Government of Nepal
Ministry of Forests and Environment

POPULATION ASSESSMENT OF SHEY - PHOKSUNDO NATIONAL PARK'S SNOW LEOPARD AND PREY

Department of National Parks and Wildlife Conservation

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CITATION

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Shey - Phoksundo National Park, Dolpa, Nepal.

FRONT COVER

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BACK COVER

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Foreword

Nepal is one of 12 countries in the world that hosts the snow leopards. This imperiled species is a key indicator of healthy mountain ecosystems. Their habitat provides ecosystem services that benefit more than a billion people of the planet and sustain unique high-altitude cultures. Yet, they are threatened globally by retributory killings, wildlife crime, habitat degradation, among others; climate change is understood to be a threat multiplier, with research indicating severe impacts on snow leopard habitats.

In Nepal, snow leopard habitat is distributed over the Himalayan eco-region that ranges from Kangchenjunga Conservation Area in the east to Api Nampa Conservation Area in the west. Considering the importance of the species, Government of Nepal has given special attention to understand the species better through research and aid informed conservation and management. In line with the country's commitment through the Global Snow Leopard Ecosystem Protection (GSLEP) Program, Nepal has coordinated national snow leopard conservation through the periodically updated national Snow Leopard Conservation Action Plan. Likewise, the country was the first to prepare and launch the climate-smart Snow Leopard Ecosystem Management Plan for the Eastern Himalayan Landscape.

Snow leopards are among the least studied of the big cats. Accordingly, the government of Nepal has prioritized robust and expansive monitoring of snow leopard populations. As part of this prioritization between 2019 to 2022 the government of Nepal supported by WWF Nepal undertook this detailed study and assessment of snow leopard population in Nepal's largest and only trans-Himalayan National Park Shey Phoksundo National Park.

This report highlights the major findings of Shey Phoksundo National Park's snow leopard population and density, prey abundance and trends, and provides management recommendations to strengthen conservation in the park. Furthermore, the report also acts as a galvanizing tool to extend the survey in the remaining snow leopard habitats of the country and come up with the national estimate in line with GSLEP's Population Assessment of the World's Snow Leopards (PAWS) guidelines.

I would like to express my sincere thanks to the technical team and frontline staff involved from Shey Phoksundo National Park, technical and field team from WWF Nepal, citizen scientists from community-based Snow Leopard Conservation sub- committees, Red Panda Conservation sub-committees and field coordinators for bringing this report alive with several months of strenuous field work, painstaking data compilation and analysis. I specially thank Shey Phoksundo National Park for leading the survey, and WWF Nepal for technical and financial support. Finally, I would like to thank local communities and all the relevant stakeholders who have contributed towards the long-term survival of this magnificent species.

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Sindhu Prasad Dhungana, PhD
Director General

Government of Nepal
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Department of National Parks and Wildlife Conservation

Shey-Phoksundo National Park

Acknowledgement

Nepalis committed to conserve and secure snow leopard population across the country. Snow leopard and prey survey in Shey-Phoksundo National Park has generated a reliable and robust baseline status of snow leopards and prey and aid in effective conservation. This gives us pride and encouragement to continue our tireless efforts to save this enigmatic species.

The survey was conducted by the Government of Nepal- DNPWC/SPNP in partnership with World Wildlife Fund-Nepal office. We would like to thank Dr. Maheshwor Dhakal, former Director General of DNPWC, Dr. Ram Chandra Kandel, former Director General, DNPWC, present Joint Secretary and Chief, REDD Implementation Centre, Mr. Ajay Karki, Deputy Director General of DNPWC, Mr. Bed Kumar Dhakal, Deputy Director General- DNPWC, Dr. Ghana Shyam Gurung - Country Representative, WWF Nepal, Mr. Shiv Raj Bhatta, Senior Adviser- Conservation Program, WWF Nepal for their support and advice in making this survey a success.

We extend our thanks to the former and current technical committee members – Mr. Haribhadra Acharya, Dr. Ganesh Pant, Ms. Madhuri Karki, Ms. Sabnam Pathak, Mr. Hem Raj Acharya, Mr. Ashim Thapa, Dr. Kanchan Thapa, Dr. Naresh Subedi, Dr. Chiranjibi Prasad Pokhrel, and Dr. Bhagawan Raj Dahal for their technical advice and recommendation for the survey to materialize.

Our special thanks go to then chief conservation officers and staff of SPNP, Mr. Pramod Kumar Yadav, Mr. Saroj Mani Poudel, Mr. Gopal Khanal and Mr. Lal Bahadur Bhandari; as well as staff of WWF Nepal for their active role and support in the field survey implementations. Mr. Gopal Khanal, Mr. Samundra Ambuhang Subba, Mr. Sheren Shrestha, Mr. Chandra Jung Hamal deserve special thanks for designing the survey, field technical and implementation support, data analysis, report writing, and publication. Special thanks to Dr. Gokarna Jung Thapa for map generation and output. Many thanks to National Trust for Nature Conservation for providing complementary camera traps to conduct the survey. Sincere thanks to field coordinators- Mr. Purnaman Shrestha, Mr. Tashi Tobgyal Tamang, Mr. Bijay Bashyal, Mr. Naresh Kusi, Mr. Sandesh Lamichhane, Mr. Amrit Subedi, Mr. Bhumi Prakash Chaudhary Tharu, Mr. Temba Lhundup Gurung, Mr. Bibek Raj Shrestha, Mr. Kabindra Shahi, Mr. Prasun Ghimire, Ms. Deepa Pun, Ms. Yankee Lama and Ms. Tashi Tsomo Gurung for their outstanding contribution in field coordination and data compilation. Additionally, we would like to thank all hardworking members of Snow Leopard Conservation sub-Committees, Red Panda Conservation sub-Committees, buffer zone user committees and citizen scientists for their active role and participation in the survey.

We hope this technical report will be useful to all policy makers, protected areas and divisional forest managers, conservationists, academia, and general readers nationally and internationally. Finally, we reiterate our sincere thanks to every individual and institution who contributed to this success in estimating snow leopard population of Shey- Phoksundo National Park.

Bishwa Babu Shrestha
Senior Conservation Officer

Bishwo Babu Shrestha
For Senior Conservation Officer

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EXECUTIVE SUMMARY

Snow leopard (*Panthera uncia*) is a vulnerable flagship species, and indicator of healthy mountain ecosystems. It is distributed in 12 range countries with an estimated global population of about 3,921 - 6,290. Its population is believed to be declining in the last century mainly due to the ever-increasing threats of poaching, retribution killing and climate change impacts on their habitat.

Nepal along with other snow leopard range countries is committed to global pledge of securing 23 landscapes by 2020 (Global Snow Leopard and Ecosystem Protection Plan 2015). Accordingly, Nepal adopted the landscape conservation approach and identified three snow leopard conservation landscapes viz. Western, Central and Eastern. In line with GSLEP priorities, Nepal has prepared and periodically updated its National Snow Leopard Conservation Action Plan; the country has also prepared climate integrated Snow Leopard and Ecosystem Management Plan for the Eastern Snow Leopard Landscape, 2017-2026, and is in the process of preparing a similar plan for the Western landscape. Additionally, GSLEP's second steering committee meeting held in Kathmandu 2017 identified the need for more robust and expansive monitoring of snow leopard populations. Nepal is believed to host around 301-400 snow leopards, an estimate based on sign surveys, carried out in the last decade. However, there is an urgent need, as well as interest, to update the national population with more robust scientific methodologies, to better understand the status of the country's snow leopard populations, and aid in improved conservation interventions.

In order to contribute to the nation's snow leopard population estimation, Shey - Phoksundo National Park's (SPNP) management plan, Nepal's national Snow Leopard Conservation Action Plan and to aid in developing national snow leopard monitoring protocol, a camera trap survey was carried out in SPNP of western landscape in 2019-2020. This survey carries special merit as the SPNP constitutes Nepal's largest and only trans Himalayan National Park. The survey was led by SPNP with financial and technical support from conservation partner World Wildlife Fund - Nepal (WWF Nepal). Frontline park staff, field coordinators comprising of students and researchers, community-based citizen scientists and volunteers from Snow Leopard Conservation sub-Committees were engaged for the park-wide survey. The objectives of the survey were to establish a reliable baseline population status of snow leopard in Shey - Phoksundo National Park and adjoining buffer zone area in the Dolpa district, Nepal.

The survey was carried out in 62 grid cells (8x8 km^2) encompassing a sampling area of 4,156.5 km^2 (effective trapping area of 8,562.8 km^2) across all potential snow leopard habitats within SPNP and its buffer zone between October 2019 and January 2020. Overall effective sampling effort of 9,531 trap days was achieved through a total of 2,220 person days. Snow leopard abundance and density were estimated using spatial capture-recapture models in '*secr*' and 'SPACECAP' package in R environment, respectively.

Likewise, double observer survey method was applied to estimate population of blue sheep – the main prey of snow leopard in this region. The survey was conducted in sub-watersheds (ranging from 10 to 25 km^2) delineated based on watershed terrain, during the autumn season covering an area of 1920.5 km^2 in 61 sub-watershed blocks. Data were analyzed in Bayesian framework using BBrecapture package in R.

Snow leopards were captured in 41 grids (66%) out of the total 62 grids. 62 individual snow leopards were identified from the total of 2,703 images. Independent detections (298) of identified individuals were analyzed to estimate SPNP's snow leopard populations. Based on the most parsimonious spatial capture-recapture model, an abundance of 90 (SE 8; range 78 -109) snow leopards were estimated with density of 2.21 snow leopards (SD 0.22) per 100 km^2 in Shey- Phoksundo National Park. Overall population size of blue sheep in SPNP was 6167.1 (5542.4 - 6823.8) in 2022. Trend analysis using BBrecapture showed a positive linear trend in terms of both abundance and density over the period of 3 years.

This study was the first intensive research carried out to understand the status of the snow leopard in SPNP. As such, it provides a baseline for snow leopard and prey abundance and density in and around SPNP. The survey results also provide key information including estimated population, high-density pockets, etc for informed conservation and management. A single study may not capture the intricate complexities of species' population dynamics and ecology, this provides key strategic guidance for improving conservation and management for long-term well-being of both people and nature.

1. INTRODUCTION

Snow leopard is a charismatic species of Himalayan Mountain ecosystems. The snow leopard (*Panthera uncia*) – a species whose presence represents healthy mountain ecosystems, inhabits a wide but fragmented range throughout Central Asia and the Himalayas (Snow Leopard Network 2014). The species distributed across 12 range countries with global population estimated to be between 3921 – 6290 individuals (Snow Leopard Working Secretariat 2013). Snow leopard is listed as an 'vulnerable' species by the International Union for Conservation of Nature (IUCN) Red Data Book and under Appendix-I in Convention on International Trade on Endangered Species of Wild Fauna and Flora (CITES) (McCarthy et al. 2017). Nepal is believed to host around 301-400 snow leopards in the country's northern Himalayan region (DNPWC 2017). The extant habitat has been administratively divided into three snow leopard conservation landscapes. The Eastern Snow Leopard Conservation Landscape extends from the Kangchenjunga Conservation Area (KCA) to Langtang National Park (LNP), including Makalu Barun National Park (MBNP), Sagarmatha National Park (SNP) and Gaurishankar Conservation Area (GCA). The Central Snow Leopard Conservation Landscape covers Manaslu Conservation Area (MCA) and Annapurna Conservation Area (ACA). The Western Snow Leopard Conservation Area extends from the west of Kali Gandaki gorge covering Shey- Phoksundo National Park (SPNP), to Api Nampa Conservation Area (ANCA). Snow leopard habitats existing outside the protected areas are also included in all three snow leopard landscapes.

Compared to world's other big cats (e.g., tiger, lion), little conclusive information is available on the ecology, distribution and population status of the elusive snow leopards. Due to their elusive nature, low population densities, expansive territories and inaccessible terrains, snow leopards are, by nature, difficult to monitor directly and indirectly. It has become imperative to understand their ecology in order to formulate sound and effective conservation plans and interventions. Recent studies by camera traps, satellite telemetry and fecal genetic study has provided us vital information of their transboundary range, critical habitats and dispersal corridors (McCarthy et al. 2008; Karmacharya et al. 2011; Alexander et al. 2015; Johansson et al. 2015, 2016; Janecka et al. 2017). However, those studies were conducted in only few parts of their massive Himalayan range of Nepal. Further studies on their population dynamics, dispersal habits, identifying critical habitats and corridors and information on their entire ecology in other landscapes are crucial for making conservation interventions effective.

Figure 1: 12 dimensions of snow leopard conservation.

The conservation of snow leopards in Nepal is largely steered by the Snow Leopard Conservation Action Plan for Nepal highlighting the 12 dimensions of snow leopard conservation (Figure 1) and National Snow Leopard and Ecosystem Protection Priorities (NSLEP) of Nepal (2014-2020) under the framework of Global Snow Leopard and Ecosystem Protection. Additionally, during GSLEP's second steering committee meeting held in Kathmandu, Nepal in January 2017, governments from the snow leopard range countries identified the need for more robust and expansive monitoring of snow leopard populations. Furthermore, the International Snow Leopard and Ecosystem Conservation Forum 2017 (SL Forum 2017) in Bishkek where the governments from the snow leopard range countries came together and set the goal of developing their respective nation's robust estimate contributing to the global snow leopard population. With the conventional estimates of Nepal in 2009 considered rudimentary, there is urgent need, as well as interest to update the national population with more robust scientific methodologies, to better understand the status of the country's snow leopards, and aid in improved conservation interventions (Sharma et al. 2019).

Western landscape is believed to host the highest densities of snow leopards in the Nepal Himalayas, making the region critical for long-term conservation of the species. This landscape also hosts the largest and the only trans-Himalayan protected area: Shey - Phoksundo National Park (SPNP). In order to contribute nations' snow leopard population estimate and strengthen implementations of SPNP management plan, Snow Leopard Conservation Action Plan (2017-2021) and to aid in developing national snow leopard and their prey base monitoring protocol, this survey was carried out in SPNP of western landscape.

2. OBJECTIVE

The main objective of the population monitoring exercise is to establish a reliable baseline population status of snow leopard and trends of prey population in Shey - Phoksundo National Park and adjoining buffer zone area, Dolpa.

3. STUDY AREA

Western landscape assumed to be harboring highest snow leopard density in Nepal, making the region critical for long-term conservation of the species. This landscape also hosts the largest and the only trans-Himalayan protected area – SPNP (Figure 2). The park derives its name from two famous attractions – the Shey monastery, believed to have been built in the 11th century, and Phoksundo lake, a Ramsar site. Covering over 3,555 km^2 and gazetted in 1984, this is Nepal's largest national park and the only one whose micro-climatic condition, ecology, ecosystem and flora and fauna resemble the Tibetan desert type. It shares its northern boundary with the Tibetan Autonomous Region of China. With altitudes ranging from 2,000 to 6,883 metres, the park and its buffer zone have a sub-temperate to Trans-Himalayan climate which produces 15 forest types, 260 species of birds, 33 species of mammals, 28 species of butterflies, 6 species of reptiles, and more than 500 species of medicinal plants. The SPNP is extremely valuable ecologically as it provides the main habitat for the globally threatened snow leopard, musk deer (*Moschus spp*), argali (*Ovis ammon*) and red panda (*Ailurus fulgens*) as well as a diverse floral life. Other animals found in the park are blue sheep (*Pseudois nayaur*), the main prey of the snow leopard, goral (*Naemorhedus goral*), Himalayan tahr (*Hemitragus jemlahicus*), grey wolf (*Canis lupus*), golden jackal (*Canis aureus*), Eurasian lynx (*Lynx lynx*), Pallas's cat (*Otocolobus manul*), Himalayan black bear (*Ursus thibetanus*), Altai weasel (*Mustela altaica*), Himalayan marmot (*Marmota himalayana*), Royle's pika (*Ochotona roylei*), Nepal gray langur (*Semnopithecus schistaceus*) and rhesus monkeys (*Macaca mulatta*). Despite the prevalence of Buddhism in the region, certain communities within have chosen to maintain and uphold the Bon religion, preserving its unique rituals, beliefs, and practices. Agro-pastoralism is the main source of income for the local people where animal husbandry is traditionally very important with the number of livestock reflecting the wealth of the family.

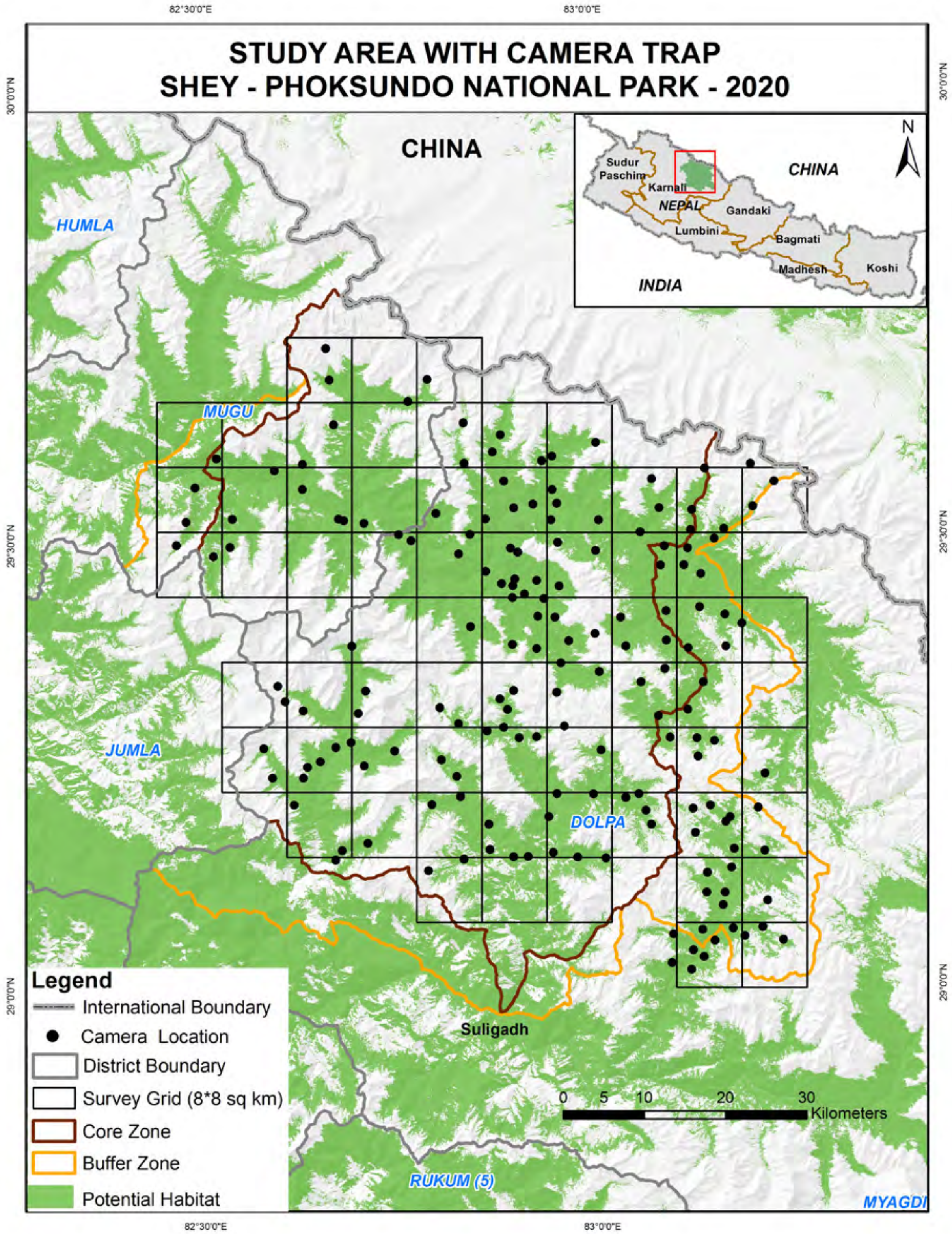

Figure 2. Map of Shey- Phoksundo National Park (SPNP) displaying camera trap locations (black dots) in their respective camera trap grids of 8x8 km^2 (square colored grids).

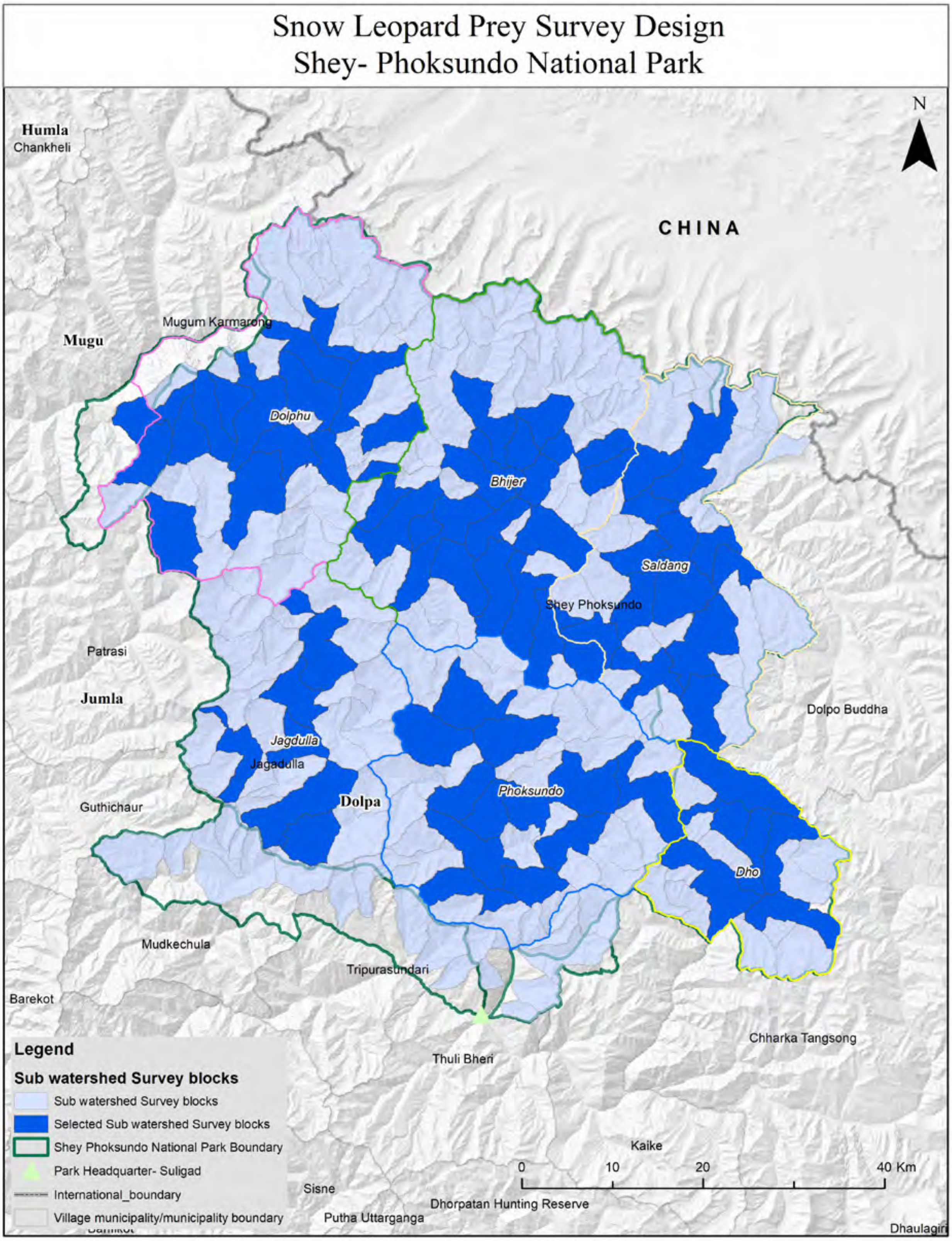

Figure 3. Prey base survey design for SPNP, light blue represents the overall sub watershed blocks (n=218) and darker blue represents the selected block where the survey was planned to be conducted.

4. MATERIALS AND METHODS

4.1. Field training, survey time frame and human resources

4.1.1. Snow leopard survey

Field work was initiated by appointing 13 field coordinators to assist the park staff and citizen scientists / Snow Leopard Conservation sub-Committee (SLCC) members for technical coordination. These coordinators were independent wildlife researchers/conservationists, or environment (related) graduates, with prior experiences and ability to work in these difficult terrains. A short orientation training program was provided for field coordinators in DNPWC, Kathmandu before the field work. They were oriented on the methodology and approach as well as their role in engaging with the community representatives, SLCC members and SPNP park staff. Their role was to help coordinate the field work with the park staff and SLCC members, systematic data recording and collation for analysis.

Park staff members of SLCCs/citizen scientists and newly formed Red Panda Conservation Sub-Committee (RPCC) of six habitat blocks (Dolphu, Dho, Jagdulla, Phoksundo, Saldang and Bhijer), were capacitated by providing training on the survey methodology for snow leopard monitoring. A two-day training package was developed, all members of 6 blocks were trained in two sites (Ringmo, Phoksundo and Shey Gumba, Saldang) on snow leopard monitoring by camera traps (Figure 4, 5 and 6). Participants were specifically trained on the use of hand-held GPS units and camera traps along with systematic data collection and recording. The trained personnel were strategically deployed in groups of 6 across their respective 6 habitat blocks of the park, to conduct the surveys. A total of 154 field staff (111 SLCC members and citizen scientists, 30 park staff and 13 coordinators; ♂:♀ - 151:3) were involved in the survey (Annex 3).

The field survey was conducted from October 25, 2019, to January 31, 2020 (3 months). However due to field inaccessibility caused by heavy snowfall over that period, some camera traps operated until March 31, 2020. An extensive effort of 2,220 person days was invested to complete the park wide survey.

Figure 4. Frontline park staff and Snow Leopard Conservation sub-Committees of Saldang and Bhijer engaged in 2 days training in Shey Gumba, SPNP.

Figure 5. Training organized in upper Dolpa, Shey Gumba, Saldang block to SLCCs of Saldang, and Bhijer, citizen scientists and frontline park staff.

Figure 6. Training organized in Ringmo, Phoksundo to SLCCs, frontline park staff and citizen scientists of Phoksundo, Dho, Dolphu and Jagdulla.

4.1.2. Prey survey

Prey base monitoring training to frontline park staff and citizen scientists/community-based Snow Leopard Conservation sub-Committees (SLCCs) of all blocks (Jagdulla: Red Panda Conservation Committees - RPCCs) was provided every year so as to serve as a refresher, learning and improving from the past efforts and strengthening their capacity. A two day training program was conducted prior to the survey between November-December (Figure 7). A total of 72 (♂:♀ - 71:1) participants (50 SLCCs, 10 RPCCs and 12 park staff) were involved in the survey each year with 12 (1:11 – park and SLCC/RPCC) in each habitat blocks spending two weeks to complete the field work.

Figure 7. Prey base monitoring training conducted in Saldang (2020) - top left and Ringmo (2021 & 2022) - top right and bottom.

4.2. Survey design and field surveys

4.2.1. Camera trap survey

The snow leopard survey was undertaken by dividing the study area (both core area and buffer zone) into six major blocks based on terrain, logistic and management feasibility, viz. Bhijer, Dho, Dolphu, Jagdulla, Phoksundo and Saldang (Figure 2). Following a systematic grid-based sampling approach (8 x 8 km^2) were used for camera trap monitoring of snow leopard. The grids were selected by overlaying on the potential habitat map of snow leopard and examining each grid based on field access and potential snow leopard site (WWF Nepal 2009). They were further divided into 4 x 4 km^2 sub-grid cells and examined based on habitat suitability and field access in ArcGIS/QGIS and Google Earth Pro (Barber-Meyer et al. 2013). Out of four sub-grid cells, two of the sub-grids were selected based on accessibility and habitat suitability for snow leopards and a pair of camera traps was placed in each of the selected sub-grids with spacing of ≥ 3 km apart after intensively searching for snow leopard activities (Jackson et al. 2005). Following the handbook prepared by Jackson et al. (2005) and from the experiences gathered during the implementation of camera trapping survey in Kangchenjunga Conservation Area (KCA) and in Bhijer block of SPNP in 2018, camera traps were systematically deployed in the study area. Cuddeback (C1) and Reconyx (HC550) automated cameras were used. Camera traps were placed in all potential snow leopard activity sites on systematic grids cells. A total of 62 out of 70 grids covering the entire snow leopard habitat in SPNP were surveyed (see figure 2). The cameras were programmed to take three pictures per trigger with no delay (FAP mode). Camera traps were monitored for battery power, available memory and functionality on a regular interval depending on site accessibility and logistic complexity. The total trap period was set for three months (Alexander et al. 2015). Primary data and associated covariates like grid and GPS positions, elevation and habitat type ruggedness were recorded. Necessary adaptations like selecting alternate sub-grid cells were made in the field to address practical challenges as encountered.

4.2.2. Double observer survey

The modified form double observer survey method were used for snow leopard prey base (primarily focusing on blue sheep) survey (Suryawanshi et al. 2012). First, each of the six habitat blocks were divided into small sub-blocks (named as sub watershed blocks - SWB) of 10 - 25 km^2 based on watershed characteristics so that entire visual coverage of the area was achieved- a critical assumption of double observer survey method (Figure 3). Due to the large extent of the park (3,555 km^2 and buffer zone of 1349 km^2), it was logistically very challenging to cover the entire area. Therefore, based on the discussions with snow leopard experts (national and international)), following 3 criteria was used to select the survey sites 1) sites that are deemed to be a prime hotspot, 2) accessibility to survey and monitor over the long run and, 3) ease of applying management actions. In doing so, firstly, these sub watershed blocks (n=218) were overlaid into snow leopard and prey distribution layers generated by MaxEnt modelling. For distribution models, data collected over the 8 years (camera traps, genetic, conventional prey counts and GPS collars) were used to predict the habitat suitability in SPNP. Based on the predicted distribution values, weighted scales of both prey and snow leopards, past conservation and monitoring efforts in the park, the sub watershed blocks >20% weights were selected (n=68).

Human used trails, valley bottoms and ridgelines of about 4-5 km were then mapped as potential survey routes in each sub-block with the help of topo map and Google earth. Potential start points based on the site accessibility and discussion with the local people were also mapped. Two groups of observers (each group two persons: one observer and one data recorder) separated by >30 min gap, aided with binoculars(8x42) conducted surveys along these routes. While conducting surveys, both group of observers recorded the group size, geographic location, time of the sighting, sex composition and age classes (Suryawanshi et al. 2012). Observers collected sufficient information so as to enable them to identify the common groups (recaptured) as well as unique groups sighted by both the groups of survey. This was imperative for applying capture-mark-recapture (CMR) technique to estmate the population size (Karanth and Nichols 1998). All three main assumptions of double observer surveys were met (Suryawanshi et al. 2012). Each survey took ~ 2 weeks to complete, each block had a team of 12 field staff divided into 3 groups who carried out survey in different sites within the survey block.

Figure 8. Field camera trap survey (left) and prey survey (right) conducted in SPNP.

4.3. Data analysis

4.3.1. Snow leopard population abundance and density

Camera trap survey is a well-established technique for density and abundance estimation of elusive carnivores (Alexander et al. 2015, 2016; Karanth and Nichols 1998). Recent development of spatial capture-recapture methods has led to greater clarity in abundance estimation by integrating spatial or "location" information of animal captures. This involves identification of snow leopards based on their unique pelage (spot) patterns, developing a capture history matrix detailing snow leopard ID, capture locations and sampling occasions over the sampling period (Jackson et al. 2005), and analysis of capture history data using spatial capture-recapture framework that uses maximum likelihood (Efford and Fewster 2012; Efford 2021) and/or Bayesian framework (Royle et al. 2009; Gopalaswamy et al. 2012). The data is also amenable to analysis in a non-spatial framework and can be used for conventional mark-recapture analysis (White and Burnham 1999).

Individual snow leopards were visually identified by field coordinators and wildlife biologists at three levels (i.e., 1 round- field coordinators, 2 & 3 rounds- wildlife biologists) by thoroughly examining all the images obtained (Johansson et al. 2020). Snow leopards were individually identified by comparing spot patterns on the forehead, forelimbs, flanks, and tails (Figure 9)

(Jackson et al. 2005). Each individual snow leopard was given a unique ID and each day (24 hr) was considered a unique sampling occasion (Alexander et al. 2015). The snow leopard images were also segregated based on sex (identification of genitals and presence of cubs); images that didn't allow detection of sex were classified as 'unknown'. Only animals that were classified as adults (>2 years) were included in the analysis (Jackson et al. 2005). Adult snow leopards were identified following recommendations of other snow leopard camera trap studies (Alexander et al. 2016; Rode et al. 2021) and other species like tiger (DNPWC & DFSC 2018) and common leopard (Kumbhojkar et al. 2020) based on solitary nature classified as adults and group capture classified as mother and cubs. Furthermore, adults were also identified based on body size, facial size and structure, pelage color and texture. Snow leopard images from different habitat blocks with connectivity were also compared and common snow leopards was identified, for analysis. Based on the population estimating model requirement (Efford and Fewster 2012; Gopalaswamy et al. 2012), all seasons (Autumn to Spring) were comparatively assessed based on number of recaptures, range, and number of individual snow leopards. Thus, the snow leopards detected in the study period (October 2019 to January 2020) were included in the analysis and other recaptures and individuals captured February onwards were not included.

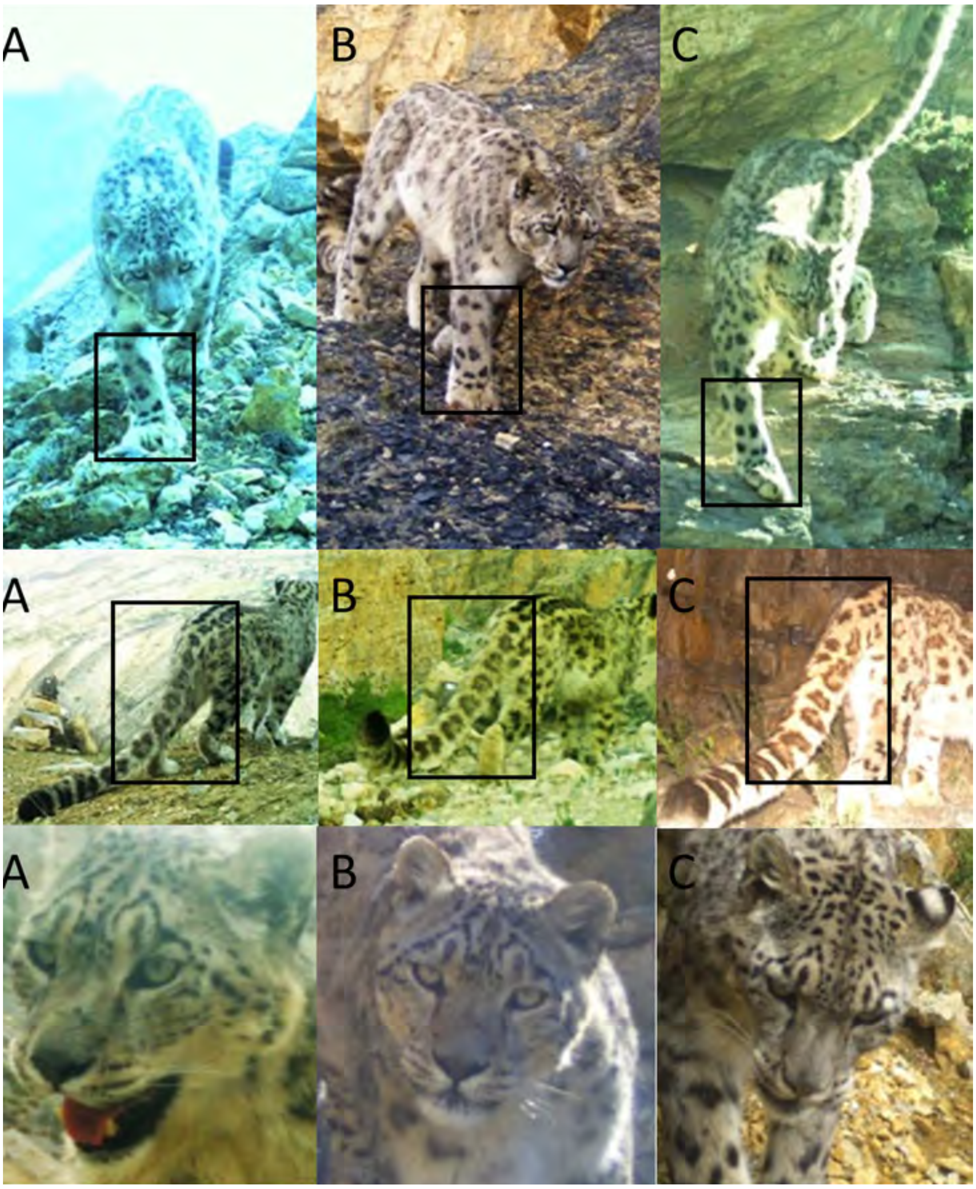

Figure 9. Individual snow leopard identification in SPNP- Dolpa: Individuals were identified based on the spot patterns of their fore limbs, tail, and forehead. Photo no. A and B are similar individuals and C is different.

Snow leopard population abundance estimates

Snow leopard abundance was estimated using Maximum Likelihood based spatially explicit capture-recapture (SECR) models (Borchers and Efford 2008). The spatial capture history matrix, trap layout matrix, habitat mask excluding non-habitat areas were prepared as input files. The data was analyzed using '*secr*' package (version 4.4.7, Efford 2021) in the R statistical environment (version 4.2, R Development Core Team 2022). Population closure test under '*secr*' was also conducted whether our sample population met the assumption of population closure during the survey period (Otis et al. 1978).

A range of standard models on detection probability (g0) and space range (sigma) were considered. The effects of time factor (t), time trend (T), animal's learned response (b), transient response (B), animal x site learned response (bk), animal x site transient response (Bk), and two-class mixtures (h2) were specified and modelled for both detection and distribution. All models were ranked based on Akaike's Information Criterion (AICc) and model-averaging was done with models having delta AICc<2 (weightage >95%) to determine population estimates. SECR models were fitted using the stable buffer size of 15 km. Preliminary analyses indicated that density estimates stabilized prior to 15 km buffer distance and that further increase in buffer width did not change the estimates (Alexander et al. 2015). Population estimates were exclusively derived for the effective trapping area or the ellipse that contained all the detectors (camera traps).

Snow leopard density estimates

SECR models under Bayesian framework using Markov-Chain Monte Carlo (MCMC) calculation process was used to estimate snow leopard density in SPACECAP (version 1.1.0) (Gopalaswamy et al. 2012) in R 3.4.0 (R Core Team, 2017). Three input files - "animal capture" file detailing trap location, animal ID and sampling occasion, "trap flag" file, and "habitat mask" were prepared. Trap flag was created and included in the model to specify active days of each camera trap station. This incorporated explicit accounts of dysfunctional cameras on account of theft, weather conditions like snow coverage or malfunction. Habitat mask was created for area that included camera trap array (MCP: minimum convex polygon) surrounded by a similar buffer size of 15 km (density stabilization point). Pixelated habitat mesh size of 1.96 km^2 was used (Alexander et al. 2015). Models with two different combinations - trap response - present and absent, with half normal and negative exponential detection function were used to fit the data.

MCMC simulations with 100,000 iterations, burn-in of 10,000, thinning rate of 1 and data augmentation value of 5 times the number of animals captured was set for running the site-specific analysis (Alexander et al. 2015). Geweke diagnostic scores (-1.64 to 1.64) were used to check the convergence of chains and data fit (Gopalaswamy et al. 2012). Pixelated map showing snow leopard density was produced in ArcGIS (Ver. 10.8). Output file contained posterior estimate on population density (number of snow leopards/sq km, which was later changed to numbers/100 sq km) including an estimate on sigma value and their corresponding standard deviation.

Snow leopard abundance was also estimated by multiplying the estimated density from Bayesian SECR models with the respective effective trapping areas (Srivathsa et al. 2015). Effective trapping area was calculated by adding a buffer of estimated sigma (σ) x sqrt (5.99) to the camera trap array (Thapa and Kelly 2017) excluding non-habitat areas.

4.3.2. Prey population abundance and trends

Data were compiled in Excel stacking both Observer 1 (O1) and Observer 2 (O2) together in line with the prey group similarities and dissimilarities. Compilation also involved transforming raw field data into a data analyzable format: painstaking scrutinization and correction of the data with respect to transects ID, group sizes and GPS locations.

Abundance

Spreadsheet of capture IDs were prepared for respective blocks and BBrecapture package in R studio (version 2023.6.0) were used for population estimation (Khanyari et al. 2019). It is a bayesian framework where the population estimate ($\hat{N}$) is generated by the product of randomly picked estimated number of groups ($\hat{G}$) and randomly picked estimate of mean group sizes (μ) from the posterior distributions (Khanyari et al. 2019). 10,000 iterations were conducted to get the $\hat{N}$. Observer with highest number of group size was considered in the final spreadsheet, similar was used for population age and sex structure analysis.

Although, utmost attempts were made to cover entire set of selected Sub Watershed Blocks (SWBs) (n=68) in all surveys, the effort has not been consistent over the period due to logistical and climatic constraints (for e.g. early snowfall in 2020 & 2021). Consequently, 55, 52 and 60 SWBs were surveyed in 2020, 2021 and 2022, respectively. For population estimation of respective years (2020-2022), all SWBs surveyed were considered and, for the annual trends SWBs that were surveyed in all three years were considered (n=46). Since one of the objectives was to come up with the prey base population estimate of the whole park, the most recent estimate of 2022 was considered as the total prey population for SPNP as 1) it is the most recent figure and 2) it has more sampled area - 60 SWBs. For population and density estimates, block wise estimates and whole park estimates were used with the area taken of total size of the SWBs surveyed.

Trends

For population trends, the overall prey data were sub sampled by selecting sub watershed blocks (SWBs) that were surveyed for all three years (Figure 11). Since blue sheep population are philopatric (designated to one particular area and in this study a sub watershed block was assumed) and considering the disproportionate number of sub watershed blocks covered in the last three years (Table 6), there may be groups missing to assess the trends over the three years. Furthermore, the population estimate through Bayesian framework provides estimate of missing groups for the surveyed area covered (SWB) and not the other areas missed, the data collected had to be truncated down to those sub watershed blocks where the survey was conducted for all three years. These blocks were also conservation priority areas which overlap with the community rangelands, yartsa pastures and high-density snow leopard areas (DNPWC 2023). Thus, these blocks (n= 46 and area= 1225.7 km^2) were selected to assess the trends. For annual trends comparison, population density was used.

A spatial distribution of prey population size was also generated through Kernel Density in ArcGIS to have an assumable understanding of the relatively high and low prey distribution.

5. RESULT

5.1. Snow leopard population abundance and density

5.1.1. Sampling effort and snow leopard captures

Two pairs of cameras were deployed in each of the 62 grid cells (8 km x 8 km) across SPNP, with a total effort amounting to 14,628 trap nights. A total of 2,703 snow leopard images – stills (2579) and videos (124) were recorded on 471 independent occasions, with an average snow leopard trap rate of 3.2 per 100 trap nights. Snow leopards were captured in two thirds of (66.1%) the grid cells (Table 1). However due to multiple season extension of survey effort until March 2020 and to align with the model requirement of population abundance and density estimation, total trap effort of 9,531 trap nights with 298 independent occasions of snow leopards were used. Total effective trapping area (ETA) was calculated as 8,562.8 km^2.

A total of 62 individual snow leopards were identified out of which 25 individuals (40%) were able to categorized to sex with 12 males and 13 females.

Table 1. Survey effort and number of snow leopards captured in SPNP.

Site	Surveyed camera trap grid cells (assigned %)	Number of grid cells with snow leopard captures (%)	Sampling effort	Sampling area (km2)	Snow leopard photos	Independent detections	Minimum individual snow leopards (Mt+1)
SPNP	62 (89%)	41 (66%)	9,531 days	3,968	2,703	298	62

5.1.2. Snow leopard population abundance estimates

The population closure test supported the assumption that the population was closed during the survey period (z = -1.44, P = 0.08). The estimated abundance of snow leopards in SPNP is 90 (SE 2.8) (Table 2). The details of the model used, and the real parameters are provided in Annex-1.

Table 2. Snow leopard population estimates in Shey - Phoksundo National Park, 2022.

M_{t+1}	Model	Detection Function	RN	SE	95% Confidence interval
62	g0~h2 sigma~h2	EX	90	8	78-109

M_{t+1}: Minimum individuals; RN: Realized Number which refers to the number of snow leopards detected (N) plus a model-based estimate of snow leopards in the study area of interest that remain undetected; g0: detection probability; Sigma: space range; h2: two-class mixtures; EX: Negative exponential.

Table 3. Summary of Spatially Explicit Capture Recapture (SECR) models for population estimation of SPNP. Only the top models are presented.										
S.N.	**Model**	**DETECTION FUNCTION**	**PAR**	**LOGLIK**	**AIC**	**AICc**	**dAICc**	**AICcWT**	**g0**	**Sigma**
1	g0~h2 sigma~h2	Exponential	5	-569.267	1148.5	1149.6	0	1	0.08	2361.75
2	g0~h2 sigma~1	Exponential	4	-582.7	1173.4	1174.1	24.5	0		
g0: detection probability, Sigma: space range, T: time trend, B: transient response, bk: animal x site learned response, and h2: two-class mixtures.										

5.1.3. Snow leopard density estimates

Using the Bayesian-SECR, the mean posterior density of snow leopards per 100 km^2 was estimated at 2.2 (SD 0.22) (Table 4). The Bayesian P-values of both our models ranged from 0.92 to 0.96. The Geweke test for the half-normal model generated all model parameters converging with z scores, that fell between 1.64 and -1.64 (sigma = 0.62; lam0 = -1.41; psi = -0.49; N = -0.45). The Geweke test results for the negative exponential model, however, indicated lack of convergence for two parameters (sigma = -2.05; lam0 = 2.49; psi = -1.4; N = 1.14). Therefore, the half-normal model was selected for density output. The pixelated snow leopard density map produced by combining site-wise pixel values generated by program SPACECAP is provided in Figure 10. Summaries of real parameters for each of the models are provided in Table 5.

Table 4: Snow leopard density estimates of Shey- Phoksundo National Park		
Mean	**SD**	**95% CI**
2.21	0.22	1.76- 2.62
SD: Standard Deviation.		

Table 5. Bayesian spatially explicit capture-recapture (SECR) analysis summary outputs from program SPACECAP. Density is presented as per 100 km^2

S.N.	DETECTION FUNCTION	PARAM	POSTERIOR MEAN	POSTERIOR SD	95% LOWER HPD LEVEL	95% UPPER HPD LEVEL	BAYESIAN VALUE	GEWEKE DIAGNOSTIC SCORE
1	Half normal	σ	3896.10	205.76	3508.04	4318.67	0.96	-0.54
		λ0	0.01	0.00	0.01	0.01		-0.23
		ψ	0.35	0.04	0.27	0.44		1.62
		N_{super}	130.65	13.14	104	155		1.53
		P	0.05	0.001	0.04	0.06		
		D	2.21	0.22	1.76	2.62		
2	Negative exponential	σ	4977.93	194.65	4614.75	5360.79	0.92	-2.05
		λ0	0.03	0.01	0.02	0.04		-2.49
		ψ	0.35	0.04	0.27	0.43		-1.4
		N_{super}	128.91	12.90	103	153		-1.14
		P	0.02	0.00	0.02	0.03		
		D	0.03	0.01	0.02	0.04		

PARAM: parameters; PA: Protected Area; σ: Range parameter; λ0: Expected encounter rate; ψ: Ratio of number of animals actually present within given space to the maximum allowable number; Nsuper: Population size for prescribed state-space; P: Encounter probability: D: Density

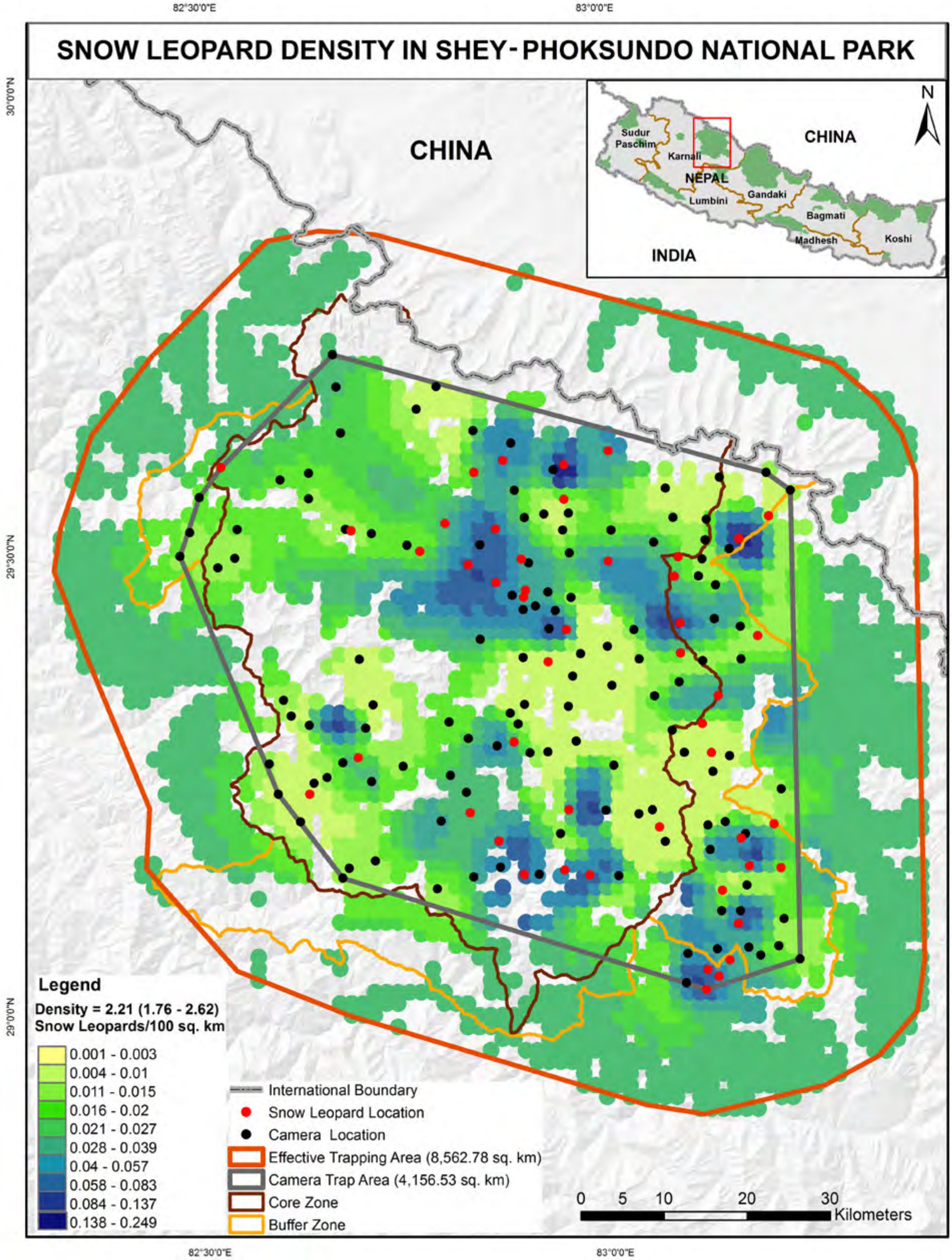

Figure 10. Snow leopard density within Shey - Phoksundo National Park. The density map is composed of pixels (1.9 km^2) representing potential activity centers of individual snow leopards.

5.2. Prey population abundance and trends

5.2.1. Population Abundance

Overall population size of blue sheep in SPNP was estimated at 6167.1 (5542.4- 6823.8) in year 2022. Year wise estimates are also provided in table 6 with varying proportion of the total no. of sub watershed blocks covered and the total area surveyed. 98% of the sample groups in 2022, were blue sheep and the rest 2% were Himalayan tahr and Himalayan goral.

5.2.2. Population Trends

Trend analysis using BBrecapture showed a positive linear trend in terms of both abundance and density. A significant difference was observed between abundance and density estimates of 2020, 2021 with 2022 (P value: <0.05). Block wise trends are presented in Annex 2. Due to the low sample size and inconsistent survey in the different SWBs, Jagdulla block was not included in the analysis.

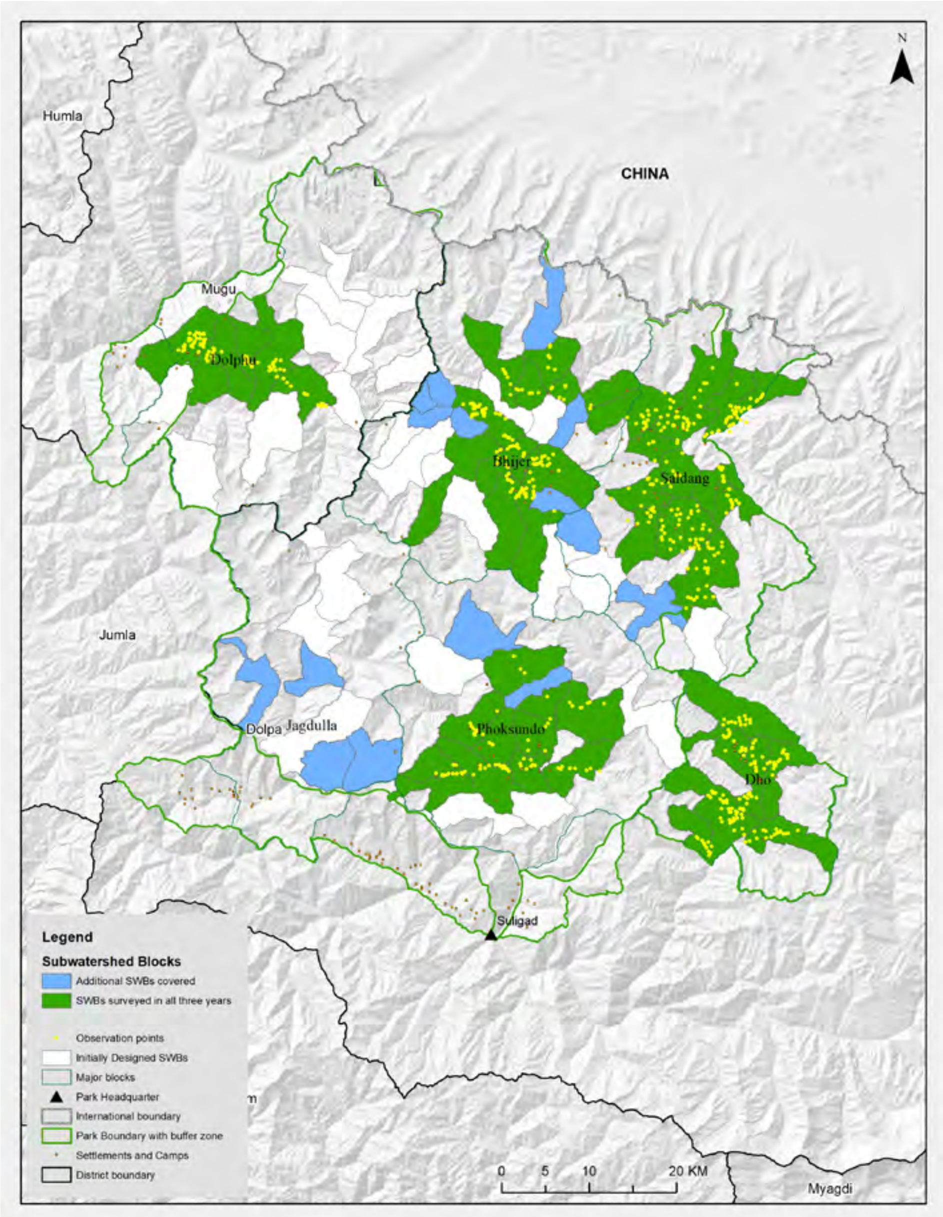

Figure 11. Survey layout of Double observer count survey conducted in all three years (2020, 2021 & 2022),

- Green polygons: SWBs surveyed in all three years.
- Blue polygons: SWBs surveyed in one of three years.
- White polygons: SWBs identified in the initial design.
- Yellow points: Observation points for the survey.

Table 6. Population estimation of snow leopard's prey in SPNP (2020-2022) with no. of Sub Watershed Blocks (SWB) and area covered; block wise estimation is also provided.

BLOCK	FALL 2020					FALL 2021					FALL 2022				
	NHAT (LL-UL)	P1	P2	SWB	AREA	NHAT (LL-UL)	P1	P2	SWB	AREA	NHAT (LL-UL)	P1	P2	SWB	AREA
BHIJER	2225.8 (1890-2585.1)	0.8	0.8	55	1372	1056.1 (870-1240.8)	0.9	0.8	52	1357.4	1765.3 (1449-2122)	0.9	0.9	61	1503.6
DHO	1574.9 (1293-1884)	0.9	0.9			1144 (889-1424)	0.98	0.98			1430 (1061-1844)	0.9	0.8		
DOLPHU	763.2 (555.8-1043.3)	0.8	0.7			726.1 (608.4-859.1)	0.8	0.8			1079.5 (721.9-1752)	0.5	0.4		
JAGDULLA	465.7 (321.1-737.3)	0.6	0.6			1077 (351-3803.9)	0.4	0.3			251 (157-358.1)	0.8	0.9		
PHOKSUNDO	1067 (891-1279.7)	0.9	0.9			742.5 (576.6-943.6)	0.8	0.8			676.3 (512.6-853.5)	0.9	0.8		
SALDANG	1715.8 (1466-1987)	0.96	0.9			1107 (899-1326)	0.95	0.95			1272 (1080-1494)	0.96	0.9		
SPNP (Total)	7694.8 (7070.3- 8349)	0.9	0.8			5107.323 (4620.3-5615.3)	0.9	0.9			6167.1 (5542.4-6823.8)	0.9	0.9		

* Nhat: Population estimated value, LL- Lower limit, UL- Upper limit, P1- detection probability of observer 1, P2- detection probability of observer 2, SWB- Sub watershed block no

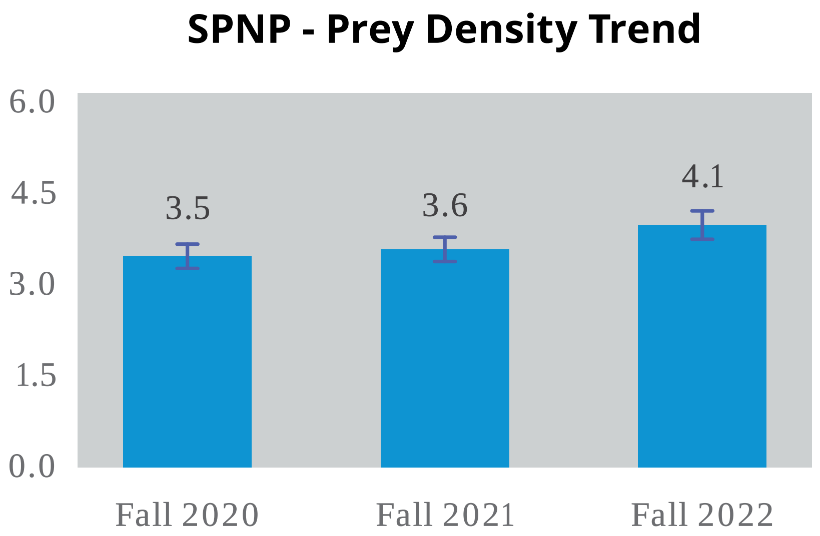

Figure 12. Prey population trend of SPNP in the last three years Fall 2020- 2022. Density values are in per km^2.

Kernel density (KD) prediction based on the size of prey population groups accounting the observer's location from where the count was conducted do not provide the exact spatial density of the prey, but it does provide the proximal prey density for sub watershed blocks. Therefore, it provided an idea of sites with relative population numbers. Based on the three-year data, the spatial kernel density didn't vary significantly (P>0.05) and was highest in more or less similar sites of all five blocks.

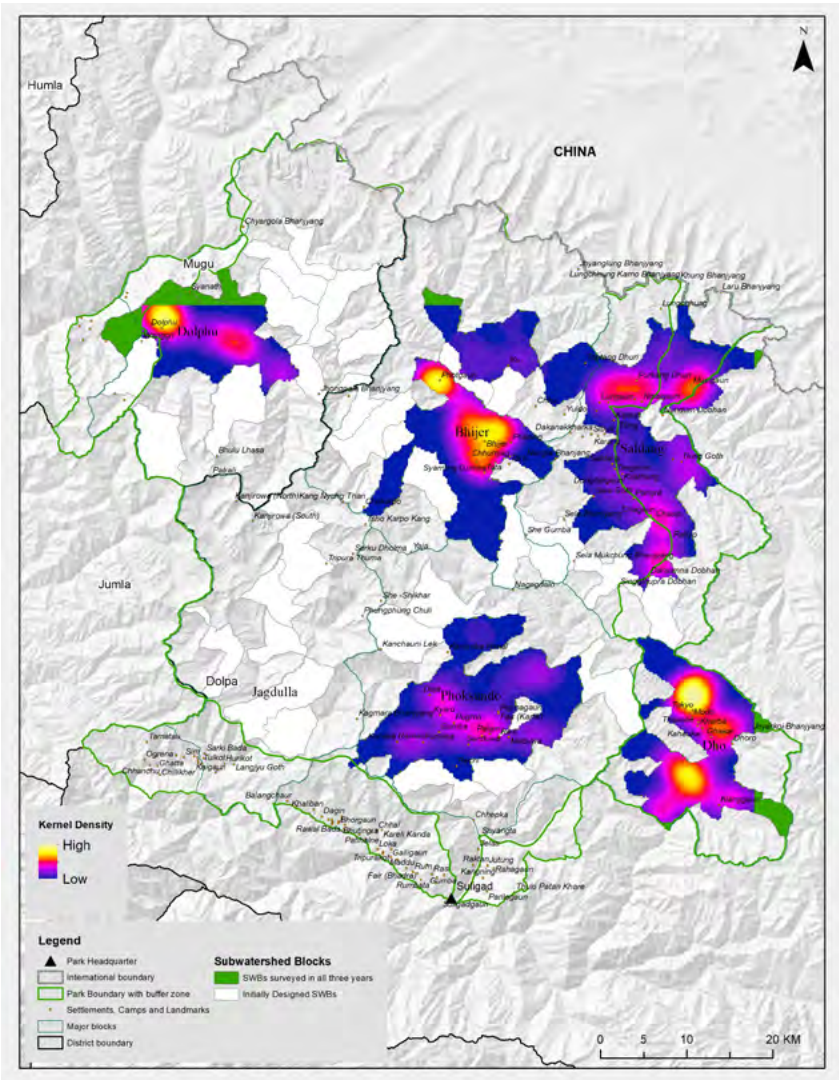

Figure 13. Kernel density distribution of prey population groups counted in SWBs for all consecutive 3 years combined.

6. DISCUSSION

6.1. Snow leopard population abundance and density

6.1.1. Methods used, and the Extent of Areas covered

SECR-ML and SECR-B are commonly used techniques in deriving population and density estimates (Gopalaswamy et al. 2012; Alexander et al. 2016). In the present survey, snow leopard population estimate was derived using SECR-ML while density estimate was derived using SECR-B (Table 8).

SECR-ML gave relatively lower abundance estimates compared to SECR-B and the opposite is true in the case of density estimates. Therefore, in order to provide a conservative estimates, abundance and density estimates have been reported using SECR-ML and SECR-B, respectively.

Table 8: Comparison of Population abundance and density estimates using SECR-ML and SECR-B

Site	**SECR-ML**				**SECR-B**			
	Estimate	SE	95% CI	CV (in %)	Estimate	SE	95% CI	CV (in %)
Abundance	90	8	78-109	8.9	106	11	85-126	10.1
Density	2.4	0.3	1.8-3.2	12.5	2.2	0.2	1.8	9.1

CV: Coefficient of Variation, Mt+1: Minimum individual identified, SE: Standard error of Mean, SECR: Spatially Explicit Capture Recapture, ML: Maximum Likelihood, B: Bayesian. Final parameter values used for inference are highlighted in bold.

The survey extensively covered potential snow leopard habitat of SPNP. The sampling effort in this survey was maximized by covering most of the known records of snow leopard distribution based on findings of earlier snow leopard surveys and distribution modelling of 2018 and satellite collared data. Snow leopard captures were recorded in 66% (41) of the 62 grids. Although 12% of the assigned grids were not covered during the survey, only 3% of grids having more than a quarter of snow leopard habitat were omitted due to site inaccessibility. Total camera trap array covered the adequate locations required for population estimates of the park.

6.1.2. Snow leopard abundance and density estimates

Status of snow leopards in SPNP was estimated at 90 individuals (SE ± 8) and density of 2.2 individuals/100 km^2. This varies from earlier estimate for SPNP of around 5-10 individuals/100 km^2 (Jackson and Ahlborn, 1989). However it was based on an assessment in a section of Dolphu block in Langu valley, eastern Mugum Karmarong rural municipality of Mugu district, which is ~7% of current study area. Our block-wise interpretation of snow leopard density may also indicate similar population density for this block - Dolphu (M_{t+1} = 5; Annex 1). Higher density pockets were indicated in upper dolpa regions of Bhijer and Saldang blocks.

This is the first-ever comprehensive snow leopard population covering nearly all potential habitats within SPNP by camera traps. Furthermore, the study has provided a baseline number of snow leopards in one of the high-density areas of Nepal. Not surprisingly, our results show the highest number of snow leopards in SPNP among the protected area of Nepal. This further signifies the importance of the national park as one of the potential source sites for natural dispersal of snow leopards in the western landscape and beyond.

Snow leopard density in the park indicates a higher density in the trans Himalayan undulating rain shadow terrains of upper Dolpo region (Bhijer, Saldang and Dho) compared to the alpine windward terrains of lower Dolpo (Dolphu, Jagdulla and Phoksundo). The former can be attributed to higher prey density and diversity (SPNP 2020), with favorable terrains harboring both alpine steppe and cliff-dwelling prey species such as blue sheep, marmots and woolly hares supplemented by high livestock density. Only one individual snow leopard was found to be common among the blocks between Phoksundo and Dho, which could indicate limited movement between the blocks which are separated by high mountain ranges between 5000-5500 meters (Annex 1). It could be due to survey period coinciding with snow season with occasional heavy snowfall potentially limiting snow leopard movement in high passes during the period (also observed in collared snow leopards). Thus, a long-term corss-seasonal monitoring is warranted to obtain further insights into this.

Density of top carnivores like snow leopards are primarily dependent on prey availability (Karanth et al. 2004), prevention/reduction of human conflict and safe habitat for breeding. Snow leopard conservation measures in Nepal focusing on appropriate protection measures, managing human-snow leopard interactions and integrated habitat management for increasing prey densities, habitat connectivity across the country will directly contribute to increasing the snow leopard density and abundance.

6.2. Prey population abundance and trends

Prey population abundance of SPNP in the last three years depicts potentially adequate prey base for the current snow leopard population. Data from satellite collared snow leopards (n=2) based on kill site verifications of prey (n=38) revealed a snow leopard requires an average of 36 major prey kills in a year (DNPWC 2022). 46% of the kills were blue sheep and the rest were goats (42%), mules (3%), yaks (3%), dzos (3%) and horses (3%). These major prey kills do not account for the small sized prey such as marmots, hares and pika which are occasional prey in their food habits. Other studies estimated a snow leopard requires 20-30 blue sheep in year (GSLEP 2013). With a naïve calculation our estimate of 90 snow leopards with 109 upper limits in 2019-2020 survey may require a total of 3240 prey with upper limit of 3924 prey numbers. Our prey survey estimates were 6167.1 in autumn season of 2022; this indicates that SPNP has enough staple food for snow leopards and may have enough provision for co-predators like grey wolf and Eurasian lynx as well. The calculations here are naïve and are only focused on general understanding of prey requirements for the park.

With regards to population growth over the three years, it appears to be stable in all the five blocks considered for this assessment (Figure 12). Many studies in mountain ungulates and other prey types covering the survey period as long as 15 years have shown an integral role of predator-prey dynamics in depicting prey population status that often resulting into cyclic period of time (Zang et al. 2012; Borg and Schirokauer 2022; Begon et al. 1996; MacLuluch 1937). Since our study was conducted for only three years and baseline snow leopard density estimate conducted in fall of 2019, it is difficult to assess the relationship between predator and prey interactions. However, the trend indicates no significant fall of prey population and is in a positively stable trend. Without the availability of multiyear data over a long period of time, it is challenging to arrive at any conclusion with regards to their population dynamics. Therefore, a long term study is recommended to properly assess the population trends.

6.3. Management implications

The 2019 camera trap survey for population estimation of snow leopards was the first intensive research carried out to obtain a science-based knowledge on the population status of the species in SPNP. The survey itself has provided several key information, including the population estimates, high-density pockets, etc. to help guide conservation and management of the Park in the days ahead.

While a single study may not capture the detailed complexities of species population dynamics, this provides key strategic guidance for improving conservation and management for long-term well-being of both people and nature. When contextualized with additional information generated from other assessments, research, observations, efforts, and experiences documented over time, this information provides valuable guidance for management. Accordingly, the management implications and recommended actions (below) reported here not only reflect the findings of this study but incorporate other available information, including ongoing conservation efforts, for greater practical value.

6.3.1. Baseline for conservation and management planning – snow leopard high-density sites, prey base abundance and trends

This study provides a baseline for high snow leopard density areas within and near SPNP during winter seasons. While the overall average density for SPNP and surrounding areas was found to be around 2.21/100 sq km, there were several high-density pockets identified. These high-density pockets appear to be scattered within the core and buffer areas of SPNP; some even falling outside of SPNP. This presents an opportunity to collaborate with stakeholders including local governments and division forest office, forest authorities outside protected areas, for joint efforts towards conservation management and sustainable development.

Similarly the result obtained through prey base kernel density is especially helpful as it maps out the sites with higher spatial densities where management interventions could be intensified (Figure 13). These sites also correlate with the 2019 snow leopard survey where higher prey kernels correlated with higher snow leopard pixel densities (Figure 10). Some of the identified high density areas are as follows; Bhijer block: Bhijer, Tata, Phalang and Shyamlin Gumba; Saldang block: Luri, Nisal, Musi, Rakyo, Rapa, Komas, Pongra, Kirathang, Tangkhor and Saldang; Dho block: Tokyo, Thakse, Ghakar, Kalang; Phoksundo: Palam, Pungmo, Kunasa, Punikha, Sumduwa and Chholoppu; Dolphu block: Dolphu and towards eastern sites. In general upper Dolpa and Dolphu have relatively higher prey density compared to Phoksundo block probably due to more favourable grazing pastures and low coverage of rugged terrains. The figures also reflect well with snow leopard density relatively higher in upper Dolpa like Bhijer, Saldang and Dho. Sites like these should be considered as park hotspots which are to be periodically monitored, embedded in rangeland management strategies, and avoid/mitigate human development projects like linear and urban infrastructures.

6.3.2. Scope for future research

The analysis done and reported here meets the prime objective of identifying the status of the snow leopard population and high-density areas in SPNP. As such it also paves a way for more in-depth studies to glean a more comprehensive insights into the ecology and conservation of snow leopards and their ecosystem. For example, additional analysis of density and habitat use with specific to blocks, core and buffer zones complemented by added covariates of prey and environmental data would further enhance our understandings on snow leopard ecology and aid in applying systematic management interventions.

Moreover, this may also help guide further regular strategic low-resource intensive monitoring of wildlife to evaluate efficacy of interventions and to guide necessary adaptations and additional actions. Likewise, all four GPS collared snow leopards during the survey period (2019 and 2021) which had been camera trapped in this survey have died. This implicates potentially high turn-over rate within this population, which can only be better understood through regular monitoring. Periodic monitoring of snow leopard population, along the lines of tiger monitoring, would provide additional information on their population dynamics. Thoughts also must be given to ensure continuity of such long-term research, by leveraging government funds, within the management plans of relevant government authorities.

As in other parts of Nepal, infrastructure (specifically linear) development is moving at a rapid pace in Dolpa, including creation of a North-South linkage along the eastern part of SPNP. High-density pockets identified overlap with the road towards the south of Dho village as well as towards the north of Taksi village. These roads are not yet fully operational, with connectivity to lower Nepal yet to be constructed. Systematic and low-cost monitoring of wildlife in these critical sections within the constructed sections, overlapping high-density sites, would provide a baseline and help better understand impacts to aid mitigation measures in the future.

6.3.3. Strengthening Conflict Management

High number of snow leopards alongside the high dependence of communities on livestock for livelihood, indicates possibility of heightened human-wildlife conflicts in SPNP. Increasing trend in human-snow leopard conflicts have also been reported in previous assessments, including a 2018 baseline assessment that found 96% of herders (N=124) reporting conflict-related livestock losses. High proportion of livestock in the snow leopard diet (>40%) within the landscape, also reflects the severity of human-wildlife conflicts within this region. Conflict management, therefore, becomes a key priority to ensure coexistence.

DNPWC/SPNP-WWF partnership has been supporting to implement holistic conflict management strategies in close coordination with local conservation leaders (citizen scientists and BZ-SLCC members). Strengthening the local leaders, DNPWC/SPNP-WWF have supported conflict prevention through awareness and improving livestock corral conditions to reduce surplus killing by snow leopards and other predators. Likewise, DNPWC/SPNP-WWF has also been working with SPNP communities to facilitate relief against losses due to conflict. Through Wildlife Damage Relief Guideline 2069, a sum of 1,94,98,000/- has been supported to the conflict victims caused by snow leopard and wolf in the last five years (2017-2022) in SPNP. 2,413 livestock were depredated by snow leopards contributing 80% of the livestock kills. A significant progress has been made with the claims escalating from NPR 91,000/- in 2016 to NPR 1,14,05,500 in 2022.

The engagement of community conservation leaders, even during winters (high conflict events), ensured the availability of immediate support to households facing conflict losses. Such support may reduce the risks of livestock herders resorting to retaliatory measures. These efforts have yielded promising results; these must be further strengthened and scaled-up, for sustainability, and improved conflict management benefiting both local households and snow leopards.

6.3.4. Strengthening wildlife crime control

Majority of wildlife crime involving snow leopards in Nepal indicate towards conflicts as a source for illegal trade. Direct poaching of snow leopards for trade, while believed to be in low numbers, is not implausible; accordingly, this study provides strategic guidance for wildlife crime control, by identification of high-density pockets that need to be protected.

Some high-density pockets identified by this study lie in remote regions, and beyond easy access of outsiders, reducing risks of poaching. Yet, there are some key sites in more accessible regions in and around SPNP such as the vicinity of Phoksundo lake. Risks of poaching have been previously identified, for instance, in areas surrounding Phoksundo Lake. Camera trap photos (separate study) have shown accidental snaring (from snares purportedly kept for prey) of snow leopard from this area, during the winter when the locals and park staff seasonally vacatethe Rigmo village due to cold conditions. However, efforts are ongoing to improve conditions (including supporting solar power plant by DNPWC/SPNP-WWF) to ensure the year round stay in Rigmo. This might also provide opportunities for improved wildlife crime control, engaging enforcement agencies and local communities (as Community-based Anti-Poaching Units).

Other high-density sites identified by this study lie outside of the protected area long the eastern buffer zone belt of SPNP and areas falling outside south eastern boundary of SPNP, where road construction is currently ongoing thereby increasing the risk of wildlife crime. Parts of these high-density areas fall beyond the mandate of SPNP, and therefore also needs coordination with other relevant agencies. Strengthening coordination between various stakeholders and agencies through the Wildlife Crime Control Bureau (WCCB) would benefit conservation over long-term.

Traditionally, presence of community, who largely practice Buddhism and follow non-violence, is known to have played a deterring role against external poachers. Working closely with community leaders, and special engagement of faith leaders, will also aid in protecting all high-density snow leopard sites.

6.3.5. Managing yartsa gunbu (caterpillar fungus) collection

SPNP is also known to harbor high quality yartsa gunbu (*Ophiocordyceps sp*) , providing seasonal earning opportunities for not just residents but also outsiders. The 2018 baseline assessment within Bhijer region, conducted during spring-early summer (yartsa collection season) provided evidence to potential disturbances to snow leopards from collection activities, with activity centers placed away from yartsa collection sites, indicating avoidance by snow leopards (SPNP 2018). Long-term impacts of repeated pressures on hotspots may impact snow leopard population by affecting rangeland quality and thereby ability of these rangelands to support prey populations. Yet, it should be evident from these studies and by virtue of snow leopard's shy nature that such disturbances must not go unchecked. Moreover, the impacts on these rangelands also affect community livelihood due to reduced productivity of yartsa as well as grazing lands for livestock.

Systematic rangeland management therefore is not only important for conservation but also for community well being. Nepal Government's Rangeland Policy provides an opportunity to co-design strategies and co-manage these rangelands with communities, incorporating their traditional ecological knowledge of their locality. The co-management plans can also include systematic, low-resource, long-term studies engaging local citizen scientists.

6.3.6. Communicating findings for improved understanding of the species, and to facilitate coordination among stakeholders

Snow leopard is among the least studied of the world's big cats. Findings of such research (along with its limitations) must therefore be made available to conservation practitioners spanning from local to global to aid conservation planning.

For global acceptance and acknowledgment, efforts must be made to publish the findings in peer-reviewed journals and promote improved understanding of the species' status across its global home range. Such information then can be used for informed policy formulations or adaptations for conservation of the species at global, regional, or local scale, and provide grounds for more in-depth research in the future. Additionally, general, and strategically tailored communications in popular media and direct information sharing with relevant local stakeholders must also be done.

6.3.7. Strengthening community-based conservation

Local communities, with their traditional beliefs and values promoting non-violence and sustainable existence, have laid the early and strong foundations for conservation stewardship. Strengthening this stewardship, therefore, provides the logical way forward for long-term conservation. Practically too, for SPNP, local communities are key allies for conservation.

SPNP, despite being the largest National Park of Nepal, has only about 67 deputed staff. Engaging communities in designing and implementing research not only provides additional human resources but is critical for long-term conservation. Accordingly, working with local communities as citizen scientists and local conservation leaders, DNPWC/SPNP-WWF partnership has been able to improve conservation management across the PA. Even for this study, successful implementation relied on the support of 100+ local citizen scientists. Such efforts have proven to have additional benefit of providing a stepping-stone for community conservation leadership. Improved coordination with community through local conservation leaders, citizen scientists, faith leaders, among others, will aid in addressing diverse direct and indirect threats to the snow leopards and nature. Capacitating the community leaders further, providing support to relieve pressures and improve livelihood opportunities for local community, aid in improving local conservation stewardship and thereby additional ground support for SPNP.

6.3.8. Incentivizing conservation through improved community livelihood

In addition to the pride and ownership of the species from cultural perspectives, it is crucial that local communities perceive tangible positive returns from conservation. Direct or indirect economic incentives will further solidify and sustain conservation engagement of local communities.

Local communities in SPNP are highly dependent on livestock even today. Improving or securing community livelihood must therefore focus on reducing negative snow leopard-people interactions through holistic conflict management interventions (detailed below in segment # 5). With changing development circumstances, there are opportunities to explore livelihood diversification for local communities. Over the past few decades, yartsa gunbu (*Ophiocordyceps*) trade and nature-based tourism (direct and indirect benefits to local households), are identified among the key drivers of socio-economic changes. Such options have direct implications on nature and must be managed in a way ensuring minimal negative impacts.

DNPWC/SPNP-WWF have been supporting livelihood improvement activities for local communities in the buffer zone of SPNP, including strengthening community capacity to tap into nature-based tourism potential of SPNP for example, strengthening local tourism committee, facilitating trainings as nature and trekking guides, etc, that address immediate needs of the community (for instance livestock veterinary technician, solar repair and maintenance, cultural integrity preservation), with potential to expand markets beyond the region in the future. Within high density pockets, there may be opportunity to promote snow leopard tourism, led by local communities in partnership with the DNPWC/SPNP and ensuring compliance with the national legislations.

Livelihood diversification efforts must be done with a wider vision incorporating trends in climate as well as socio-economic environment, to minimize risks and maximize benefits to both people and nature. Enhancing community earning from conservation efforts will help strengthen the stewardship ensuring improved long-term survival prospects for the species.

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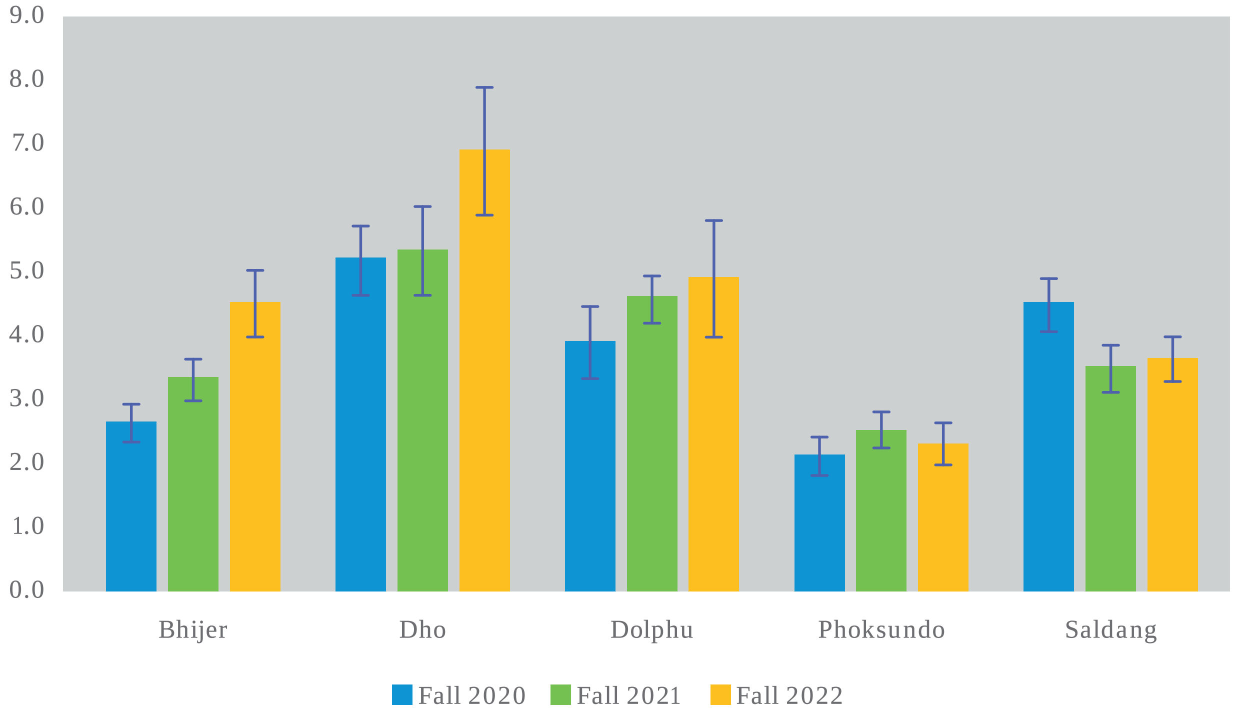
Annex 1. Number of grid cells surveyed and number of grid cells with snow leopard captures in each site.

BLOCK	Number of surveyed camera trap grid cells (assigned %)	Number of grid cells with snow leopard captures (%)	Survey effort (trap nights)	Sampling area (km^2)	Number of snow leopard photos	Number of independent detections	Number of individual snow leopards captured (M_{t+1})
Bhijer	13 (100%)	12 (92%)	2,405	832	844	103	19
Dho	6 (100%)	6 (100%)	1,216	384	427	59	11 (1*)
Dolphu	12 (80%)	3 (25%)	799	768	94	5	5
Jagdulla	9 (82%)	3 (33%)	825	576	69	12	2
Phoksundo	12 (92%)	7 (58%)	1,591	768	705	46	11 (1*)
Saldang	10 (83%)	10 (100%)	2,695	640	440	73	14
SPNP	62 (89%)	41 (66%)	9,531	3,968	2,579	298	62

* One individual in Dho and Phoksundo were common

Annex 2. Snow leopard prey population trends: density in five different blocks of SPNP.



Annex 3. Ground personnel (frontline park staff, field coordinators and citizen scientists/SLCC members) involved in the surveys.

SN.	Name	Qualification & Experience	Proposed deployment	Remarks
1	Naresh Kusi	M. Sc. in Zoology	Dolphu	Coordinator
2	Tashi Tobgyal Tamang	B. Sc. Forestry	Dolphu.	Coordinator
3	Bijay Bashyal	Master's in Environmental Science	Dolphu	Coordinator
4	Purnaman Shrestha	Post-graduate Diploma in Wildlife Conservation	Jagdulla	Coordinator
5	Sandesh Lamichhane	Master's in Wildlife Conservation & PA Management	Jagdulla	Coordinator/ Data compiler
6	Amrit Subedi	B. Sc. Environmental management	Jagdulla	Coordinator
7	Bhumi Prakash Chaudhary Tharu	Master's in wildlife Conservation & PA Management	Bhijer	Coordinator/ Data compiler
8	Temba Lhundup Gurung	B. Sc. Forestry	Saldang	Coordinator/ Data compiler
9	Bibek Raj Shrestha	Master's in applied Ecology	Saldang	Coordinator
10	Kabindra Shahi	B.Sc. Forestry	Jagdulla	Coordinator
11	Prasun Ghimire	B.Sc. Forestry	Phoksundo	Coordinator
12	Deepa Pun	Master's in Zoology	Phoksundo	Coordinator
13	Yankee Lama	B. Sc. Forestry	Phoksundo	Coordinator
14	Tashi Tsomo	B. Sc. Forestry	Kathmandu	Data compiler
15	Dil Bahadur Buda	Senior Game scout	Dolphu	SPNP
16	Karma Tamang	Game scout	Dolphu	SPNP
17	Sonam Lama	Game scout	Dolphu	SPNP
18	Mim JC Gharti	Game scout	Dolphu	SPNP
19	Tenzin Dorje Tamang	Citizen Scientist	Dolphu	SLCC Dolphu
20	Sonam Sangmo Lama	Citizen Scientist	Dolphu	SLCC Dolphu
21	Karma Yondan Lama	Citizen Scientist	Dolphu	SLCC Dolphu
22	Pema Lama	Citizen Scientist	Dolphu	SLCC Dolphu
23	Chhoisang Tamang	Citizen Scientist	Dolphu	SLCC Dolphu
24	Dawa Kami	Citizen Scientist	Dolphu	SLCC Dolphu
25	Angyal Lama	Citizen Scientist	Dolphu	SLCC Dolphu
26	Saangmo Lama	Citizen Scientist	Dolphu	SLCC Dolphu
27	Pema Norbu Lama	Citizen Scientist	Dolphu	SLCC Dolphu
28	Pema Chhoibel Lama	Citizen Scientist	Dolphu	SLCC Dolphu
29	Paljor Chhiring Lama	Citizen Scientist	Dolphu	SLCC Dolphu
30	Nima Chhiring Lama	Citizen Scientist	Dolphu	SLCC Dolphu
31	Urgen Lama	Citizen Scientist	Dolphu	SLCC Dolphu
32	Pema Hojer Lama	Citizen Scientist	Dolphu	SLCC Dolphu
33	Sange Lama	Citizen Scientist	Dolphu	SLCC Dolphu
34	Hari Krishna Bhandari	Senior Game scout	Jagdulla	SPNP
35	Suraj Nepali	Game scout	Jagdulla	SPNP
36	Susil Bista	Game scout	Jagdulla	SPNP
37	Rigjin Baiji	Game scout	Jagdulla	SPNP
38	Suresh Ghatri Magar	Citizen Scientist	Jagdulla	RPCC Jagdulla
39	Ganesh Lama	Citizen Scientist	Jagdulla	RPCC Jagdulla
40	Gyanendra Lama	Citizen Scientist	Jagdulla	RPCC Jagdulla
41	Birat Buda	Citizen Scientist	Jagdulla	RPCC Jagdulla
42	Raju Buda	Citizen Scientist	Jagdulla	RPCC Jagdulla
43	Arjun Neuapane	Citizen Scientist	Jagdulla	RPCC Jagdulla
44	Rajendra Thapa	Citizen Scientist	Jagdulla	RPCC Jagdulla
45	Mayalam Rokaya	Citizen Scientist	Jagdulla	RPCC Jagdulla
46	Sunil Rokaya	Citizen Scientist	Jagdulla	RPCC Jagdulla

47	Surya Bahadur Buda	Citizen Scientist	Jagdulla	RPCC Jagdulla
48	Sandeep Baijee	Citizen Scientist	Jagdulla	RPCC Jagdulla
49	Jagat Rokaya	Citizen Scientist	Jagdulla	RPCC Jagdulla
50	Basanta Hamal	Senior Game scout	Phoksundo	SPNP
51	Dharmendra Malla	Game scout	Phoksundo	SPNP
52	Kunka Lama	Game scout	Phoksundo	SPNP
53	Choemel Lama	Game scout	Phoksundo	SPNP
54	Suslal Rokaya	Game scout	Phoksundo	SPNP
55	Ganga Hamal	Game scout	Phoksundo	SPNP
56	June Karki	Game scout	Phoksundo	SPNP
57	Aang Dawa Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
58	Sherap Yungdung Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
59	Rigzin Waangel Budha	Citizen Scientist	Phoksundo	SLCC Phoksundo
60	Chhewang Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
61	Yungdung Tejin Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
62	Thukten Chhiring Rokaya	Citizen Scientist	Phoksundo	SLCC Phoksundo
63	Nima Tejin Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
64	Om Prasad Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
65	Suk Bahadur Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
66	Samba Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
67	Sange Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
68	Chhuldim Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
69	Lanka Bahadur BudThapa	Citizen Scientist	Phoksundo	SLCC Phoksundo
70	Danta Rokaya	Citizen Scientist	Phoksundo	SLCC Phoksundo
71	Narendra Thapa	Citizen Scientist	Phoksundo	SLCC Phoksundo
72	Phurba Sangmo Baiji	Citizen Scientist	Phoksundo	SLCC Phoksundo
73	Lakpa Sangmo Baiji	Citizen Scientist	Phoksundo	SLCC Phoksundo
74	Chimme Baijee	Citizen Scientist	Phoksundo	SLCC Phoksundo
75	Chhewang Gyalbo Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
76	Chiring Tarbo Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
77	Serap Chuldim Rokaya	Citizen Scientist	Phoksundo	SLCC Phoksundo
78	Samten Nima Baije	Citizen Scientist	Phoksundo	SLCC Phoksundo
79	Puni Prasad Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
80	Bijaya Kumar Karki	Citizen Scientist	Phoksundo	SLCC Phoksundo
81	Dharmendra Karki	Citizen Scientist	Phoksundo	SLCC Phoksundo
82	Gimi Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
83	Puni Prasad Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
84	Bikas Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
85	Gyaljen Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
86	Dhuk Chewang Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
87	Tashi Tondup Lama	Citizen Scientist	Phoksundo	SLCC Phoksundo
88	Thukten Tshiring Rokaya	Citizen Scientist	Phoksundo	SLCC Phoksundo
89	Dhawa Gurung	Citizen Scientist	Phoksundo	SLCC Phoksundo
90	Ali Shahi	Game scout	Dho	SPNP
91	Ramcharan Chaudhary	Game scout	Dho	SPNP
92	Jaya Bahadur Matatara	Game scout	Dho	SPNP
93	Kailash Devkota	Game scout	Dho	SPNP
94	Tarkey Lama	Citizen Scientist	Dho	SLCC Dho
95	Lhakpa Tondup Lama	Citizen Scientist	Dho	SLCC Dho
96	Phurba Lama	Citizen Scientist	Dho	SLCC Dho

97	Tashi Gyurmey Lama	Citizen Scientist	Dho	SLCC Dho
98	Nyima Tsering Gurung	Citizen Scientist	Dho	SLCC Dho
99	Phunjo Budha	Citizen Scientist	Dho	SLCC Dho
100	Phurba Lhundup Gurung	Citizen Scientist	Dho	SLCC Dho
101	Pemba Bhote	Citizen Scientist	Dho	SLCC Dho
102	Nyima Samdup Gurung	Citizen Scientist	Dho	SLCC Dho
103	Dhawa Gurung	Citizen Scientist	Dho	SLCC Dho
104	Dawa Tshering Bhote	Citizen Scientist	Dho	SLCC Dho
105	Phurba Bhote	Citizen Scientist	Dho	SLCC Dho
106	Tenzin Gurung	Citizen Scientist	Dho	SLCC Dho
107	Changyap Gurung	Citizen Scientist	Dho	SLCC Dho
108	Dhawa Tshiring Lama	Citizen Scientist	Dho	SLCC Dho
109	Dharke Lama	Citizen Scientist	Dho	SLCC Dho
110	Chiring Migmar Gurung	Citizen Scientist	Dho	SLCC Dho
111	Semduk Gurung	Citizen Scientist	Dho	SLCC Dho
112	Migmar Lama	Citizen Scientist	Dho	SLCC Dho
113	Chombel Gurung	Citizen Scientist	Dho	SLCC Dho
114	Tshiring Lama	Citizen Scientist	Dho	SLCC Dho
115	Gor Bahadur Gurung	Game scout	Saldang	SPNP
116	Chandra Ghartimagar	Game scout	Saldang	SPNP
117	Raj Kumar Rokamagar	Game scout	Saldang	SPNP
118	Rup Bahadur KC	Game scout	Saldang	SPNP
119	Bhakta Budha	Game scout	Saldang	SPNP
120	Urgen Tenzin Lama	Citizen Scientist	Saldang	SLCC Saldang
121	Sonam Wangdi Gurung	Citizen Scientist	Saldang	SLCC Saldang
122	Lhakpa Tsering Gurung	Citizen Scientist	Saldang	SLCC Saldang
123	Tenzin Namdrol Gurung	Citizen Scientist	Saldang	SLCC Saldang
124	Dorje Tshering Gurung	Citizen Scientist	Saldang	SLCC Saldang
125	Dorje Gyaljen Lama	Citizen Scientist	Saldang	SLCC Saldang
126	Karma Choephel Lama	Citizen Scientist	Saldang	SLCC Saldang
127	Tenzin Jigme Gurung	Citizen Scientist	Saldang	SLCC Saldang
128	Chime Tsewang Gurung	Citizen Scientist	Saldang	SLCC Saldang
129	Jigme Gurung	Citizen Scientist	Saldang	SLCC Saldang
130	Sonam Tenzin Lama	Citizen Scientist	Saldang	SLCC Saldang
131	Migmar Dandhul Lama	Citizen Scientist	Saldang	SLCC Saldang
132	Karma Choepel Lama	Citizen Scientist	Saldang	SLCC Saldang
133	Karkyal BK	Citizen Scientist	Saldang	SLCC Saldang
134	Chiring Dorje Gurung	Citizen Scientist	Saldang	SLCC Saldang
135	Chewang Dharke Lama	Citizen Scientist	Saldang	SLCC Saldang
136	Thupten Lopsang Gurung	Citizen Scientist	Saldang	SLCC Saldang
137	Pema Gyalchen Lama	Citizen Scientist	Saldang	SLCC Saldang
138	Amrit Chaudhary	Senior Game scout	Bhijer	SPNP
139	Nurbu Lama	Game scout	Bhijer	SPNP
140	Dammar Bahadur Kathayat	Senior Game scout	Bhijer	SPNP
141	Sundar Lal Chaudhary	Game scout	Bhijer	SPNP
142	Govinda Adhikari	Senior Game scout	Bhijer	SPNP
143	Hiralal Chaudhary	Game scout	Bhijer	SPNP
144	Karma Tarke Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
145	Nissyar Sangmo Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
146	Karma Rinjin Gurung	Citizen Scientist	Bhijer	SLCC Bhijer

147	Dawa Tenjin Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
148	Nawanga Jigme Lama	Citizen Scientist	Bhijer	SLCC Bhijer
149	Lode Gyalchhen Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
150	Karma Rapke Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
151	Nima Chhiring Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
152	Dhawa Gyaljen Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
153	Pema Rinjin Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
154	Chhewang Gyalbo Gurung	Citizen Scientist	Bhijer	SLCC Bhijer
155	Tashi Chhewan Lama	Citizen Scientist	Bhijer	SLCC Bhijer

Annex 4. Photo album of all 62 snow leopards of Shey - Phoksundo National Park (all photo credits DNPWC/ WWF Nepal)


SLFBH1 - Front


SLFBH1 - Rear


SLFBH2 - Front


SLFBH2 - Rear


SLFBH3 - Front


SLFBH3 - Rear


SLMBH4 - Front


SLMBH4 - Rear


SLMBH5 - Front (GPS collared Snow leopard - Samling)


SLMBH5 - Rear (GPS collared Snow leopard - Samling)

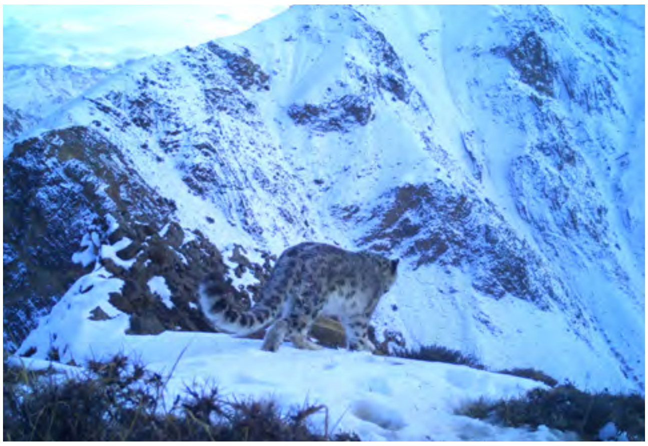

SLMBH6 - Front (GPS collared Snow leopard - Zeborong)


SLMBH6 - Rear (GPS collared Snow leopard - Zeborong)


SLMBH7 - Front


SLMBH7 - Rear


SLUBH8 - Front


SLUBH8 - Rear


SLUBH9 - Front


SLUBH9 - Rear


SLUBH10 - Front


SLUBH10 - Rear


SLUBH11 - Front


SLUBH11 - Rear


SLUBH12 - Front


SLUBH12 - Rear


SLUBH13 - Front


SLUBH13 - Rear


SLUBH14 - Front


SLUBH14 - Rear


SLUBH15 - Front


SLUBH15 - Rear


SLUBH16 - Rear


SLUBH17 - Rear


SLUBH18 - Rear


SLUBH19 - Rear


SLFDH20 - Front


SLFDH20 - Rear


SLFDH21 - Front


SLFDH21 - Rear


SLFDH22 - Front


SLFDH22 - Rear


SLMDH23 - Front


SLMDH23 - Rear


SLMDH24 - Front


SLMDH24 - Rear


SLUDH25 - Front


SLUDH25 - Rear


SLUDH26 - Rear


SLUDH - PH27 - Front


SLUDH - PH27 - Rear

SLUDH28 - Front

SLUDH28 - Rear

SLUDH29 - Rear

SLUDH30 - Rear

SLFDO31 - Rear

SLMDO32 - Front

SLMDO32 - Rear

SLUDO33 - Front

SLUDO33 - Rear

SLUDO34 - Rear

SLUDO35 - Rear


SLMJD36 - Front


SLMJD36 - Rear


SLUJD37 - Front


SLUJD37 - Rear


SLFPH38 - Front

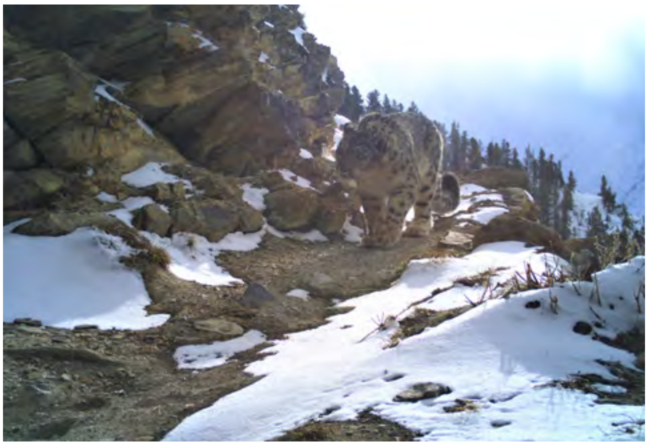

SLFPH38 - Rear


SLFPH39 - Front


SLFPH39 - Rear


SLMPH40 - Front


SLMPH40 - Rear


SLUPH41 - Front


SLUPH41 - Rear


SLUPH42 - Front


SLUPH43 - Front


SLUPH44 - Front


SLUPH44 - Rear


SLUPH45 - Front

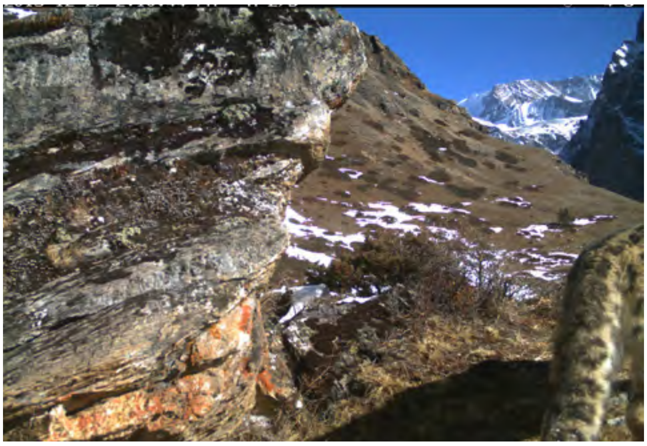

SLUPH45 - Rear


SLUPH46 - Front


SLUPH46 - Rear


SLUPH47 - Front


SLUPH48 - Front


SLUPH48 - Rear


SLFSD49 - Front


SLFSD49 - Rear


SLFSD50 - Front


SLFSD50 - Rear


SLFSD51 - Front


SLFSD51 - Rear


SLFSD52 - Front


SLFSD52 - Rear


SLMSD53 - Front (GPS collared Snow leopard - Ghangri Gapi Hyul)


SLMSD53 - Rear (GPS collared Snow leopard - Ghangri Gapi Hyul)


SLMSD54 - Front


SLMSD54 - Rear


SLMSD55 - Front (GPS collared Snow leopard - Langyen)


SLMSD55 - Rear (GPS collared Snow leopard - Langyen)


SLUSD56 - Front


SLUSD56 - Rear


SLUSD57 - Rear


SLUSD58 - Front

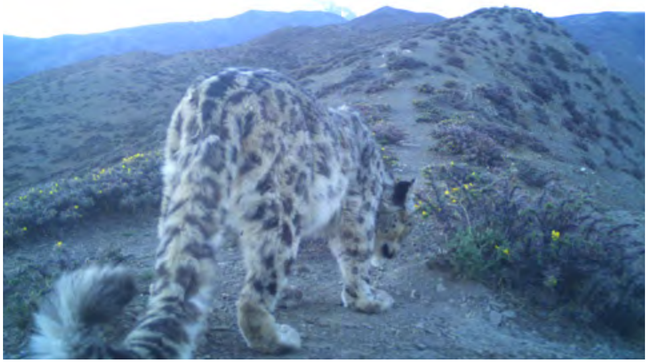

SLUSD58 - Rear


SLUSD59 - Rear

SLUSD60 - Rear

SLUSD61 - Front

SLUSD61 - Rear



SLUSD62 - Rear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