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RESEARCH

# Spatiotemporal distribution and population trends of Sindh ibex (*Capra aegagrus blythii*) in Balochistan during 2019–2022

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## Abstract

The increased pressures generated by human activities in form of climate change and habitat fragmentation have caused serious threats for Sindh ibex (*Capra aegagrus blythii*). Balochistan, recognized as one of the most vulnerable regions to climate change in Pakistan, has limited data on the distribution and population status of this species. To address this gap, our study aims to assess the spatial and temporal distribution and population trend of Sindh ibex in the Khuzdar and Lasbela districts of Balochistan. The study covered an area of approximately 45,123.97 km$^2$. It involved a double-observer survey at ten sites from 2019 to 2022, using the BBRecapture package in the R programming language to estimate ibex population trend and dispersion. We provided a comprehensive update of the species geographic range, along with estimates of its current abundance and population trends. Over the course of four years, the ibex population fluctuated. The ibexes detected dropped from 720 (male to female ratio 1:1.21) and 710 (male to female ratio 1:1.08) in 2019 and 2020, respectively, to 550 (male to female ratio 1:1.35) and 548 (male to female ratio 1:1.09). Overall, this study provides valuable insights into the population trends, gender ratios, habitat preferences, and density of Sindh ibex in Balochistan over the four-year period. These findings contribute significantly to the baseline data on the species ecology and will further help in the conservation of these species at local scale.

**Keywords** Sindh ibex · Population trend · Balochistan · Distribution pattern of ibex

## Introduction

Ibex (*Capra aegagrus*) is an ungulate species found in Pakistan, Iran, Afghanistan, Turkey, Iraq, Turkmenistan, and the Caucasus region (Macar and Gurkan 2009; Rahim 2016; Al-Sheikhly et al. 2020; Weinberg and Ambarli 2020). Globally, *Capra aegagrus* is listed as Near Threatened by the International Union for the Conservation of Nature (IUCN) Red List based on its likely population trend and potential range expansion (Weinberg and Ambarli 2020). However, the species is still facing major threats that might trigger population declines (Raza et al. 2012; Al-Sheikhly et al. 2020; Weinberg and Ambarli 2020).

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Pakistan has 11 ungulate species in a variety of habitats, from high-altitude highlands in the north to arid hills in the south (Shackleton 1997), including three species of the genus *Capra* in Balochistan (Virk 1991). Most of these species were once abundant, but over-exploitation, habitat loss, encroachment, and degradation have reduced their populations in recent decades. The Hindu Kush, Himalayan, and Karakoram mountain ranges in Pakistan are home to a wide variety of wild ungulates globally significant regarding their conservation status (Khan et al. 2014). However, these species have not been properly studied, and insufficient information about their distribution and population undermines conservation efforts in this region (Singh and Milner-Gulland 2011).

The Sindh ibex inhabits the mountain ranges of southern Balochistan, from the Makran coastal range at Pasni to Sindh Kohistan and the Kirthar range in the east. In the past, the ibex also existed in Gadabar Ghar, Loralai district, and the Bolan pass along the Quetta-Sibi highway, but it is probably extinct in such areas (Schaller 1977). Although it is protected by the Balochistan Wildlife Act of 1974 (Frisina et al. 2003), threats including poaching, overhunting, livestock overgrazing, and encroachment (Frisina et al. 2003; Nawaz et al. 2004; Khan et al. 2013; Ghalib et al. 2018) still exist in the area. Consequently, the species distribution in Pakistan is restricted to parks, sanctuaries, and remote areas (Yamada et al. 2004). Unfortunately, no systematic population studies have been undertaken in Balochistan to determine the current status of Sindh ibex, making further research imperative.

The current study was conducted to gain insights into the population dynamics and demographic characteristics of the Sindh ibex in the southern region of Balochistan. The objective of the research was to address the current knowledge deficit on population trends and temporal variations. The acquisition of information through this research study will provide baseline data that is essential for the conservation of the species.

## Material and methods

### Description of the study areas

This research study was carried out in the Khuzdar (27.5758° N, 66.8082° E) and Lasbela (25.8700° N, 66.7129° E) districts of Balochistan shown in Fig. 1, which are top-ranking areas in

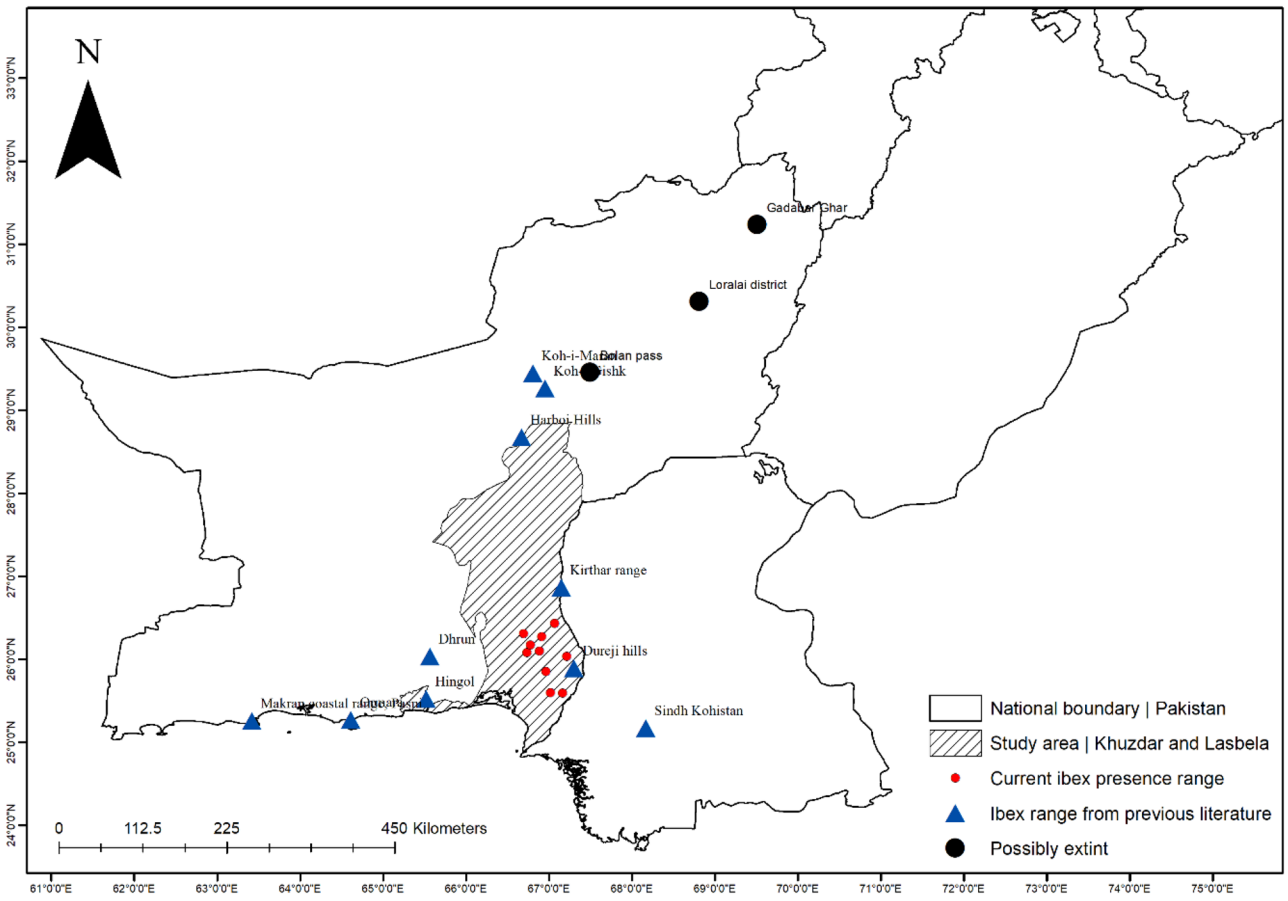


**Fig. 1** Map showing the study area (Khuzdar and Lasbela) along with the national boundary (Pakistan), current distribution of Sindh ibex, previous records of the ibex, and the areas where the species is possibly extinct

**Table 1** Survey sites, elevation, and length of the transects traveled in the study areas

| Survey number | Survey site | Species | Latitude | Longitude | Elevation (meters) | Distance (km) |
|---|---|---|---|---|---|---|
| **1** | Andhiyaar | Ibex | 26.0339 | 67.21080 | 1072.8 | 24.3 |
| **2** | Chapar | Ibex | 26.09836 | 66.88460 | 1059.2 | 18.3 |
| **3** | Chibbi | Ibex | 26.27256 | 66.90923 | 991.5 | 15.4 |
| **4** | Pubh | Ibex | 26.07918 | 66.73105 | 884.0 | 16.8 |
| **5** | Hub Kohan | Ibex | 25.85096 | 66.96059 | 731.5 | 14.6 |
| **6** | Jabal | Ibex | 25.58845 | 67.16183 | 675.7 | 15.4 |
| **7** | Khato | Ibex | 25.59649 | 67.01429 | 609.6 | 23.7 |
| **8** | Konyang | Ibex | 26.30482 | 66.6911 | 1143.0 | 16.0 |
| **9** | Padani | Ibex | 26.16913 | 66.77281 | 896.1 | 16.5 |
| **10** | Para | Ibex | 26.42860 | 67.06474 | 962.2 | 15.5 |

terms of biodiversity, holding the highest number of species in the entire province (Ali et al. 2012). These two districts are located on the Sindh-Balochistan border, which covered an area of approximately 45,123.97 $km^2$. The study area is bordered by the Kalat district to the north, the Sindh province's Malir and Karachi (West) districts to the east, the Arabian Sea to the south, and the Gwadar and Awaran districts to the west (Khan et al. 2020). The area's elevation varies from sea level up to 1494 m above sea level. The rivers and streams that flow from the Moro and Pub hills in the north and east of the plain, as well as the Haro and Hala ranges near the district's western edge, provide drainage (Khan et al. 2020).

### Climatic condition of study area

In Khuzdar and Lasbela districts, hot climate prevails during summer (April to October), while moderate climate prevails in winter (November to March). June is the hottest month, with an average temperature of 32 °C (Time and date, 2023), and January is the coldest, with an average temperature of 19 °C (Time and date, 2023). The majority of rainfall occurs between July and August during the monsoon season, with an average annual rainfall of 3.4 mm (Pakistan Poverty Alleviation Fund 2014).

### Flora of the study area

Major tree species in the study area are *Olea ferrugenia*, *Prosopis cineraria*, *Zizyphus mauritiana*, *Caparis aphyla*, *Salvadora oleoides*, *Acacia nilotica*, and shrubs, i.e., *Nannorrhops ritchiana*, *Rhazya stricta*, *Euphorbia nerifolia*, *Euphorbia caducifolia*, *Seddera latifolia*, *Zizyphus nummularia*, and *Salsola iberica*. The grass species encompass *Ochthochloa compressa*, *Lasiurus scindicus*, *Indigofera oblongifolia*, *Cymbopogon jwarancusa*, *Lepidium draba*, and *Euphorbia caduucifolia* (Kakar 2017).

## Data collection

A double-observer method using line transect survey techniques was applied from 2019 to 2022 to investigate the population trend of ibex. To facilitate data collection over the entire area, the two districts were divided into smaller blocks (union councils). Two observers, OB_1 and OB_2, were assigned to each survey block, with OB_2 starting 30 min after OB_1 (Tumursukh et al. 2016). The details of transects are given in Table 1 and Fig. 2.

The observer teams were supplied with a set of tools, including binoculars (8 × 42 WP Field 7.0, SICONG), a spotting scope (20 × 60 Swarovski), a Canon PC1331 Zoom lens 20 × cameras (to capture photographs of herds and their habitats), and a GPS device (Garmin etrex30x). The observers scanned the region along the transects using binoculars. When an ibex herd was spotted, the first step was counting the individuals and categorizing them based on their horn and body size. They were classified as males class I (0–2.5 years), class II (2.5–3.5), class III (3.5–4.5), and class IV (> 4.5) (Schaller 1977). At the end of the day, both sets of observers cross-tally their data using herd sighting location, composition, time, and unique characteristics, such as male-only herds, to verify unique and common herds and avoid double-counting (Khanal et al. 2020). Datasets were removed if there were any instances of double counting. The methodology was followed as previously reported (Masood 2011; Khanyari et al. 2021).

## Statistical analysis

The data from each study, gathered through a double-observer survey, were organized using a capture–mark–recapture framework. Three different codes were employed based on the sightings of ibex herds: "11" indicated a herd seen by both observers, "10" for observer A, and "01" for observer B. To estimate the ibex population, we employed a Bayesian behavioral capture–recapture model, utilizing the BBRecapture package in R software (Team 2010). Our approach for estimating the number of ibex groups, mean group size, total population, confidence intervals (CIs), and detection probability for both observers followed the methods outlined by Suryawanshi et al. (2021)

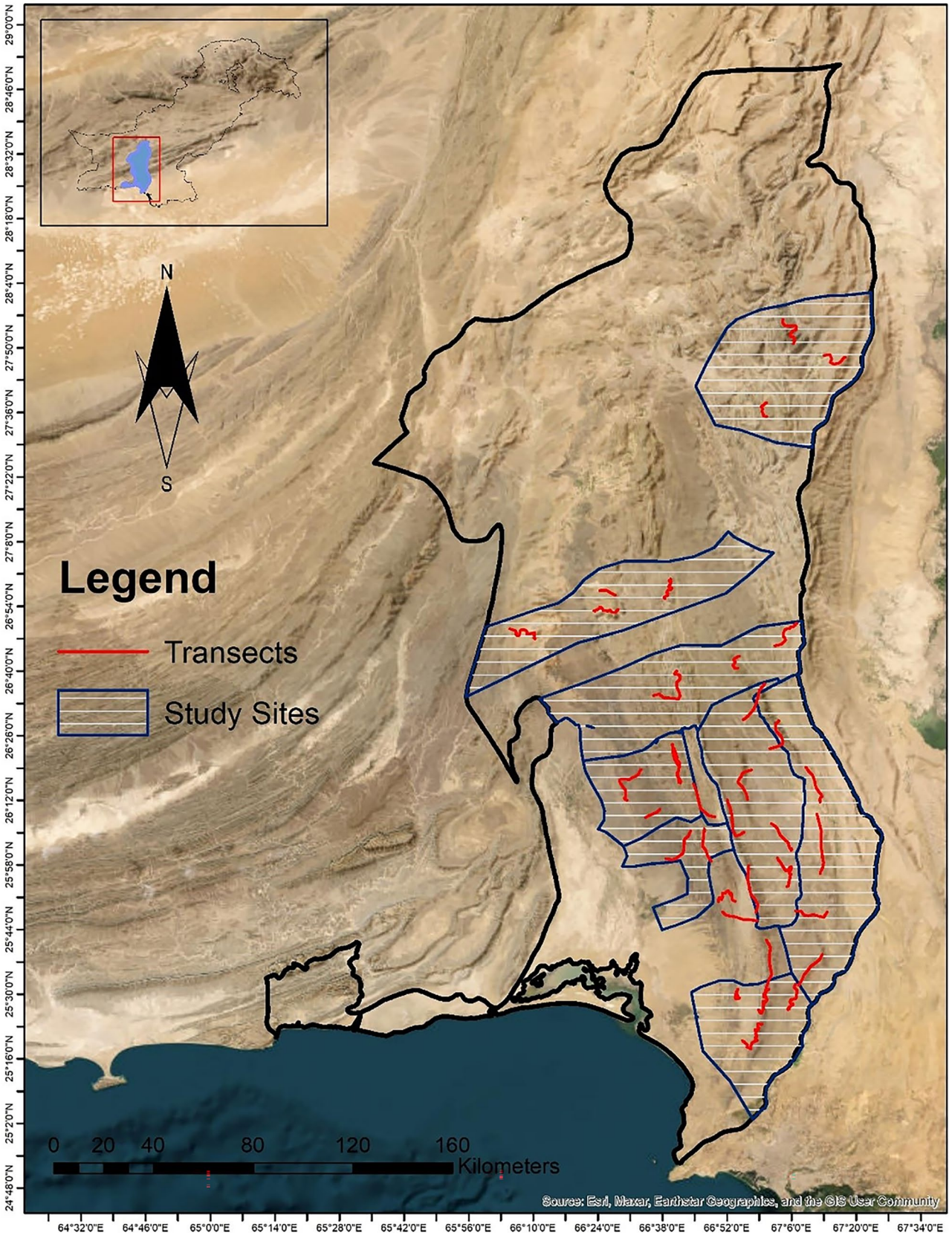


**Fig. 2** Map of the study area showing the transects and the study site blocks where the double observer survey was carried out

and Khanyari et al. (2021). To determine ibex density, we divided the estimated population by the total area of the site.

### Population standard deviation

The ibex population was ascertained by the standard deviation calculator (https://www.calculator.net) using the following equation:

$$\sigma^2 = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(xi-\mu)^2}$$

$$\sigma^2 = \frac{(xi-\mu)^2}{\mathrm{N}}$$

where $x_i$ is an individual value, μ is the mean/expected value, and $N$ is the total number of values.

In addition, the confidence interval was determined by the below equation (https://www.calculator.net);

$$\mathrm{CI} = \overline{\mathrm{X}} \pm Z \times \sigma/\sqrt{n}$$

where $Z$ is the $Z$-value for the chosen confidence level, $\bar{X}$ is the sample mean, $\sigma$ is the standard deviation, and $n$ is the sample size.

## Results

### Observational analysis

In the current study, ibex herds were observed in ten different blocks (Table 1). The mean herd size was 5.3, 4.5, 5.1, and 5.8 for 2019, 2020, 2021, and 2022, respectively. The number of groups observed by OB_1, OB_2, and both observers is shown in Table 2. The detection probabilities for OB_1 and OB_2 ranged from 0.27 to 0.37 and from 0.27 to 0.31, respectively.

### Population dynamics of Sindh ibex

In 2019, 720 ibexes were counted, including 289 males, 350 females, and 81 juveniles, with a male-to-female ratio of 1:1.21. In 2020, the counted population was 710, including 301 males, 323 females, and 86 juveniles, with a male-to-female ratio of 1:1.07 (Fig. 3). In 2021, 550 were observed ibexes, including 200 males, 270 females, and 80 juveniles, with a male-to-female ratio of 1:1.35. In 2022, 548 ibexes were spotted, including 226 males, 248 females, and 74 juveniles, with a male-to-female ratio of 1:1.09 (Table 3). The species photographed in the study area are shown in Table 3.

**Table 2** Calculation of Sindh ibex population estimates during 2019–2022 from double-observer population surveys of ten study sites in Balochistan

| Parameters | Year-wise ibex herd detection | | | | Total detection (N) | Population mean (X̄) | Population standard deviation (σ) | 95.0% confidence interval (CI) |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | 2022 | | | | |
| **Herd sighted by observer 1** | 14 | 20 | 16 | 13 | 63 | 15.8 | 2.68 | 15.8 ± 1.34 |
| **Herd sighted by observer 2** | 32 | 44 | 42 | 35 | 153 | 38.3 | 4.92 | 38.3 ± 2.46 |
| **Herd sighted by both observers 1 and 2** | 27 | 34 | 35 | 35 | 131 | 32.8 | 3.35 | 32.8 ± 1.67 |
| **Estimated number of herds** | 130.6 | 169.2 | 179.5 | 170.5 | 649.8 | 162.5 | 18.81 | 162.5 ± 9.40 |
| **Estimated population** | 691 | 765 | 911 | 980 | 3347.0 | 836.8 | 114.48 | 836.8 ± 57.24 |
| **Variance in mean herd size** | 0.02 | 0.02 | 0.02 | 0.03 | 0.1 | 0.3 | 0.04 | 0.3 ± 0.02 |
| **Variance in the estimated number of herds** | 473.76 | 551.25 | 866.97 | 1000.42 | 2892.4 | 723.1 | 217.55 | 723.1 ± 108.77 |
| **Variance in estimated population** | 13,602.87 | 11,778.61 | 23,036.41 | 33,768.7 | 82,186.6 | 20,546.6 | 8748.09 | 20,546.6 ± 4374.04 |
| **Detection probability of observer 1** | 0.34 | 0.37 | 0.31 | 0.27 | 1.3 | 0.3 | 0.04 | 0.3 ± 0.01 |
| **Detection probability of observer 2** | 0.30 | 0.31 | 0.28 | 0.27 | 1.2 | 0.3 | 0.02 | 0.3 ± 0.01 |

**Fig. 3** Photographic record of Sindh ibex grazing the rugged terrain within the study area, captured during the survey period (2019–2022)

## Distribution of Sindh ibex in 2019

This study found wide variation in the distribution of the Sindh ibex population over the subsequent four-year period. Class I distribution ranged from 0 to 15.38%, class II distribution ranged from 0 to 18.96%, class III distribution ranged from 7.54 to 31.81%, and class IV distribution varied from 0 to 30%. The proportion of female ibex ranged from 25.64 to 49.18%, and the proportion of young ibex ranged from 0 to 23.07% (Fig. 4).

## Distribution of Sindh ibex in 2020

Sindh ibex distribution was not homogeneous across the study area in 2020. Class I had a distribution range of 3.5 to 33.3%. Class II was distributed between 6.1 and 30.0%, while class III was distributed between 7.8 and 22.8%. A range of 7.8 to 18.4% was observed for class IV. The proportion of female ibex varied between 12.0 and 43.1%, and the proportion of young ibex varied from 2.0 to 18.6% (Fig. 5).

## Distribution of Sindh ibex in 2021

As in 2020, class-based distribution differences were detected among male populations also in 2021. Class I distribution ranged from 0.0 to 14.8%, class II distribution ranged from 6.1 to 27.7%, class III distribution ranged from 7.3 to 33.3%, and class IV distribution ranged from 8.1 to 28.1%. In addition, the female percentage varied from 16.6 to 59.5% throughout the study areas. Likewise, the proportion of young varied from 0.0 to 16.3% (Fig. 6).

## Distribution of Sindh ibex in 2022

A significant variation was detected among the classes I to IV Sindh ibex in the study area. The distribution of class I ranged from 0.0 to 9.8%. The distribution of class II ranged from 3.6 to 21.4%, while class III ranged from 5.6 to 25.0%, and class IV from 5.7 to 25.0%. The percentage of female ibex varied between 28.5 and 62.9%, and the percentage of young ibex ranged from 0.0 to 25.6% (Fig. 7).

**Table 3** Population dynamics of ibex: observations and ratios in 2019–2022

| Year | Species | Total numbers of individuals detected | | | | Population mean ($\bar{X}$) | Population standard deviation ($\sigma$) | 95.0% confidence interval (CI) | Male-female ratio |
|---|---|---|---|---|---|---|---|---|---|
| | | Adult male | Adult female | Young | Total | | | | |
| **2019** | Ibex | 289 | 350 | 81 | 720 | 240.0 | 115.16 | 240.0 ± 8.41 | 1:1.21 |
| **2020** | Ibex | 301 | 323 | 86 | 710 | 236.7 | 106.92 | 236.7 ± 7.87 | 1:1.07 |
| **2021** | Ibex | 200 | 270 | 80 | 550 | 183.3 | 78.46 | 183.3 ± 6.56 | 1:1.35 |
| **2022** | Ibex | 226 | 248 | 74 | 548 | 182.7 | 77.36 | 183.3 ± 6.47 | 1:1.09 |

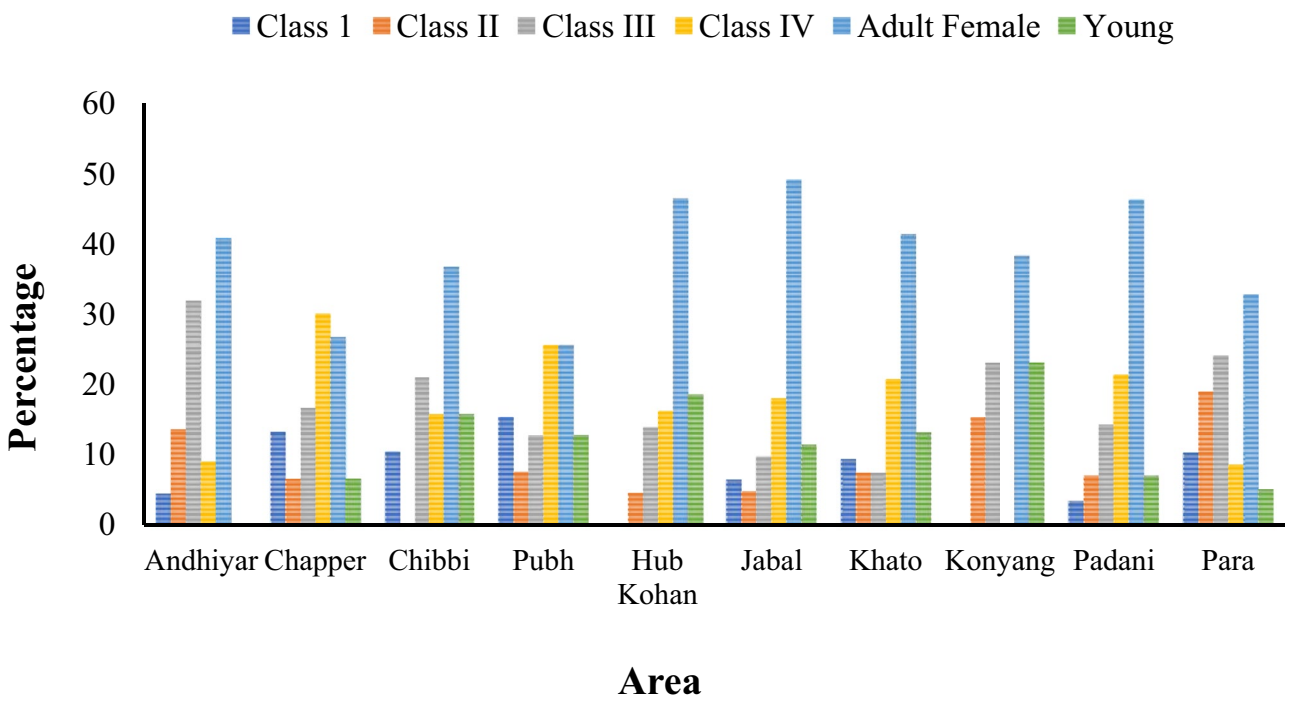


**Fig. 4** Distribution of the different ibex population sex and age classes in various locations of Balochistan in 2019

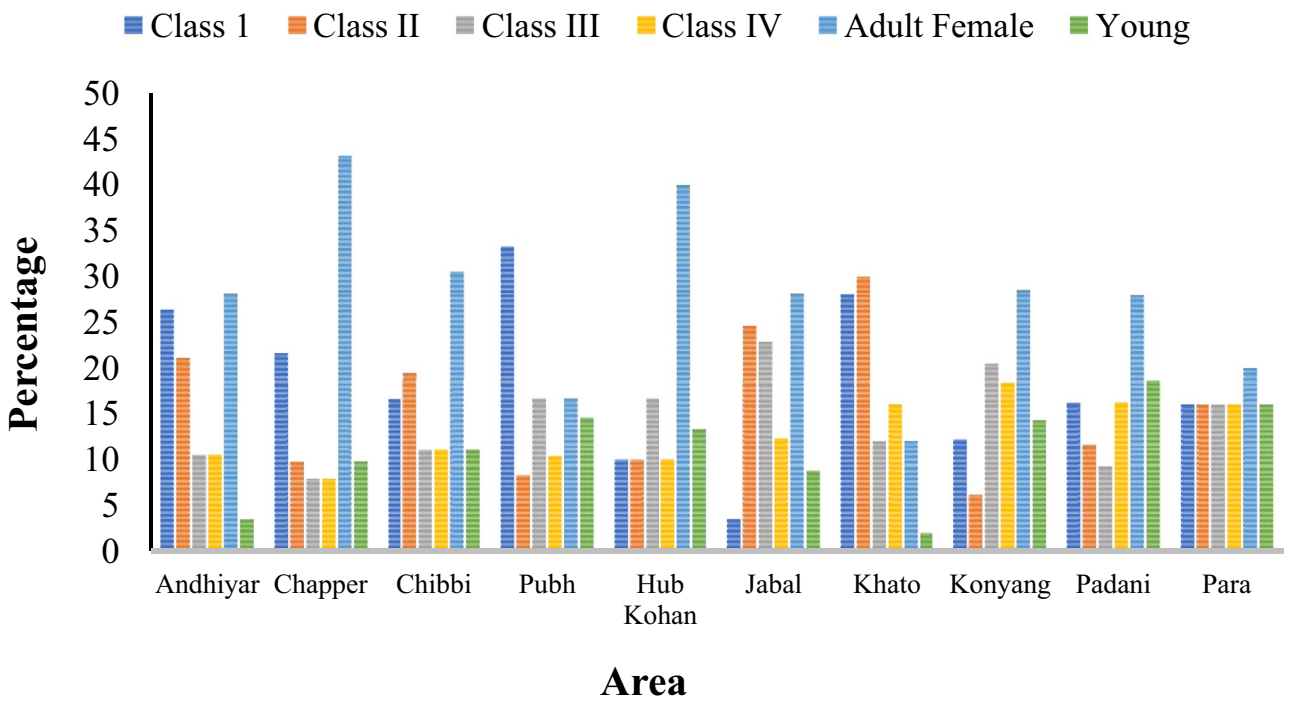


**Fig. 5** Distribution of the different ibex population sex and age classes in various locations of Balochistan in 2020

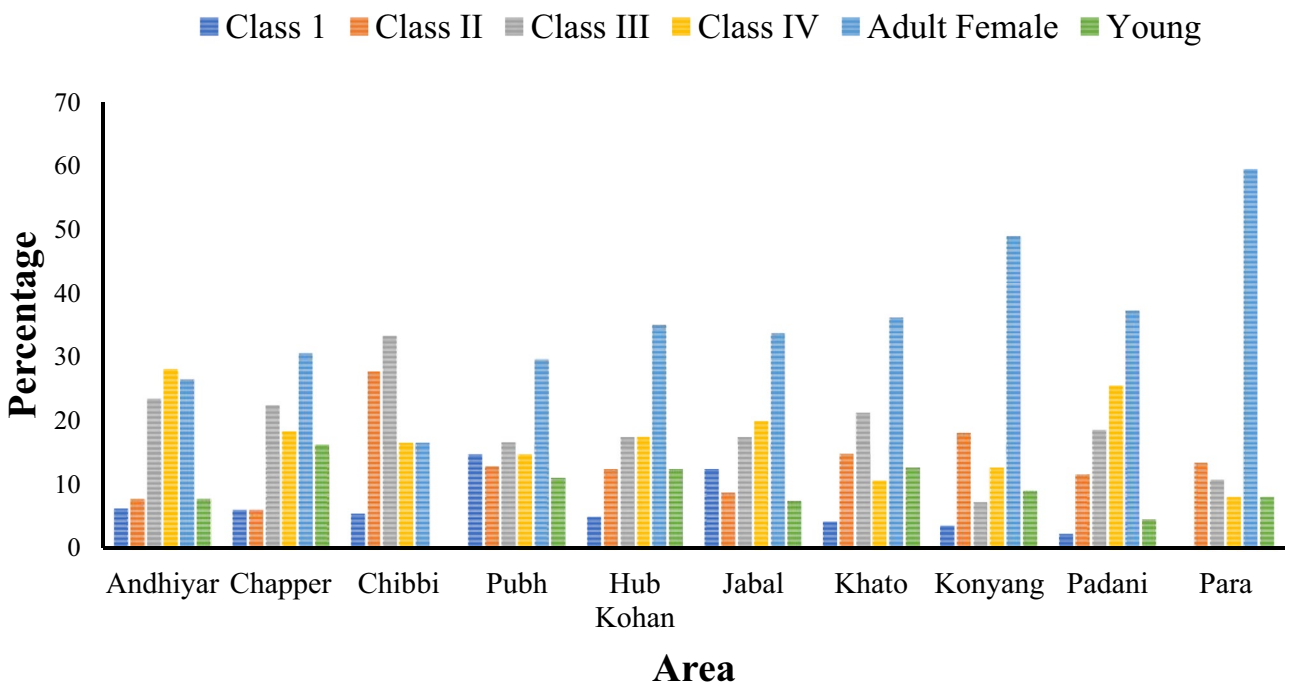


**Fig. 6** Distribution of the different ibex population sex and age classes in various locations of Balochistan in 2021

## Population density and habitat preference by Sindh ibex

The ibex population density was 0.02 individuals per square kilometer in 2019, 0.01 in 2020, 0.01 in 2021, and 0.01 in 2022.

The data presented in Fig. 8 shows the proportion of group detection depending on the habitat over the four years of the study, with rocky scrublands being the habitat where the ibex groups were most frequently sighted, followed by pastureland, hilly plains, rocky mountains, shaded rocks, and stony foothills.

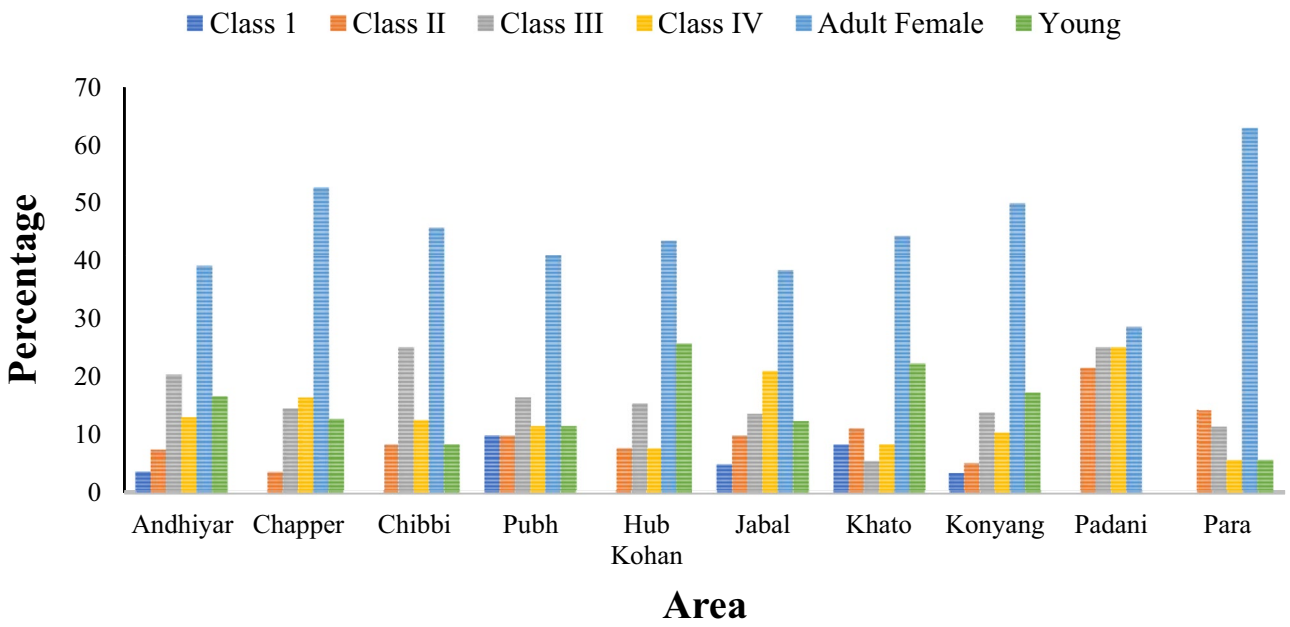


**Fig. 7** Distribution of the different ibex population and age classes in various locations of Balochistan in 2022

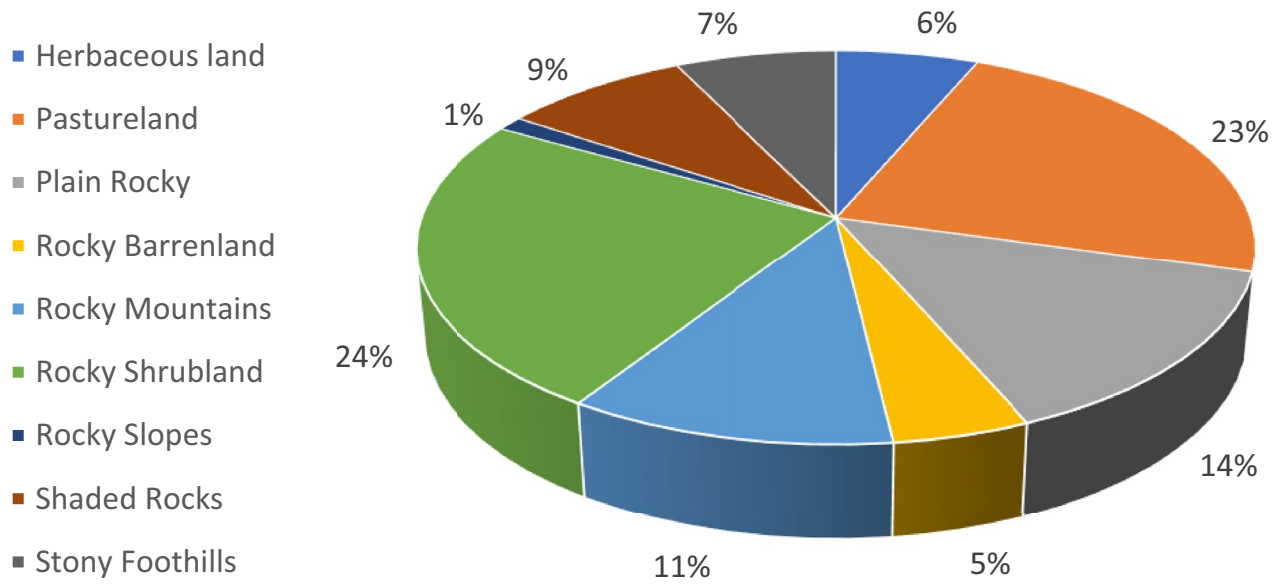


**Fig. 8** Percentages of ibex group observed in different habitat types in Balochistan during (2019–2022)

## Discussion

Balochistan landscapes represent a unique and fascinating ecosystem and are important hubs of biological diversity. Sindh ibex (*C. aegagrus blythii*) is a keystone game species that plays an important role in the trophic dynamics of semi-desert and hilly terrain landscapes, as it regulates grasses and is eaten by carnivore predator species like gray wolf (*Canis lupus*), striped hyena (*Hyaena hyaena*), and Balochistan black bear (*Ursus thibetanus gedrosianus*) (Ghalib et al. 2019). It is widely distributed across the study area, especially in rugged terrain between Balochistan and Sindh, which protects it from predators, although in rather low densities. Our findings contradict earlier studies that confined Sindh ibex presence only to national parks (Ghalib et al. 2019; Yaseen et al. 2021). Domestic herbivores in their habitat often cause food competition (Bagchi et al. 2003) and reduce habitat suitability (Krebs et al. 2007).

Monitoring the spatial–temporal distribution and population trends of Sindh ibex in southern Balochistan is imperative to increase knowledge on its population dynamics and improve its conservation. The higher probabilities of detection for observer A when compared to observer B, with the exception of the year 2022 where both observers exhibited same detection probabilities (Table 2), may be attributed to the triggering of retreat behavior in ibex by OB_1, as this species is sensitive to human presence (Suryawanshi et al. 2012). According to Thompson (2004), the detection probabilities of observers may also be influenced by the activity patterns of animals as well as other factors like climate, terrain, survey duration, and observer competence. Previous studies where the double-observer technique was employed to study mountain ungulates have consistently reported higher detection probabilities for observer A (Tumursukh et al. 2016; Salas et al. 2017; Ahmad et al. 2020; Khattak et al. 2020; Khanyari et al. 2021), attributed to the escape behavior of wild ungulates in response to the presence of the first observer. The data collected in this research provided in-depth information on the spatial and temporal distribution and population trends of Sindh ibex across the research area, which will contribute to the formulation of a comprehensive conservation plan for southern Balochistan.

This study provides the first-ever density estimates of Sindh ibex in southern Balochistan, constructed on empirical data. The study site encompasses a free-ranging area devoid of comprehensive wildlife management practices. Although a substantial ibex population inhabits these sites, the absence of effective management strategies and issues like illegal hunting and overgrazing by livestock pose a significant threat to the ibex population. Contrary to previous research (Begum et al. 2013; Nwinyi et al. 2013; Zafar et al. 2020), which primarily documented the presence of Sindh ibex in protected areas such as national parks and game reserves in the southern regions of Pakistan, the current study reveals their existence in non-protected areas. This large game animal is the most prevalent native ungulate species in Khirthar National Park (Edge and Olson-Edge 1990), where they are hunted by international trophy hunters and locals alike. The ibex form loosely connected groups that concentrate around freestanding springs within mountain ranges. In addition to hunting by humans, ibex habitat is overgrazed by domestic livestock and invaded by humans for different purposes (Edge and Olson-Edge 1990; Yamada et al. 2004; Ghalib et al. 2018). Sindh ibex is hampered by the high elevation

and relatively extensive arid zone of the Kirthar mountain ranges, at altitudes up to 3350 m (Yamada et al. 2004).

This study found a downward trend in the Sindh ibex population over the 2019–2022 period. Sindh ibex distribution and population in the study areas showed high spatial–temporal variability. The threats contributing to the population decline included prolonged droughts, poaching, habitat degradation, climate change, heavy livestock grazing in core habitats, and inadequate habitat conservation. Our results are consistent with those of previous studies across the country (Frisina et al. 2003; Nawaz et al. 2004; Ababakar et al. 2011; Begum et al. 2013; Mahmood and Hassan 2022). As a result of climate change, Pakistan is among the top ten nation's most negatively affected. As a result of climate change, Balochistan is one of the most vulnerable regions in the country, characterized by prolonged droughts, irregular precipitation patterns, and less reliance on agriculture and livestock (Jamro et al. 2020). According to Iqbal et al. (2018), the ibex habitat in the Kirthar protected area is facing severe risks from changing climatic conditions, particularly more frequent and severe droughts. Similarly, a more recent study by Faghih-Sabzevari and Farashi (2022) concluded that climate change can increase the vulnerability of this species. A substantial shift in the range of ibex was found, suggesting the need to incorporate climate change considerations into conservation strategies.

The detected ibex population was systematically biased towards female in all the years of the study, probably due to the unlawful and unregulated hunting of selectively targeted males within the population, reducing the ratio of males to females within the study area. Male ibexes typically have more prominent and impressive horns than females, making them attractive to hunters, who primarily seek out larger males as prized trophies. Milner et al. (2007), Aryal et al. (2010), and Büntgen et al. (2018) also found that selective hunting is the primary cause of the reduced ratio of males to females. In contrast, protected areas with regulated hunting practices exhibit a more balanced male–female ratio, signaling a reduced incidence of illegal hunting or poaching, particularly for adult males (Michel et al. 2015; Ahmad et al. 2022). The proactive actions taken by relevant wildlife authorities and the active participation of local communities are the main contributors to this phenomenon. This disparity in male survival rates may also be attributed to a higher mortality rate among young males, as older males often succumb to post-rutting season weakness, increased susceptibility to diseases, and hunters' preference for larger trophy males (Ahmad et al. 2020).

A study conducted by Edge and Olson-Edge (1990) stated that the population of wild goats (*Capra aegagrus*) in Kirthar National Park and adjacent areas had a male-to-female ratio for adults of 0.56:1. As a result of environmental changes, more females were also reported in Turkmenistan (Korshunov 1994). Herd structure, size, and social organization may change as a result of environmental changes. For genetic diversity and long-term sustainability, a balanced male–female ratio is essential (Tainaka et al. 2006; Morán et al. 2016). It promotes healthy population dynamics and allows for successful breeding (Compagnoni et al. 2017). The successful breeding of Sindh ibex depends on healthy population dynamics. A skewed ratio, caused by an excess of males or females, can reduce reproductive success, decrease mate competition, and have an unfavorable effect on age structure (Krackow 1995).

Moreover, various factors influenced the ibex population, including degradation and disturbance of habitat, uncontrolled livestock grazing in core habitats, food scarcity, carnivore predation, illegal hunting, an imbalance of males to females, and inadequate conservation efforts, all contributing to a declining population and a restriction on natural habitat movement. These findings are similar to those reported by previous researchers (Escos and Alados 1991; Bagchi et al. 2004; Acevedo et al. 2008). Such findings were also reported in the ibex population in Thar desert, India (Bozzuto et al. 2019). Ibex distribution in India's semi-arid regions has also been shown to be affected by climate change (Brambilla et al. 2020). Recent research reported that Arabian ibex populations in Oman are declining due to habitat destruction, overgrazing, and poaching (Tichon et al. 2023). Likewise, ibex populations are declining in India's Aravalli Range due to habitat degradation, encroachment, and human disturbances (Dookia et al. 2009). The negative impact of habitat loss and human interference on ibex populations in the Thar desert of Rajasthan is also reported by Gehlot and Jakher (2011). To protect the ibex population from further damage, proactive measures, such as habitat restoration and conservation, should be taken. Consequently, the Sindh ibex population will grow in its natural habitat, as suggested by Radtke et al. (2020).

The results of this study contributed to determine the spatial–temporal distribution and population trends of Sindh ibex. To protect this ungulate species across the Balochistan and Kirthar mountain ranges, it is essential to regularly examine the ecological, environmental, anthropogenic, and climate factors that may negatively impact the ecological integrity of Sindh ibex, as suggested by Singh and Milner-Gulland (2011). As a top priority, effective conservation actions must be ensured. Furthermore, the factors that cause population decline must be reduced in order to boost the population in their native habitat. To enhance ungulate populations in the wild, grazing of livestock and illegal hunting should be strictly prohibited (Karanth et al. 2006; Suryawanshi et al. 2017).

## Conclusion

Based on the results of this study, Sindh ibex population is declining and their dispersion has decreased as a result of human access to their core habitats. Furthermore, this ibex is under pressure from human intervention, which includes hunting, habitat degradation and fragmentation, competition with livestock for food, scarcity of food, predation by carnivores, imbalances between males and females, and climate change causing prolonged droughts and frequent floods. During the study period, loose management and conservation actions were detected. Therefore, we recommend preparing a comprehensive management plan that incorporates an ecological holistic approach, environmental factors, community participation, and climate change to collect detailed information about Sindh ibex population enhancement in wilderness areas.

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## Declarations

**Institutional review board** Not applicable.

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