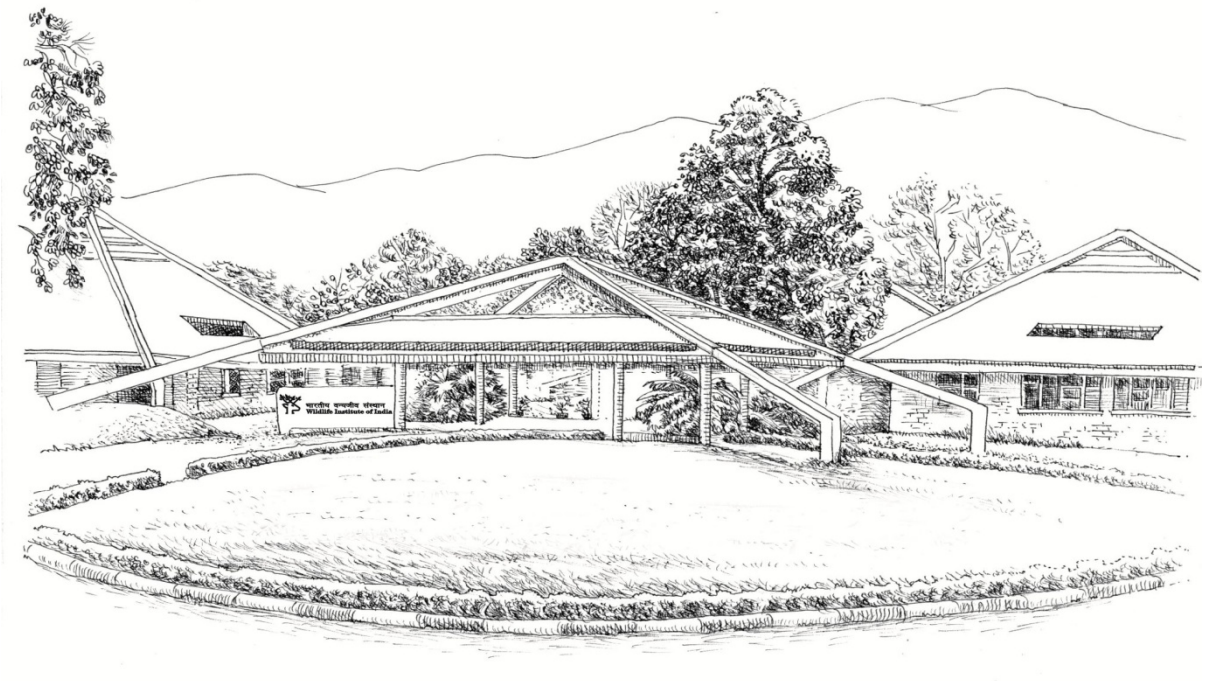
Study Area: Sikkim Himalaya. It would cover entire state of Sikkim along Teesta valley from sub-tropical, Sal bearing forest near Rangpo (500 m) to the base of Teesta glacier (5500 m asl) in the north.

Proposed Methodology: Across the entire altitudinal and anthropogenic pressure gradients, covering various forest types, a series of one ha plots would be established at an interval of 500 m asl along Teesta valley. Within each of these ha plots one/multiple sub-plots of 20 m x 20 m would be marked for quantification of tree layer. Within the sub-plot, multiple nested plots of 5m x 5m for shrubs and 1m x 1m for herbs would also be placed. Land use / land cover, current level of anthropogenic pressures or patterns of resource extraction pattern, presence of key faunal communities (especially mammals and birds) would be recorded within the plot, and phenology of major tree species would be recorded. The volunteers and young researchers from the nearest habitation and technical staff from Sikkim State Science and Technology Department would be involved in collection of baselines and they would be trained in future monitoring.

Institutional Mechanism: Major national, state and local institutions have been identified along with their strengths and weaknesses. It is proposed that the State Forest Department and Department of Science and Technology, Sikkim will be the main coordinating and managing institutions to continue monitoring activity and reporting to the government.

Keywords: Long-term ecological monitoring, NMHS, Permanent plots, Teesta valley

Project Title	: Long-Term Environmental and Socio-ecological Research Initiative in Sikkim Himalaya
Principal Investigator(s)	: Dr. G. S. Rawat
Researcher(s)	: Rishi Kumar (Project Associate)
Funding Agency	: NMHS and Ministry of Environment, Forest and Climate Change, Government of India
Project Duration	: 3 years



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