Final Report of the Major Research Project

Species distribution modeling of Western Tragopan *Tragopan melanocephalus* in Chamba district, Himachal Pradesh, India – implications of habitat fragmentation and human disturbance

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Introduction

Tragopans belong to the order Galliformes along with other popular birds like peafowl, francolins, grouse etc. Galliformes constitute one of the most beautiful orders of birds in the world. Plumage in most of the males is striking while females are cryptic in coloration. Facial adornments in the form of crest, wattles, ruffs and hackles are present in males of many species. Galliformes are large ground birds having strong feet, slightly hooked bills, poor flight ability and sexes are alike. The chief characteristics of tragopans are: heavy body, short rounded wings, brilliant colour, tendency of males to call territorially and fight during breeding season etc.

There are three families in order Galliformes and tragopans belong to family Phasianidae. There are five species of tragopans in the world (McGowan et al. 1995). They are Western tragopan *Tragopan melanocephalus*, Satyr tragopan *Tragopan satyra*, Temminck's tragopan *Tragopan temminckii*, Blyth's tragopan *Tragopan blythii*, and Cabot's tragopan *Tragopan caboti*. All the species of tragopans are endangered (BirdLife 2017). Sibley & Moroe (1990), based on DNA-DNA hybridization, classified pheasants, old world partridges, quails and francolins in the family Phasianidae.

In the Indian subcontinent, there are four species of tragopans (McGowan *et al*. 1995). They are Western tragopan *Tragopan melanocephalus*, Satyr tragopan *Tragopan satyra*, Temminck's tragopan *Tragopan temminckii*, and Blyth's tragopan *Tragopan blythii*. This project reports on the field research done on the Western tragopan *Tragopan melanocephalus* in Chamba district of Himachal Pradesh, India.

Western Tragopan

Western tragopan *Tragopan melanocephalus* is a medium sized, brightly plumaged bird. Males and females weigh 1800 – 2200 g and 1300 – 1400 g respectively. Length of males varies between 65 and 75cm and that of the females 60 – 65cm. Male possesses a red tipped long crest, feathered with reddish back, and the sides of the neck and face are red. Upper parts are covered with buffish grey and black with prominent white spots. Crest feathers are absent in females and they lack the red colour excepting on the face and legs which are pinkish. Females have pale brownish grey upper parts finely vermiculated and spotted with black, and most of the feathers have black patches and central white streaks. Males possess unique feature in the form of a naked throat which, during breeding, is called as lappet and is displayed for attracting females. Moreover, they call loudly during the breeding season to attract females and to defend territories.

Distribution Range

Western tragopan, also known as Western horned tragopan is considered to be the rarest of all living pheasants. *Tragopan melanocephalus* has a disjunct distribution in the western Himalayas (Rahmani 2012), occurring from Indus-Kohistan district, north **Pakistan**, east through Kashmir and Himachal Pradesh to Uttarakhand in north-west **India** (BirdLife International 2001). Although historically described as scarce and local, a mid-1980s population estimate of 1,600-4,800 birds was revised in the mid-1990s to c.5,000 birds following the discovery of several significant populations in north Pakistan, the largest of which (tentatively estimated at 325 pairs) is in Palas Valley. It had previously been suggested that there were now only 2,500-3,500 individuals remaining in the wild (S. Pandey *per* A. Rahmani *in litt*. 2012), given possible past overestimates and ongoing threats to the species. More recently however, estimates of >3,500 birds in the Pakistan administered Jammu and Kashmir regions (Awan 2015), together with the discovery of new populations in Uttrakhand and Kashmir, suggest global estimates might need to be revised upwards. This endangered pheasant is endemic to the northwest Himalaya with a narrow range from Hazara in north Pakistan through Jammu & Kashmir, Himachal Pradesh to the western part of Garhwal in India. Due to its beautiful plumage and large size, this bird is locally called "Jujurana" which means "King of Birds". It is reported to inhabit upper temperate forests between 2400 and 3600m in summer, and in winter, dense coniferous and broad leave forests between 2000 to 2800 m elevations.

Population of western tragopan is threatened by several anthropogenic factors throughout its range. The declining world population of this species has been estimated to be varying from 1600 to 4800 individuals (Gaston *et al.* 1983b, Johnsgard 1986), including captive population which is less than five now. Representing the endemic bird area D_{02} (Western Himalaya), Western tragopan has been described as a range-restricted species (ICBP 1992).

In western Himachal Pradesh, the Western tragopan is absent from many of the wildlife sanctuaries, but, paradoxically, it is present in several unprotected areas nearby. Disturbance from human activities, particularly the harvesting of medicinal herbs and fungi during the spring breeding season, is considered to be the main reason for this unlikely distribution pattern.

Fuller and Garson (2000) classified the Western tragopan as a 'Vulnerable' species in and recommended surveys in Chamba, Himachal Pradesh. This species is classified as Vulnerable because its sparsely distributed small population is declining and becoming increasingly fragmented in the face of continuing forest loss and degradation throughout its restricted range.

Population Status

A population estimate of at least 5,000 individuals is derived from Gaston *et al.* (1981b) and McGowan and Garson (1995). This is roughly equivalent to 3,300 mature individuals. Recent reports of additional populations in Azad Jammu and Kashmir, Pakistan and Himachal Pradesh may lead to an increase in the estimated global population size in the future, although conversely it has been suggested that the world population in the wild has been reduced to 2,500-3,500 individuals (S. Pandey *per* A. Rahmani *in litt*. 2012), prompting the need for wider surveys.

The species' population is likely to be in decline given the combined threats of trapping, hunting, disturbance by humans and livestock, and habitat degradation (F. Buner *in litt*. 2012), but this decline has not been quantified and is not thought to be particularly severe, thus the rate of decline is suspected to be moderate.

Habitat

During the breeding season (April-June), it inhabits little-disturbed temperate coniferous and deciduous forests, from 2,400-3,600 m. In winter, it makes very local altitudinal or lateral movements, to grassy or shrubby gullies with less snow cover, between 1,750 m and 3,000 m.

Major Threats

Threats to the species are thought to have intensified in recent years. Habitat degradation and fragmentation through subsistence farming, browsing of understorey shrubs by livestock, tree-lopping for animal fodder and fuelwood-collection, and illegal hunting are the main threats. Disturbance by grazers and particularly collectors of edible fungi and medicinal plants may seriously interfere with nesting. Hunting and trapping for its meat (especially in winter) and its decorative plumage pose additional threats, throughout India and Pakistan.

Objectives

This study is aimed to provide a comprehensive account on the distribution, population status and habitat ecology of the Western tragopan. The specific objectives of the study are as follows:

1. To determine the distribution and population status of Western tragopan in across space and time in District Chamba, Himachal Pradesh, India.
2. To map the distribution of Western tragopan on 1:50000 scale topographic maps with respect to GIS layers like habitat categories (at both the macrohabitat and microhabitat level including habitat fragmentation, human density and disturbance, vegetation structure etc.
3. Conduct ecological studies of the effects of human disturbance and forest product collection (especially *Morchella*).
4. To develop a species distribution model for the Western tragopan.

Study Area

Chamba is the north-western district of Himachal Pradesh (Fig. 1). It is situated between north latitude 32° 11´ 30″ to 33° 13´ 06″, and east longitude 75° 49´ 00” to 77° 03´ 30″ with an estimated area of 6,528 km2. The territory is wholly mountainous with altitude ranging from 491 to 6234 meters above mean sea level.

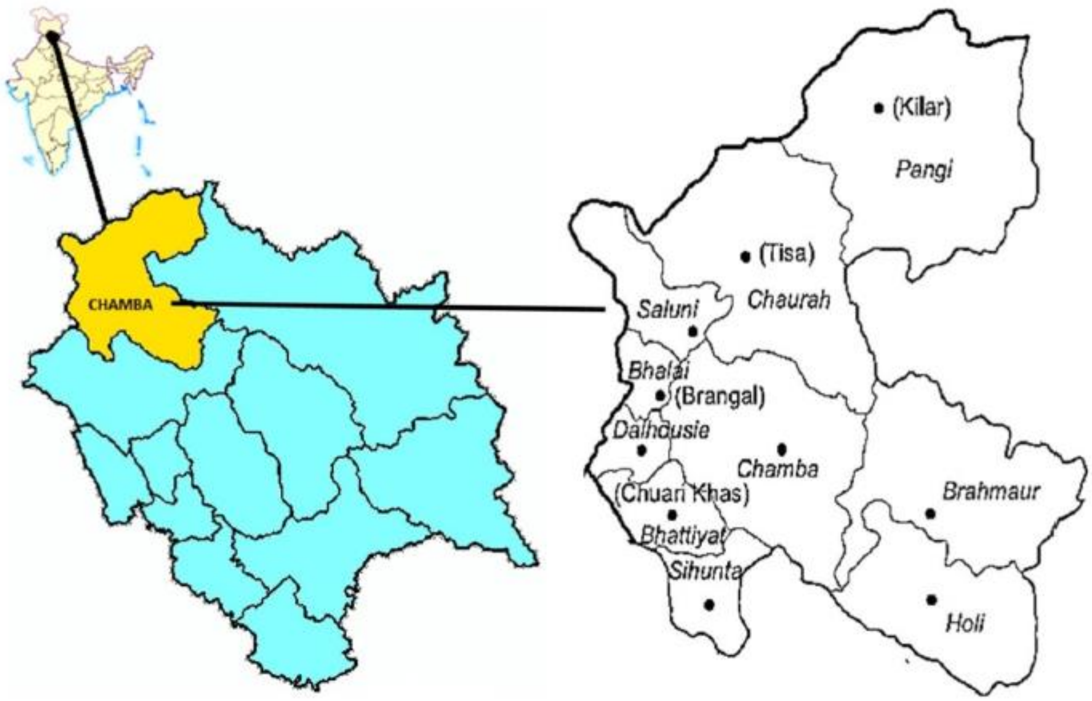

Fig. 1. Location of District Chamba in Himachal Pradesh.

Gaddis and Gujjars are the two main tribal communities of the district. The Gaddis, a semi-nomadic tribe, are the sheep and goat rearers and Gujjars tribe inhabit Siunta, Banikhat and areas adjoining the plains of Himachal Pradesh. These nomads climb up the hills during summers and return to the plains in winters. These native people are the guardians of indigenous traditional knowledge associated with their surrounding biological resources. They have been using these resources for various purposes in their daily life for ages. Because of varied altitudinal gradients and climatic conditions, the district harbours rich plant diversity, which includes around 2,000 species of flowering plants (Singh and Sharma, 2006). Besides exploring floristic diversity and inventorization of plant resources of the district (Sharma and Singh, 1990, 1997), the documentation of traditional knowledge of the plants was also carried out by several workers (Dutt et al., 2011; Singh and Banyal, 2012).

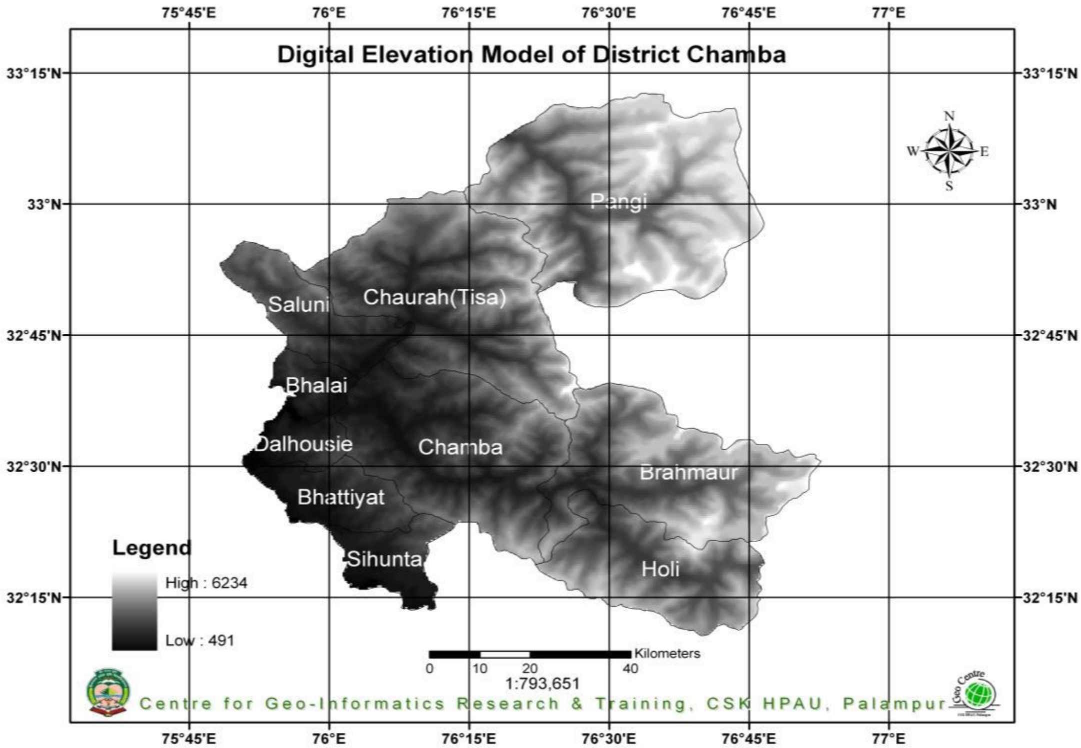

Fig. 2. Digital Elevation Model of District Chamba (Bhagat *et al*., 2009).

The major part of the district is under forest cover (48%) followed by grass & shrub (19%). Only 9% areas is under the agriculture use. Non-vegetation/rocks comprise of 13% of the total area of the district. The district has Hydropower dams reflecting 1% area under water bodies. Distributions of Land Cover classes are shown in Table 1.

Table 1. Distribution of Land Cover Classes for District Chamba.

Land Cover Class	Area (Sq. Km)	Percent
Forest	3126.60	48
Agriculture	559.63	9
Grass/Shrub	1211.43	19
Rocks/Non-vegetation	937.12	13
Snow/Clouds	297.67	5
Glaciers	331.53	5
Water body	64.02	1
Total	**6528.00**	**100**

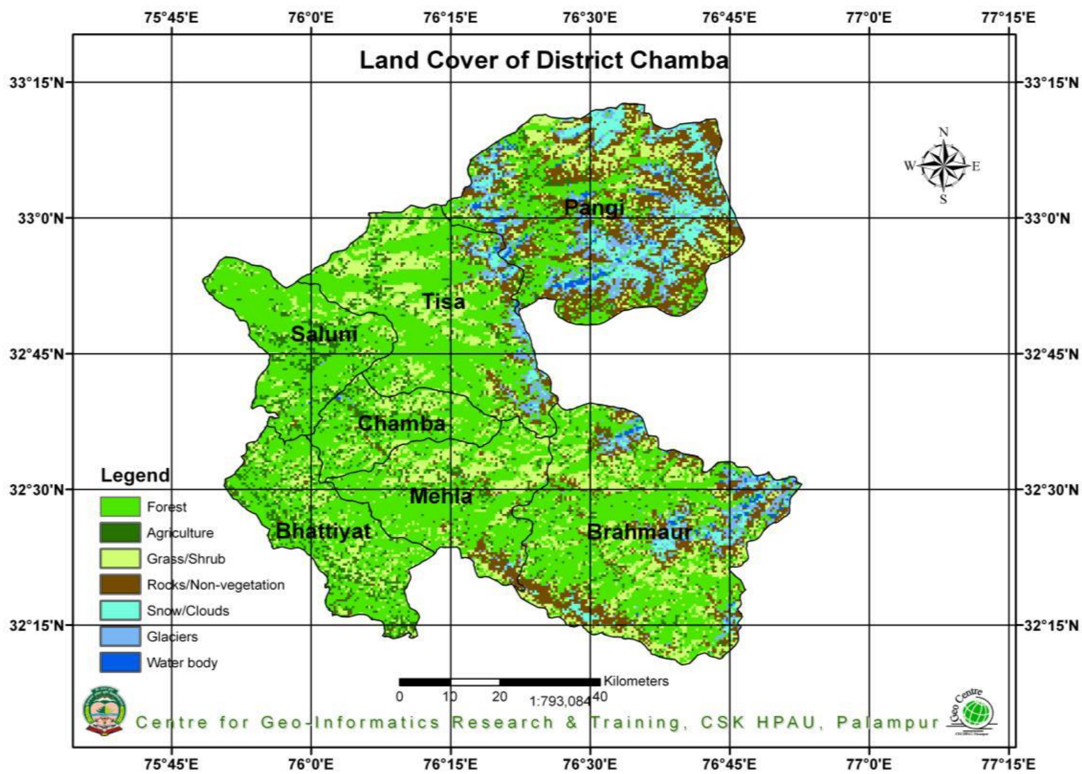

Fig. 3. Land Cover of District Chamba (Bhagat *et al*., 2009).

CLIMATE & RAINFALL

The climate of the district varies from semi-tropical to semi-arctic. Winter varies from December to February and summer extends from March to June while July to September are rainy months. The maximum rainfall in the district occurs between July to September. The rainfall in the district during 2012 was 1106 mm. Snowfall is received in the higher reaches. The minimum and maximum temperature at Saloni in 2011 was 1.1°C and 32.9°C in January and May respectively.

GEOMORPHOLOGY & SOIL TYPES

Chamba district presents an intricate mosaic of mountain ranges, hills, and valleys. It is primarily a hilly district with altitudes ranging from 600 m amsl to 6400 m asl. Physiographically the area forms part of middle Himalayas with high peaks ranging in height from 3000 to 6000 m amsl. It is a region of complex folding, which has under gone many orogeneses. The topography of the area is rugged with high mountains and deep dissected by river Ravi and its tributaries. Physiographically the district can be divided in to two units-*viz.* (i) high hills, which cover almost entire district (ii) few valley fills. Three types of soils observed in the district are 1. Sandy Loam 2. Loam, 3. Sandy Clay Loam.

Methodology

Population estimation

Trail walks, call counts and spot mapping were the basic data collection strategies for field testing count techniques and estimating relative abundance. The identified trails were walked in morning hours within the standardized time schedule (one hour per km and sampling within 2 hours from sunrise) and data on bird species, number, sex, composition, sighting angle and sighting distance was recorded. Western tragopan males, which produce loud advertisement or breeding calls were counted from fixed and open radius circular plots laid at 500m interval along the trails. The trails inclusive of call count stations were sampled sequentially so that time gap between sampling plots/trails would be constant. Locations of Western tragopans recorded from direct count during trail walk and opportunistic searches, and call count was plotted on a map. Habitat variables represented by major vegetation types, elevation, aspect and slope categories at macroscale and the microhabitat features, which comprise immediate environment of the individuals at a microscale were documented. The geographic coordinates of all contacts with the species were recorded using portable GPS receivers. Field data on sighting locations were plotted on 1:50,000 scale topographic maps for GIS based spatial analysis.

For call counts, the birds were counted from predetermined points and the radius within which the counts were made were kept variable (known as Variable-radius circular plot). The calls were counted from fixed points (or call-count stations) positioned 500 m apart, and depending on the length of the trail available in each habitat or strata. The counts were translated into an abundance index expressed as number of calling males per calling station or point. An estimate of density was derived from the data.

For spot-mapping, during the breeding season, presence of the territorial birds was usually conspicuous by their characteristic display behaviour, such as songs (crowing in Galliformes), nuptial dance/flight, and some deliberately exposed their breeding plumage (which grows only during breeding season) and other body parts. Such birds were easy to detect in the field and systematically plotting of records species occurrence on a gridded spatial map provided a useful index of relative abundance. This method, known as spot mapping, was useful for territorial birds (Manuwal and Carey 1991). Once the observations obtained through several visits to the locality are marked on the map, territorial boundaries were subsequently delineated to obtain an estimate of abundance, i.e. number of territorial males per plot.

Habitat use

Macrohabitat use – Macrohabitat was quantified at hierarchical scales, based on correlative (relating abundance with major vegetation types, elevation, aspect and slope) and focal bird approaches (measuring habitat characteristics at bird locations) as described by Block and Brennan (1993). Abundance of the study species in each of the vegetation types was estimated based on trail monitoring or call counts. Estimates from trails and call count stations were pooled to represent the vegetation types and the mean encounter rates associated with the standard errors were compared to describe relative habitat preference by the species in different seasons. Availability of absolute area under different elevation, aspect and slope categories was enumerated using the GIS domain and, proportional availability and use of these habitat parameters by the study species was assessed graphically.

Microhabitat use – As and when the study species was sighted along the trail, the sighting points were flagged at nearest points. After completion of the walk, various microhabitat features were quantified at the bird (flagged) locations. Quantification was made within circular plots of 10m and 5m radius, respectively, for tree and shrub associated variables. One-meter quadrats were laid at the center of bird location to measure herb, grass, and litter covers and soil depth. Soil samples within the quadrats were searched to record presence of potential invertebrate food sources. Physical variables such as elevation, aspect, slope, and distance to water sources were measured from the center of 10m circular plots.

Species Distribution Modeling

Species distributions are the focal interest in a vast number of studies in ecology, biogeography, and related sub-disciplines, including metapopulation ecology, invasive species, and global warming studies. Typically, a model is used to relate the probability of species occurrence to explanatory variables, for example those describing environmental conditions. A species distribution model allows covariate relationships to be tested for and for these relationships to be extrapolated to un-surveyed sites (e.g. as a distribution map) or to un-surveyed times (e.g. to predict response to climate change). In recent years, species distribution modeling has experienced vigorous development at the intersection of ecology, biogeography, applied statistics and computer science, and several new techniques have appeared (Elith et al., 2006; Phillips et al., 2006).

Environmental variables – A range of environmental variables was used as potential habitat variables including land cover, terrain topology, bioclimatic variables, and human impact.

Bioclimatic variables – A series of 19 bioclimatic variables obtained from WorldClim database were used. The 30-s database, which was roughly equivalent to 1-km² cells was used. NDVI (Normalized Difference Vegetation Index) images from Moderate Resolution Imaging Spectroradiometer (MODIS) onboard NASA Terra satellite at 250 m resolution), rescaled to NDVI images at to 1-km² resolution were used.

Habitat fragmentation and Human impact – These parameters were measured as forest fragments, road density, human density, cutting and lopping of trees, number of humans entering tragopan habitat for collecting forest produce, and number of cattle heads. Data on road density was obtained from Survey of India topographic map (1:250000) spatial scale. Road density was calculated as the total road length within each grand pixel. The human density data was obtained from Global Human Footprint data center at 1x 1 km^2 spatial resolution. These data was re-sampled to the grand pixel by summing the values of the 1x1 km^2 pixels within each grand pixel. Data on habitat degradation and fragmentation through commercial timber extraction, browsing of understorey shrubs by livestock, fuelwood collection, disturbance by graziers, and particularly collectors of edible fungi and medicinal plants was collected and their implication on the species distribution model worked out.

All environmental variables were developed as GIS layers in UTM 1984 WGC 43N at 1 km^2 and converted to ASCII format for use in the Maxent software.

Species Distribution modeling using Maxent – Maxent is a machine learning modeling approach has been recently applied to ecology (Phillips et al., 2006). Maxant works by constructing a distribution of the presence records in contrast to the background environmental conditions. Maxant estimates the most uniform species distribution (maximum entropy) across the study area given the constraint that the expected value of each environmental predictor variable under this estimated distribution matches its empirical average (Phillips et al., 2006). The modelled probability is a 'Gibbs' distribution (i.e. exponential in a weighted sum of the features) and the model logistic outputs have a natural probabilistic interpretation representing degrees of habitat suitability (0 = unsuitable to 0.99 = best habitat) (Pearson et al., 2007). Maxent software with default values, up to 1000 iterations and implementing linear, quadratic and product features types will be used. The occurrence locations will be partitioned randomly into two sub samples, using 70% of the locations as the training dataset and the remaining 30% for testing the resulting (partitioned) models. The measure of fit implemented by Maxent was the area under the curve (AUC) of a receiver operating characteristic (ROC) plot (ranging from 0.5 = random to 1 = perfect discrimination).

The relative contribution of each environmental variable to the Maxent model was evaluated in a jackknife cross-evaluation procedure. For the variables with highest predictive value, the response curves showing how each of these environmental variables affects the Maxent prediction were evaluated.

Summary of Results

Past studies on the Western tragopan were consulted and the following localities in the Chamba District were surveyed for selecting sites for call-counts:

1. Dukund and its surroundings.
2. Bakan and its surroundings.
3. Kainthly and its surroundings.
4. Ranikot and its surroundings.
5. Mangli and its surroundings.
6. Makkan-Chachool and its surroundings.
7. Sara
8. Tali
9. Ghraatbada
10. Chanjoo
11. Banni-di-Behi
12. Okhi Dramini
13. Panchungula
14. Padri Dramini
15. Maithla Ghot
16. Inga ka Ghot
17. Paniwala Ghot
18. Kudnu ki Nakki
19. Khanda Danda
20. Speka
21. Ghrossan
22. Chathi
23. Mandollu
24. Raila

Subsequently, the following fifteen sites were selected for the call-count surveys:

1. Kalwara

2. Rakoon
3. Khadtab
4. Kandlot
5. Sundari
6. Butalwan
7. Chatrehdi
8. Jote
9. Kuler
10. Madrani
11. Chatrani
12. Kalwara
13. Drabad Kota
14. Drone
15. Odda

The selected sites mainly had conifer forests, mixed with grass and scrub. The main trees were West Himalayan Spruce or Morinda Spruce *Picea smithiana* and Himalayan Fir *Abies pindrow* along with other conifer species. Most of the sites were under disturbance by the graziers and collectors of grass, firewood, *Morchella*, and other forest products. Temporary shelters of graziers called “Kothas” were scattered throughout the area. At few places, there were signs of fire.

Western tragopans were found at the following sites Khadtab, Kandlot, Sundari, Butalwan, Chatrehdi, Kuler, and Chatrani. The number of the Western tragopans from call-counts is given in Table 2. The details of distribution, density estimates, habitat use, anthropogenic disturbance and distribution model of the species in the district Chamba are given in the full report.

Table 2. Number of the Western tragopans from call-counts in selected sites in District Chamba, Himachal Pradesh.

Sr. No.	Name of Site	Number of calling Western Tragopans
1	Khadtab	1
2	Kandlot	3
3	Sundari	1
4	Chatrehdi	2
5	Kuler	3
6	Chatrani	4

The sites named Chatrani harbored the maximum number of Western tragopans. It was mainly an area with coniferous forest and thick scrub undergrowth. The area suffered human disturbance in the form of cattle grazing, grass and firewood collection, collection of *Morchella* and other forest products.