

PHASE- I : FINAL TECHNICAL REPORT

Addressing Knowledge Gaps in Breeding Biology and Enhancing Awareness of Forest Owlet (*Athene blewitti*) in Dangs Forests, Gujarat

Reporting period: 1st March 2024 to 31st August 2025



Forest owlet in the dangs landscape | Rucha Bhawe/WCS-India

ACKNOWLEDGEMENT

The study on territory occupancy and the breeding biology of the Forest Owlet in the northern Western Ghats of Dangs district, Gujarat, aims to illuminate an ecologically important yet neglected landscape. We owe gratitude to the many individuals and organizations who believed in us and supported the initiation and execution of this long-term monitoring project.

Our progress was made possible by generous financial support from several funding agencies, including the Raptor Research and Conservation Foundation (RRCF), Global Raptor Research and Conservation Grant (GRRCG) from HawkWatch International, The Habitats Trust (THT) Seed Grant, Burnham Fund from The Peregrine Fund, and the Duleep Matthai Nature Conservation Foundation; without this funding, a comprehensive study would not have been feasible.

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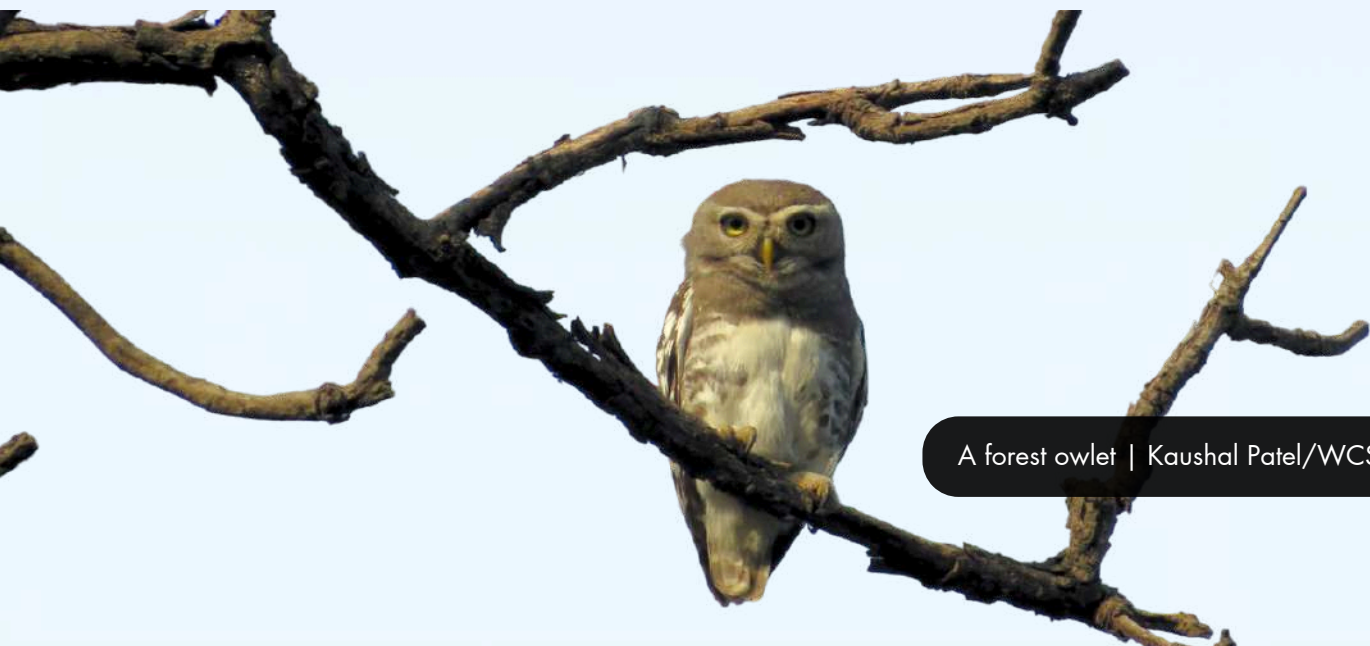
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EXECUTIVE SUMMARY

The Forest Owlet (*Athene blewitti*), a rare and endangered species endemic to India, has faced significant conservation challenges since its rediscovery in 1997. Once thought extinct, the species is now known to inhabit a restricted range in Central India and the Northern Western Ghats. Classified as "Endangered" under the IUCN Red List and legally protected under Schedule I of the Wildlife (Protection) Act, 1972, the forest owlet remains at risk due to habitat destruction, human disturbances, and competition with sympatric species. To address critical knowledge gaps, the Phase-I of this project focuses on understanding its breeding biology, assessing habitat occupancy, and fostering conservation awareness within the Dang forests of Gujarat.

The project aims to investigate territory occupancy and breeding success, map key stakeholders, and establish a long-term conservation monitoring program. Using a multi-state occupancy framework, surveys were conducted in the breeding season (October 2024 to June 2025), employing call play-back techniques to detect presence and monitor reproductive success. Data sources included previous surveys, online repositories such as eBird, and collaboration with research institutions to enhance species distribution mapping. The study adopted a systematic grid-based sampling approach, analysing ecological factors influencing breeding success and species distribution.

The project's pilot surveys (April–June 2024) confirmed the presence of the forest owlet at 82 sites, with 125 individual sightings across an altitudinal range of 175 to 604 meters, the highest recorded for the species globally. The discovery of fledglings at five locations provided the first substantial evidence of active breeding populations in the Northern Western Ghats. However, field observations highlighted significant anthropogenic threats, including habitat degradation from logging, land conversion for agriculture, and road traffic disturbances.



A forest owlet | Kaushal Patel/WCS-India

Based on the pilot surveys, we designed sampling units (grids) and conducted surveys from November 2024 to June 2025 to understand the territory occupancy and breeding success employing an occupancy framework. Four independent replicates/surveys across 164 grids revealed that 123 grids were observed to be occupied by the Forest Owlet, resulting in a naïve occupancy estimate of 0.75. Whereas, of the occupied grids; 54 grids had confirmed breeding activity, indicated by the presence of at least one juvenile, giving a naïve breeding success rate of 0.44.

We analyzed our detection-non detection data employing both single-state and multi-state occupancy models. Both the models identified the Slope and Cropland percentage in surveyed grids as the best predictors for detection probability. Cropland and number of tree cavities were identified as the best predictors for the probability of forest owlet occupancy in both the models. Number of tree cavities was by far the most important predictor for the probability of reproduction, highlighting the importance of these resources as an important ecological requirement and must be considered for developing conservation strategies for the species as well as its habitat. Top best model estimated the occupancy probability ($\hat{\psi}$) of 0.786 (± 0.038 SE) by the Single-state occupancy models which was very similar to the naïve occupancy of 0.75. On the other hand, top model in multi-state occupancy models estimated the probability of forest owlet occupancy ($\hat{\psi}_1$) close to 1 (0.974 ± 0.044 SE). The multi-state occupancy model predicted higher occupancy estimates compared to the single-state model. While, the best model for the probability of reproduction given occupied ($\hat{\psi}_2$) was 0.660 (± 0.070 SE), which was again higher than the observed probability of reproduction of 0.44. Number of tree cavities and Cropland percentage positively influenced occupancy as well as reproduction. While, the mean slope value of the grid negatively influenced the probability of forest owlet occupancy.

Sightings of mature individuals and juveniles are surpassing the known Melghat population, suggesting Dangs to house the largest population globally and one of the strongholds of the species. In total, 55 breeding pairs were recorded with a total of 104 juveniles, an observed brood size per pair being 1.89 (SE \pm 0.10), suggesting that the species is able to thrive outside Protected Areas and in agricultural fields close to forest patches. The species seems to tolerate a degree of human disturbance but is likely to be sensitive to habitat alteration or disturbance that reduces resources.

Notably, all the roosts and nests were observed on live trees with secondary excavated cavities at heights (9–15 meters) that were higher than previously reported averages from Central India. Alarmingly, the discovery of a deceased forest owlet raised concerns about direct threats such as illegal hunting or unintentional harm. Recognizing that conservation success in such human-use landscapes relies on community participation, the project identified and engaged with key stakeholders, including local communities, the Gujarat Forest Department, educational institutions, and eco-development committees. Collaborative efforts with the Forest Department facilitated conservation-oriented discussions and improved site monitoring. Engagement with the Education Department in Ahwa resulted in plans for awareness programs in schools, fostering a conservation ethos among students. Research collaborations with institutions such as IISER Tirupati and SACON provided critical insights and supported data validation efforts.



Forest Owlet surveys in the Dangs landscape |
Kaushal Patel/WCS-India

The Forest Owlet Conservation Day (October 24, 2024) served as a crucial awareness event, bringing together forest personnel, researchers, and bird guides to discuss conservation strategies. A Sustainable Lifestyle Practices Workshop (January 29, 2025) was also conducted at the Mahal Ecotourism Site, reaching over 100 students and forest officials with educational materials on owlet conservation and habitat preservation. Dangs Bird Festival 2025 (18th & 19th March 2025), a two-day event, drew 120 participants, including students from five different schools, forest officials, and research scholars. The festival offered a comprehensive exploration of bird ecology, starting from fundamental bird identification techniques to more advanced topics such as raptor conservation including forest owlet and the vital role of maintaining a balanced food web. Emphasizing the importance of preserving each ecological layer within the Dangs landscape, the event aimed to raise awareness about ecosystem health and biodiversity conservation.

Moving forward, the project will expand stakeholder collaboration to enhance nest monitoring and habitat protection. The first phase of the project has significantly contributed to understanding the distribution, breeding ecology, and potential threats facing the forest owlet in the Dangs forests. However, continued efforts are required to mitigate human-induced threats, secure habitat, and ensure sustained conservation of this endangered and endemic bird species. Strengthening local participation and enforcing conservation policies will be essential in ensuring the survival of the forest owlet in the coming years.



Birding during the awareness campaigns in the Dangs landscape | Dinesh Chaudhary/WCS-India

BACKGROUND

The forest owllet (*Athene blewitti*) is a rare, small-sized, diurnal owl endemic to India. It was named after F. R. Blewitt, who collected the type specimen in December 1872. Between 1872 and 1884, only seven specimens of the forest owllet were collected, leading to its presumed extinction in the wild (Rasmussen and Collar, 1998). After 113 years, in 1997, the species was rediscovered in Khandesh, Maharashtra (King and Rasmussen, 1998). Currently, the forest owllet is restricted to a limited geographic range in Central India and the northern Western Ghats. It is classified as "Endangered" with an estimated 250–999 mature individuals, and is legally protected under Schedule I of the Wild Life (Protection) Act, 1972.

In the 25 years following its rediscovery, the forest owllet has been documented breeding at only five locations across India, with the Melghat and Dangs forests supporting the largest known populations. While earlier research in Central India has provided insights into the species' ecology (Ishtiaq et al., 2002; Jathar and Rahmani, 2004; Ishtiaq and Rahmani, 2005; Mehta et al., 2007, 2015, 2017, 2020), significant knowledge gaps remain. These gaps pertain to nesting biology, breeding success, survival rates, and the impacts of human activities, particularly in the northern Western Ghats populations. Additionally, the coexistence of the forest owllet with other sympatric species may lead to resource competition (Jathar and Rahmani, 2004; Mehta et al., 2018), potentially affecting its reproductive success (Sergio et al., 2003). These factors underscore the need for a comprehensive study focusing on the northern Western Ghats population.



This project aims to address these knowledge gaps by conducting a detailed study on the breeding biology and demography of the forest owl in the Dangs forests of Gujarat. Using a multi-state occupancy framework, the research investigated the species' habitat selection, behaviour and responses to environmental factors. The study methodology included revisiting previously identified territories and conducting intensive surveys using a grid-based sampling framework to identify new forest owl sites. Surveys were planned from October to June, the known breeding season when the species is highly vocal and can be effectively detected using call playback methods (Mehta et al., 2007; Ishtiaq and Rahmani, 2005; Jathar and Rahmani, 2004). This study was of particular significance as it represents the first ecological research effort in the Dangs forests and the northern Western Ghats since the species' discovery in the region in 2014 (Patel et al., 2015). Previous status and distribution surveys indicate that the species is not confined to protected areas such as Purna Wildlife Sanctuary and Vansda National Park but is also found in agricultural fields and fragmented forest patches (Jambu and Patel, 2021).

The project established a foundation for a long-term monitoring programme, addressing crucial research gaps in the northern Western Ghats. It will also provide essential guidance for conservation initiatives aimed at protecting this unique and endangered species. By identifying nesting sites, the study will advocate for their designation as primary conservation zones within the Dangs landscape. A proactive approach will be adopted, involving key stakeholders, local communities, and other relevant parties to raise awareness about the importance of preserving the forest owl's habitat. The findings from this study will serve as the basis for developing a comprehensive, landscape-level conservation action plan for the forest owl.



Measuring the height of the nest and its tree | Kaushal Patel/WCS-India

PROJECT ACTIVITIES

1. TERRITORY OCCUPANCY AND BREEDING SUCCESS

Collation of primary and secondary data collection on the species' presence in the northern Western Ghats of Gujarat state

1. We utilised the positive locations of the forest owlet identified in our previous surveys conducted in 2015-2016 as our primary information source (Jambu and Patel, 2021).
2. We compiled GPS locations from the eBird online repository as secondary data (Sullivan et al. 2009).
3. We also requested survey locations from IISER Tirupati and SACON (Khan et al., 2024) and from the Voluntary Nature Conservancy (Patel et al., 2017) for the years 2015-16 and 2018-19, respectively.

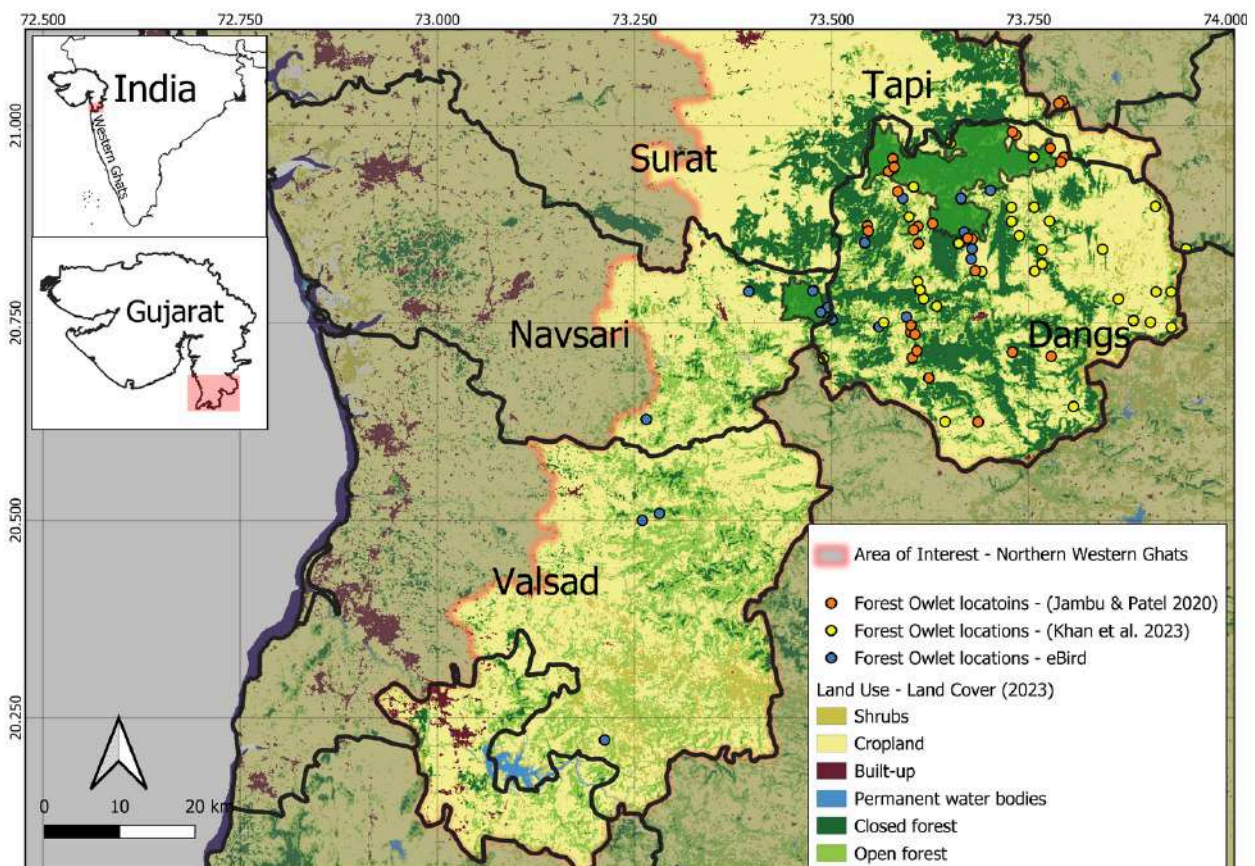


Figure 1: Forest owlet locations mapped using primary surveys and secondary data sources in the northern Western Ghats.

Resurveys to determine species' presence in the Dangs District, Gujarat

1. Drawing from previous surveys and considering the abundance and distribution of forest owl-positive locations (see **Figure 1**), we conducted occupancy surveys in the Dangs forests during the breeding season of the species.
2. Occupancy was assessed using a standardised method for the forest owl, employing a call playback technique - one minute of call playback followed by five minutes of silence (Mehta et al., 2007).
3. We also used the same method to detect the presence of other sympatric species (**Figure 2**) such as the Spotted Owlet (*Athene brama*) and Jungle Owlet (*Glaucidium radiatum*).

Grids of 1x1 sq. km were marked using QGIS, informed by prior knowledge of the area. Calls were broadcasted from the centroid of each surveyed grid. Data collection included noting the species' presence, breeding status, number of individuals, presence of juveniles, date and time, geographic coordinates, localities, and any human activity in the area. Additionally, we also explored other potential areas (outside the surveyed grids) for the species' presence and breeding status within the Dangs forests.



Figure 2: Three sympatric owl species - **A.** Forest owl, **B.** Spotted owl, and **C.** Jungle owl | Kaushal Patel/WCS-India

OUTCOMES: PILOT SURVEYS (APRIL 2024 - JUNE 2024)

Collation of species' presence from primary and secondary data sources

In total, we collated 87 forest owlet locations from 1) our previous surveys (Jambu and Patel, 2021) - 30 locations, 2) eBird - 18 locations and 3) Khan et al. (2023) - 39 locations from the landscape.

During the survey, we initially used data from 18 eBird locations but found the GPS coordinates to be often inaccurate, possibly due to intentional non-disclosure or GPS limitations. Consequently, we decided to exclude eBird locations from further surveys.

With sympatric species: Among the 169 survey locations, we found the spotted owl (*Athene brama*) in 87 locations and the jungle owl (*Glaucidium radiatum*) in 62 locations. Interestingly, the forest owl and spotted owl were observed together at 39 sites (47%), while the forest owl and jungle owl shared 26 sites (31%), whereas the spotted owl and jungle owl cohabited 41 sites (50%). There were 18 locations (21%) where all three owl species coexisted, highlighting the forest owl's ability to thrive alongside its sympatric counterparts.

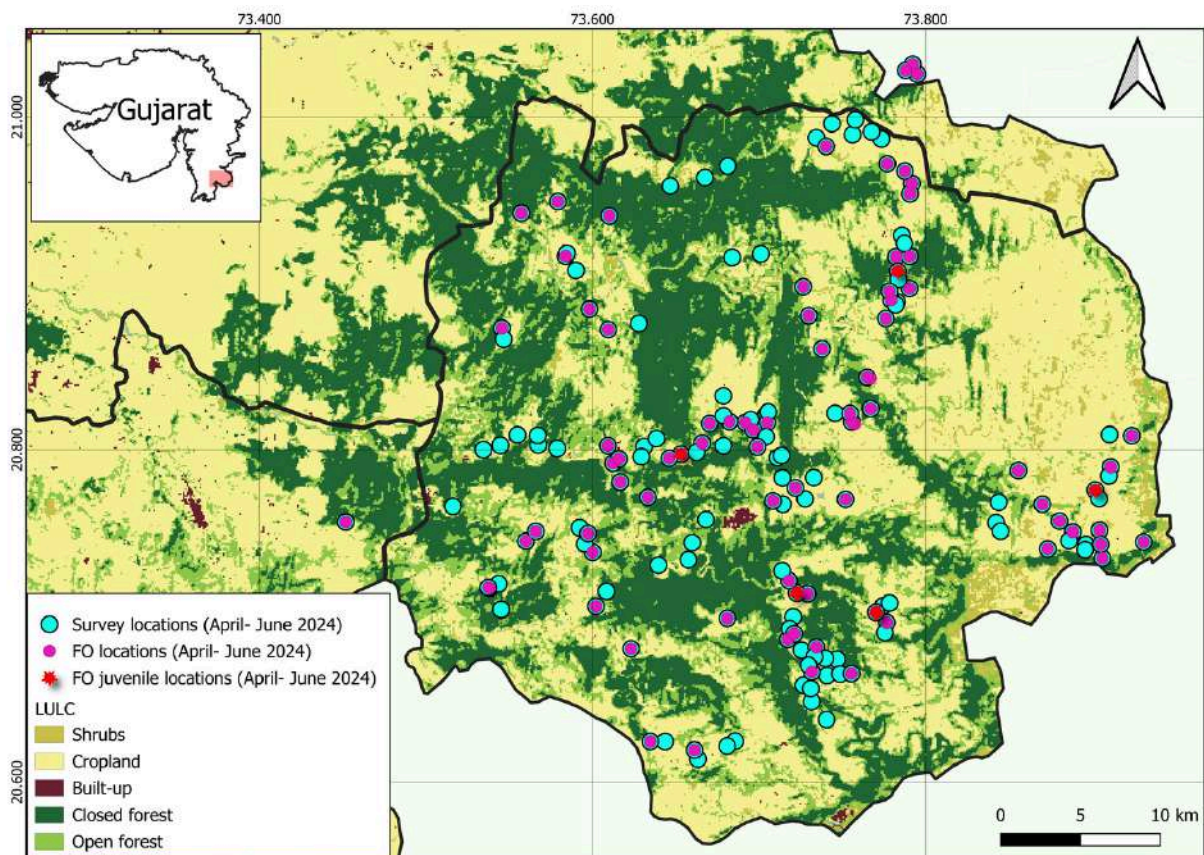


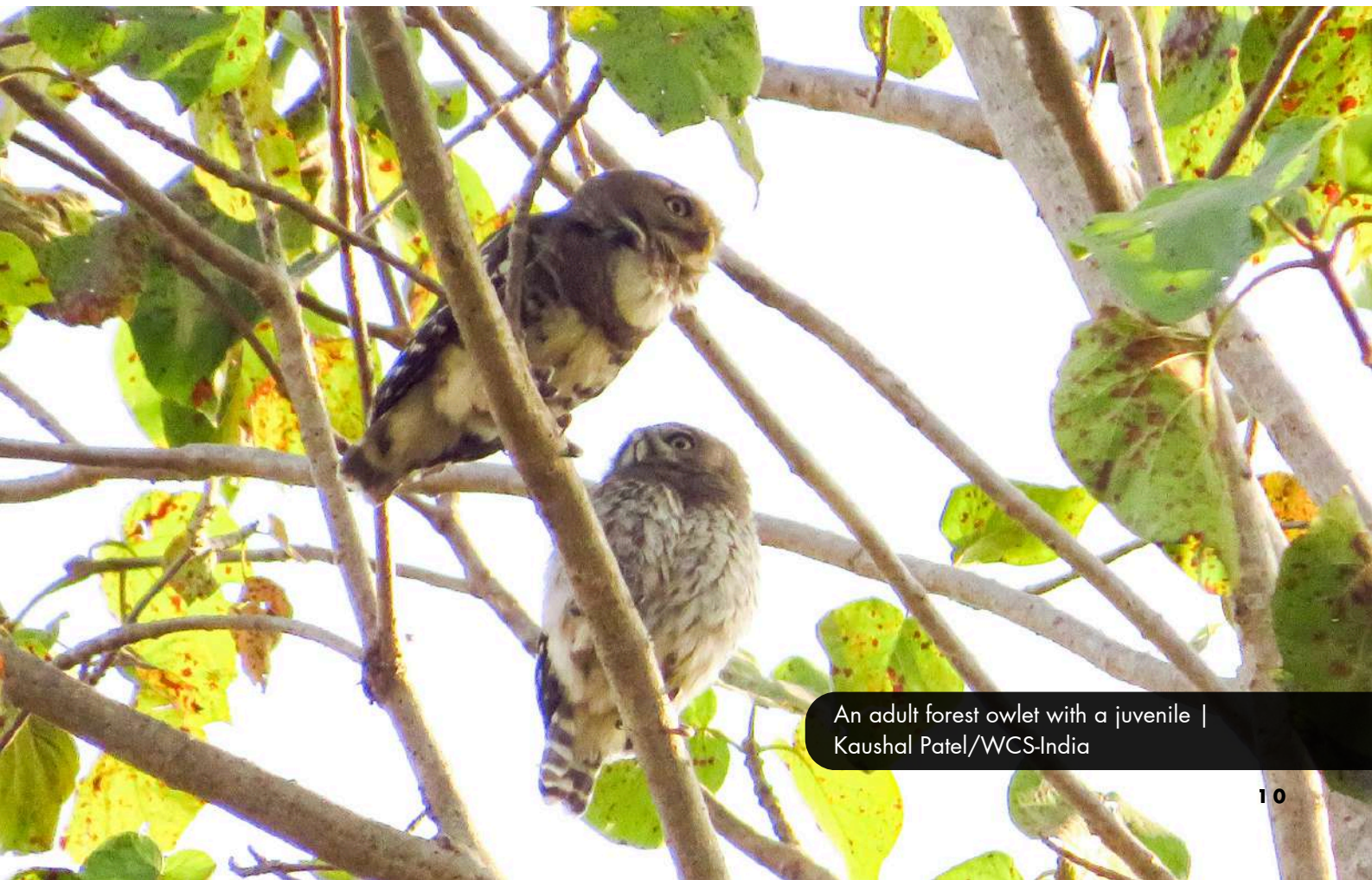
Figure 3: Occupancy and reproductive status survey in the Dangs forests (April-June 2024). Sky-blue circles represent all the survey locations; Purple circles indicate confirmed Forest Owl presence among the survey locations; and red stars show the presence of forest owl juveniles.

Pilot survey in the Dangs district (April – June 2024): In total, we identified 82 locations with 125 individual sightings of the forest owlet (**Figure 3**) across an altitudinal range of 175 to 604 metres above sea level, the highest recorded globally. We documented fledglings (**Figure 4**) at five sites, providing the first evidence of the species' reproductive status and highlighting one of its strongholds in the northern Western Ghats. All the forest owlet-positive sites are found primarily in agricultural lands close to forest patches where human activities like lopping and logging, clearing ground cover for agricultural practices, grazing and road traffic were observed.

Potential threat identified: During our survey, we observed that local households keep wild animals, including forest owlets, as pets. The exact nature and extent of this practice is not known and may stem from traditional beliefs, culture or other personal reasons which needs to be investigated and changed by working with the youth of the community.

Natural history insights on the forest owlet fledglings and parental care.

Our first observation of a juvenile: On May 5, 2024, while approaching our next broadcasting location for the day's survey, we noticed a forest owlet foraging at a height of approximately six feet on a tree. We stopped our vehicles to observe its hunting behaviour. While watching the owlet, we heard a distinct call 'kee ... k, kee ... k' that sounded like distress coming from the background. Using our 8x42 binoculars, we scanned in the direction of the sound and spotted another individual consistently calling but remaining mostly still.



An adult forest owlet with a juvenile |
Kaushal Patel/WCS-India

Distinct plumage description of a juvenile compare to an adult: This individual's plumage differed significantly from that of the adult Forest Owlet - which typically has a flat head with few to no spots compared to the spotted owl. In addition, the adult also has scapulars with some white tips and bars, but mostly uniform and dark brown breast and barring on upper flank which are broader and highly prominent, a clean white belly and upper-part. In contrast, the juvenile individual we had observed had streaks on chest and belly against a whitish-brown background, barring on the flanks were absent and it had a rounder head compare to adult with clear spots (Figure 4). Since it was new to us, we recorded the call for future reference, and thanks to our newly learnt ability to recognize this juvenile call, we were subsequently able to locate juveniles at four additional sites (Red color spots in **Figure 3 map**). The plumage description of a juvenile forest owlet is noteworthy because we did not find any other detailed descriptions during our literature survey. Pande et al. (2011) encountered an individual which they thought was a possible discovery of a hybrid between the forest owlet and spotted owl, but Ishtiaq (2011) responded suggesting that this is a juvenile of forest owlet. We have since observed five different juvenile individuals with developing plumages progressing towards adult colouration, from streaks to clean upperpart and belly and developing barred upper flanks (**Figure 4**).



Figure 4: Plumage development of a juvenile forest owl: **A.** Streaks on breast and belly with bars on upper flank absent; **B.** Some streaks on the belly, breast barred-like dark brown with developing bars on upper flanks; **C.** Prominent breast dark-brown and barred flanks with a clear white belly and other upperparts; **D.** A juvenile with an adult. | Kaushal Patel/WCS-India

Begging call : This begging call (**Figure 5**) was reported by Rasmussen and Ishtiaq (1999) for the very first time from Shahada-Taloda Road, Maharashtra with confidence that it was of the forest owlet, but they were unable to locate the calling individuals at that time. Later, while conducting breeding biology observations in Toranmal forests in Shahada range in Maharashtra, Ishtiaq and Rahmani (2005) observed that the begging call is also given by the females during courtship display. They continue to do so even after receiving food from males probably to solicit the attention of a male in selecting the nest site. The call was even continued during the copulation period by the female. Also, when the juveniles left the nest, the begging calls were given frequently but they have not observed this call from the males. During our observations, we only heard this call from the juveniles, probably because it was the end of the breeding season.

Natural history, behavior of juveniles and parental care: We noticed that the juveniles remained mostly still and occasionally moved in a radius of 5-20 meters in the presence of both parents. Also, one of the parents is always attentive to the fledglings while the other individual, more often male, goes foraging. All the juvenile sites were in the agriculture field with a mix of teak, mahua and kadam trees. In all the juvenile sites, we observed anthropogenic activities including logging, lopping branches, cleared ground cover for slash and burn agriculture, close human habitation, low to moderate traffic roads, cattle grazing, etc. (**Figure 6**). The fledglings did not respond to human activities, or to the presence of cattle and goats close to them, but instead stayed still on the branch and continued giving begging calls to their parents for food. These breeding sites and behaviour suggest that the adult pair selected locations that possibly offer abundant resources or shelter from predation rather than human activity, challenging our initial assumption that they would prefer undisturbed areas.

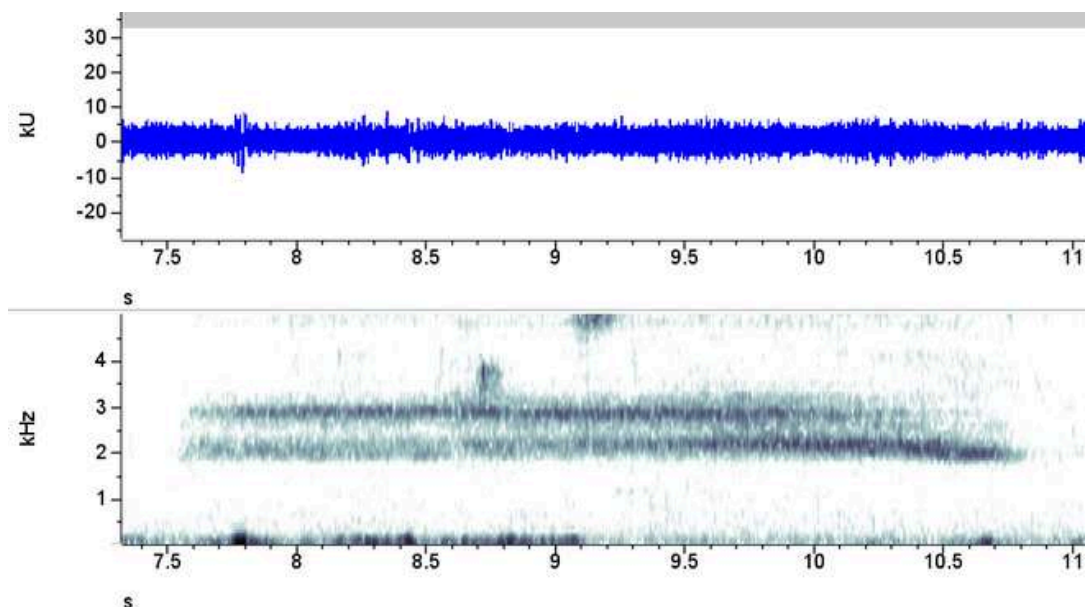


Figure 5: Spectrograph of a begging call of a juvenile forest owlet



Figure 6: Anthropogenic activity in forest owllet positive locations - **A.** Agriculture field close to road, **B.** Locals collecting leaf litter and lopped trees for slash and burn technique, **C.** Cattle grazing, **D.** Slash and burn with lopped trees, agricultural field with almost cleared ground cover, **E.** Agriculture field close to human habitation and road, **F.** Legal logging of timber trees.



SURVEYS ON OCCUPANCY AND BREEDING SUCCESS (NOVEMBER 2024 TO JUNE 2025):

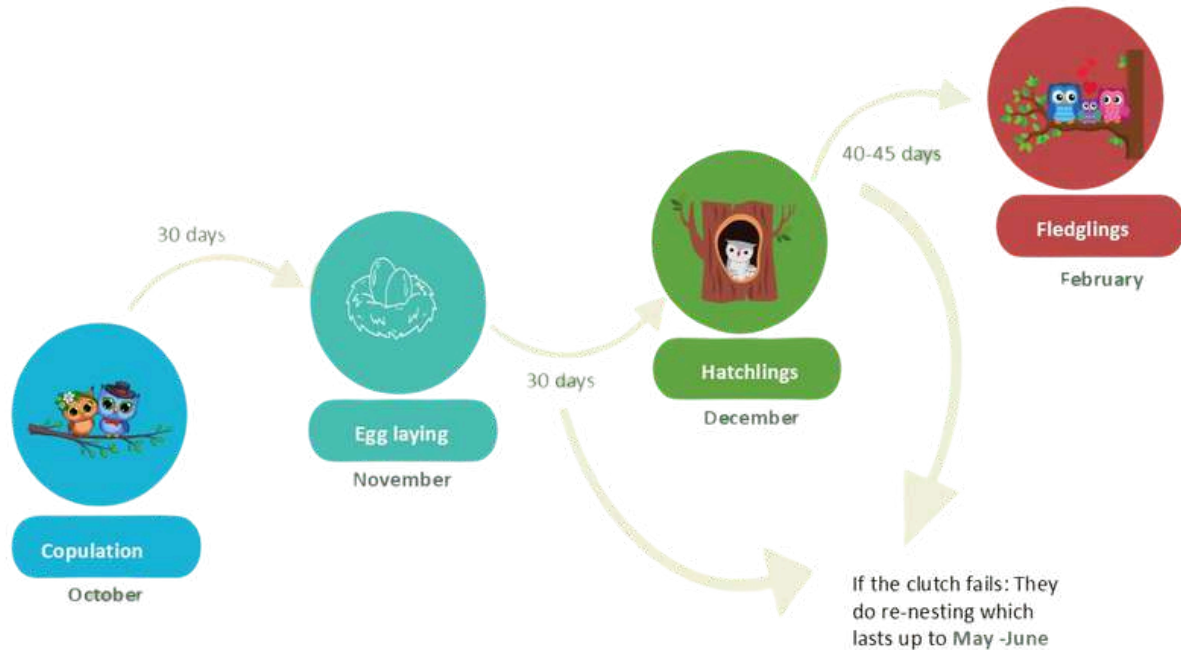


Figure 7: Breeding biology of the forest owlet based on previous studies from central India | Ishtiaq and Rahmani 2004, Jathar and Rahmani, 2004

We followed the field protocol for multi-state occupancy modeling by incorporating the breeding biology of the forest owlet (please see **Figure 7**), where, the first of four replicates/surveys was aimed to assess the occupancy in the month of (1) November 2024 to January 2025. The following three replicates were aimed to assess both occupancy and the breeding status of the species with surveys conducted in (2) January 2025 to March 2025, (3) April 2025 to June 2025 and (4) May 2025 to June 2025 (**Figure 8**).

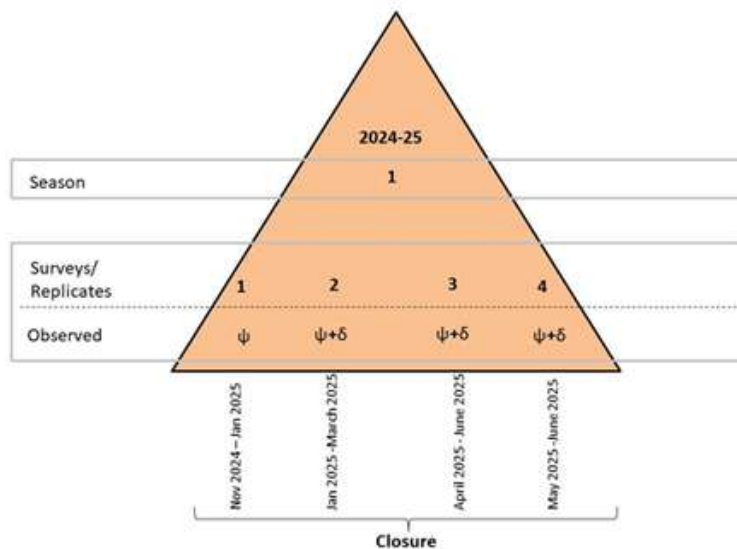


Figure 8: Surveys conducted in 2024-25 breeding season to model occupancy and reproduction of the forest owlet following Pollock's robust occupancy framework, where, ψ is probability of occupancy and δ is the conditional probability that owlets are breeding at site 's' given they are present.

Please refer to figure 9 for the distribution, occupancy, and breeding status of the forest owl within the Dangs district from our recent surveys in 2024-25 breeding season. The individual forest owl sightings per grids ranged from 1 to 8. Our four replicates (Please see the Annexure Table A1, containing the sightings of mature and juveniles per grid) recorded the highest sightings of mature forest owlets (89, 117, 182, 177). This suggests that the Dangs hosts the largest known population to date and is a global species' stronghold, surpassing Melghat (100+ Mature individuals, Kasambe et al. 2005). Additionally, the report of 104 juveniles suggests the Forest Owllet population is thriving outside Protected Areas in Dangs and coexists with local communities, providing an opportunity to work in partnership with the local stakeholders for long-term conservation in this landscape.

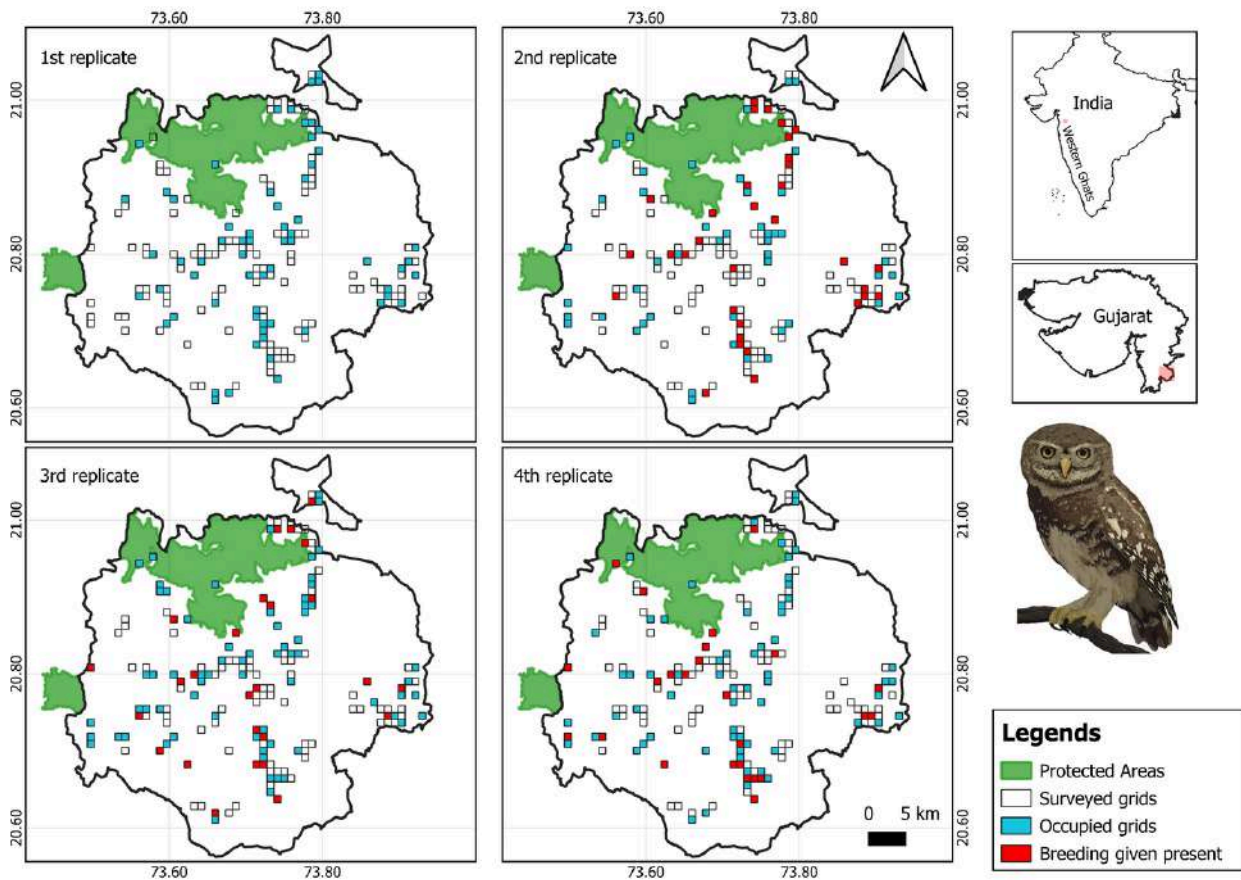


Figure 9: Map of surveyed grids per visit to assess the presence and the breeding success based on the sighting of at least one juvenile per grid for all four replicates separately. Empty (or non-colored) grids indicate unoccupied areas, blue-colored grids represent occupied sites, and red-colored grids denote confirmed breeding based on the sighting of at least one juvenile within the grid.

By the end of the field surveys, 123 of the 164 surveyed grids were observed to be occupied by the Forest Owlet, resulting in a naïve occupancy ($\tilde{\psi}_1$) estimate of 0.75. Of the occupied grids; 54 grids confirmed breeding activity, indicated by the presence of at least one juvenile, giving a naïve breeding success ($\tilde{\psi}_2$) rate of 0.44 (please see **Figure 9**). Juveniles were confirmed based on the plumage of an individual (**Figure 10**) and their behaviour - as they remained mostly still at one place waiting for their parents to provide food without getting disturbed by the presence of humans, and giving the begging call (**Figure 5**).

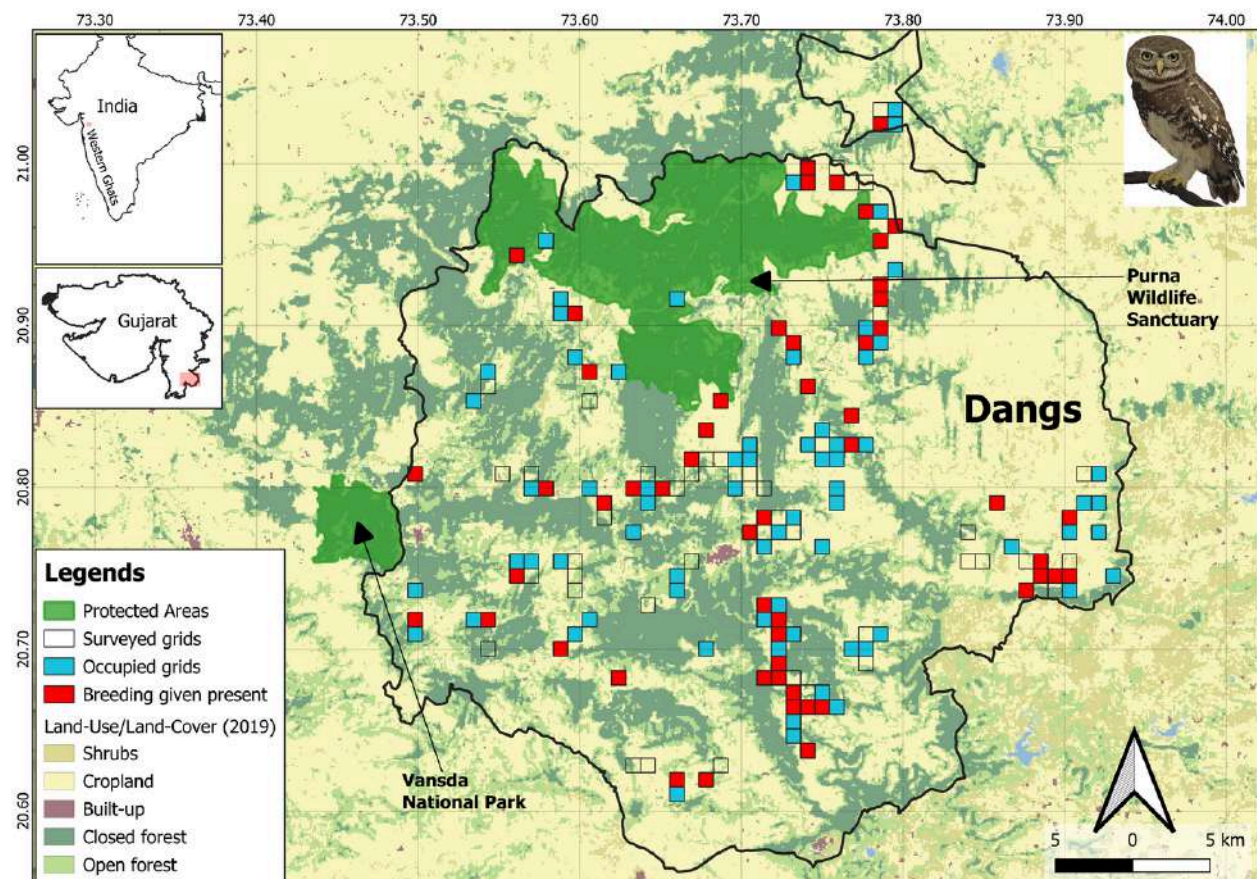


Figure 10: Map of surveyed grids in Dangs district, showing combined occupancy and breeding status across four replicates. Empty (or non-colored) grids indicate unoccupied areas, blue-colored grids represent occupied sites, and red-colored grids denote confirmed breeding based on the sighting of at least one juvenile within the grid.

Except two sites in the reserve forests, all other forest owlet positive grids, including breeding sites, were reported in agricultural fields close to small and large patches of forests dominated by teak trees and human settlements, indicating that they do tolerate human presence, anthropogenic activity to some extent. However, during our four replicates we noticed that they are sensitive to logging and small to medium scale developmental activity that alter the habitat or induce high human activities, even temporarily.



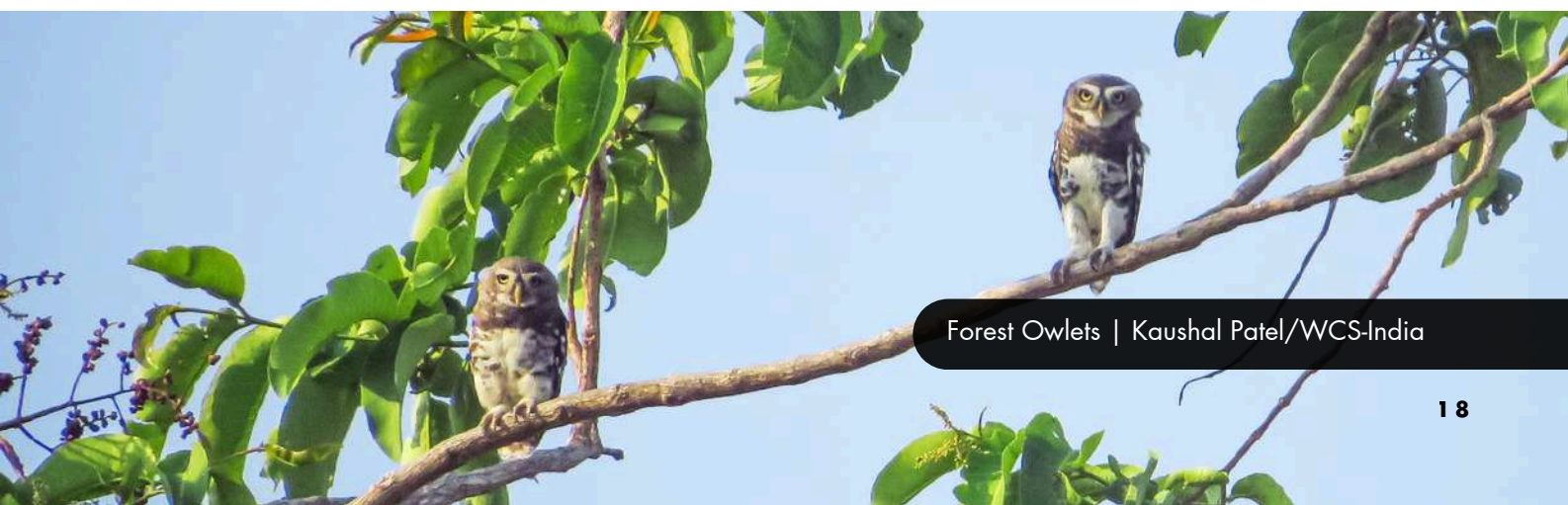
Figure 11: Juveniles observed in Dec 2024 - Jan 2025. **A.** Two chicks waiting for parents for food (prey); **B.** A juvenile forest owlet with streaks on breast and belly with barred upper flank absent; **C, D, E, & F.** A juvenile with prominent breast dark-brown and barred flanks with clear white belly and other upperparts. | Dinesh Chaudhary/WCS-India (**A, B, D, E, F**); Kaushal Patel/WCS-India (**C**)

OCCUPANCY MODELING

We analyzed our detection–non-detection data applying the occupancy models using the R package “unmarked” (Kellner et al. 2023). This approach estimates species occurrence in relation to environmental covariates while accounting for imperfect detection (Mackenzie et al. 2006). In occupancy modeling, detection probability is the chance of observing a species at a site that is actually occupied, and it is estimated from repeated surveys. The framework also evaluates how site characteristics influence occupancy probability (ψ) and how survey conditions influence detection probability (ρ).

First, we established a single-state occupancy model for forest owlet occupancy (i.e., sightings of the forest owlet regardless of breeding status) to serve as a baseline for comparison. We then developed multi-state occupancy models to identify the habitat variables that influence territory occupancy and breeding success (Nichols et al. 2007; Mackenzie et al. 2009). Our models incorporate three occupancy states: state 0 - unoccupied by forest owlet; state 1 - occupied by forest owlet; and state 2 - evidence of reproduction, indicated by juvenile sightings when the site is occupied. These states are described by two primary parameters: ψ_1 , the probability of occupancy by the forest owlet, and ψ_2 , the probability of reproduction given occupied.

Multi-state models accommodate state uncertainty and allow detection probabilities to vary by state. Detection is parameterized as: ρ_1 - probability of detecting the forest owlet when the true state is 1; ρ_2 - probability of detecting the forest owlet when the true state is 2; and δ -probability of detecting juveniles when present. We constrained ρ_1 to be equal to ρ_2 (denoted ρ) because this constraint improved model fit and parsimony. We assumed that the reproductive state remained constant within a breeding season (October–June) to satisfy the closure assumption of the occupancy models (Kendall et al. 2009). Although some sources indicate the species’ breeding season can extend into May and early June (Ishtiaq & Rahmani 2005; Mehta et al. 2007; Jathar & Rahmani 2004; our observations from surveys conducted in March–June 2024 indicate that some mortality of the juveniles likely occurred.

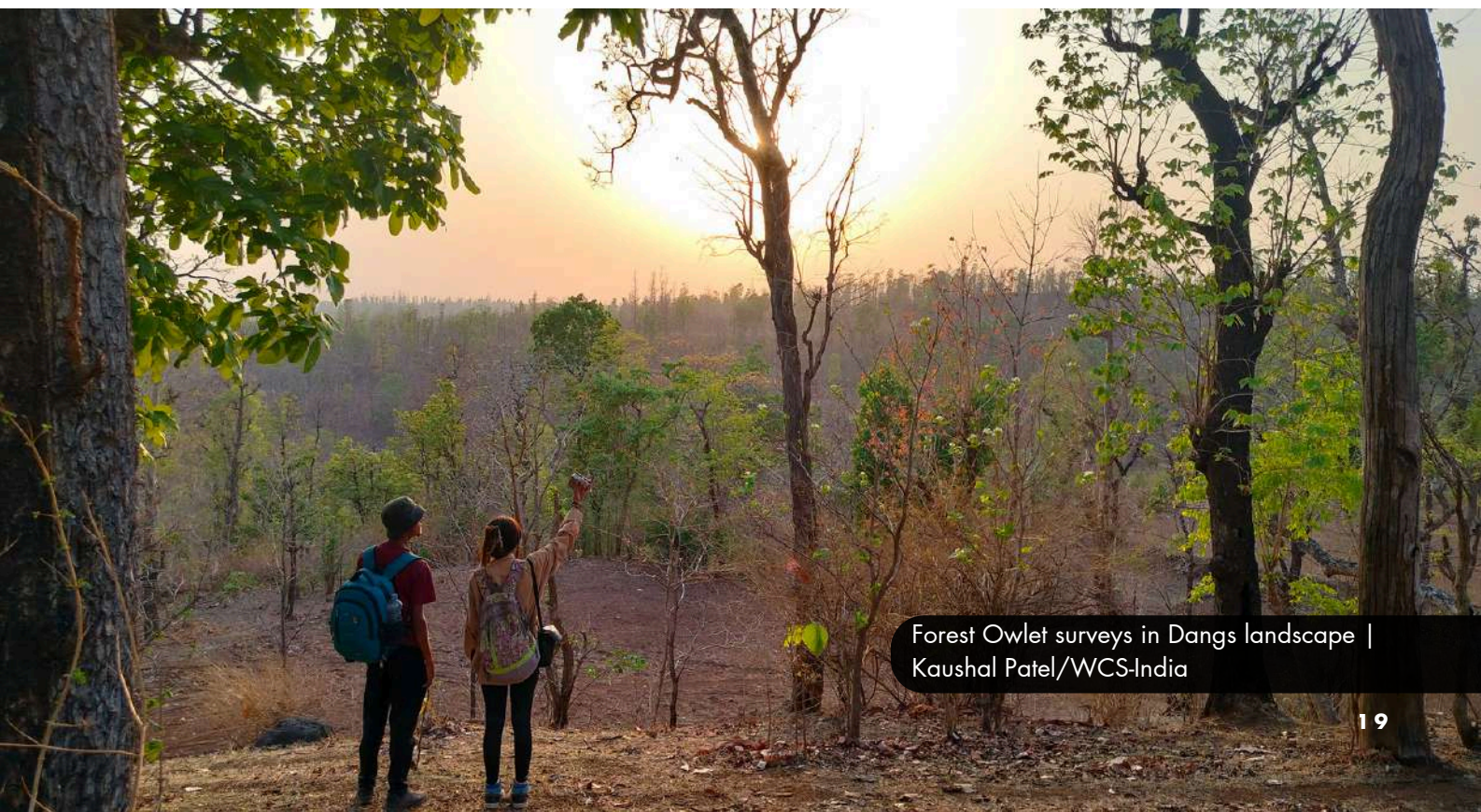


We divided the surveys into four major replicates. However, the range of surveys per grids ranges from one to ten temporal replicates included in the analysis.

The candidate set of occupancy models included single-variable models and additive combinations of variables representing habitat, anthropogenic activities, resources, and food (Table 1). We standardized continuous predictor variables, and correlated predictors ($r > 0.7$) were not included in the same models (Dormann et al. 2013).

Before running occupancy models, we determined the most plausible detection probability model by fitting different combinations of site-and survey-specific predictor variables and compared them against the Null model. We then incorporated the best detection model into subsequent occupancy models. We surveyed mostly in the Cropland and Open Forest with low degree of Slope value so we decided to use these three predictors (Cropland, Open.forest and Slope_mean) as detection predictors for both single-state and multi-state models.

We followed a step-wise process for developing occupancy models. We first found the most supported detection model against global model, then evaluated the strongest predictors of occupancy ψ for the single-state models. In the case of multi-state models, we incorporated an additional step: we held the best ψ_1 (forest owlet) model constant while we evaluated predictors of ψ_2 (the probability of reproduction given occupied). We chose the best models based on the lowest AIC value.



Forest Owlet surveys in Dangs landscape |
Kaushal Patel/WCS-India

Table 1. Description of covariates used to model variation in detectability p and occupancy ψ across grids. The “+” signifies a positive effect on the response variable, and “-” signifies a negative effect on the response variable.

	Covariate	Description	Expected effects on forest owl detectability (p)	Expected effects on forest owl occupancy (ψ1)	Expected effects on forest owl reproduction given present (ψ2)
1	Elevation (Alt_Mean)	Digital Elevation Model (DEM) was derived from Open topography (McMahon 2022), Mean value of the sampling grid was derived using Zonal Statistics tool in QGIS.		-	
2	Tree height (Treeheight_mean)	Global forest canopy height model was derived from Global Ecosystem Dynamics Investigation (GEDI) for year 2019 (Potapov et al. 2020). Mean value of the sampling grid was derived using Zonal Statistics tool in QGIS. This was used to surrogate Tree density in a given area.		-	+
3	Slope (Slope_mean)	Slope model was derived from Opentopography (McMahon 2022), Mean value of the sampling grid was derived using Zonal Statistics tool in qGIS.	-	-	
4	Cropland percentage (Cropland)	Total % of the cropland in 1sq.km grid. Landuse-landcover raster layer (2019) was used to calculate % of the feature using Zonal Statistics tool in QGIS	+	+	+
5	Open Forest percentage (Open.forest)	Total % of the Open forest in 1sq.km grid. Landuse-landcover raster layer (2019) was used to calculate % of the feature using Zonal Statistics tool in QGIS	+	+	+
6	Closed Forest percentage (Closed.forest)	Total % of the Closed forest in 1sq.km grid. Landuse-landcover raster layer (2019) was used to calculate % of the feature using Zonal Statistics tool in QGIS		-	-
7	Dominant tree (Dom_tree)	Dominant tree species in a surveyed grid, in three categories 1- Teak, 2- Teak+Mixed species, 3- Teak+Mixed species+ bamboo		-	
8	Number of tree cavities (Cavities)	Total number of cavities observed during the occupancy surveys		+	+
9	Fellow period (FeL_Period)	Observed variable. Subtraction of last harvesting time to the monsoon season. E.g. Last harvesting time was in February 2025 then June-2025 - February 2025 = 3 months of fellow period		+	
10	Agriculture period (Agr_Period)	Observed variable. Total number of months, starting from October, having standing crop in the agriculture field in a grid.		+	
11	All anthropogenic pressure (AL_Anth_Pressure)	Observed variable. Total of potential anthropogenic pressure reported in previous studies including 1. Axe mark on the cavities, 2. leaf litter collection, 3. Cattle grazing, 4. Lopped trees, 5. Logged trees, 6. any developmental activity, 7. person with catapult.		-	
12	Average Precipitation (Avgprec_mean)	Precipitation data was downloaded 30sec (~1km) resolution from WORLDCLIM (Hijmans et al., 2005) for year 2024, represents average monthly climatic data. Mean value was calculated for the months 05 to 12 using Raster calculator, and in QGIS		+	+

RESULTS: SINGLE-STATE OCCUPANCY

Of the six models used for detection probability in the single-state occupancy model, the Slope (Slope_Mean) and Cropland model received around 30% of the Akaike weight (AICwt = 0.297, Table 2). Further, we used Slope and Cropland as a covariate to account for any heterogeneity for the probability of forest occupancy. The best models suggest that the detection probability for the forest owl (ρ) was $0.672 (\pm 0.022 \text{ SE})$ and the occupancy probability (ψ) was $0.790 (\pm 0.037 \text{ SE})$ in Dangs district.

Table 2. Summary of top ranked models for estimating detection probability (ρ) for the forest owl in the Dangs, Gujarat, India. Please see Table 1 for descriptions of covariates.

	Model	AIC	delta	AICwt	cumltvWt
	Single-state forest owl occupancy				
1	p(Slope_mean + Cropland), ψ (Avgprec_mean + Open.forest + Slope_mean + TreeHeight_mean + Dom_Tree + Cavities + AL_Anth_Pressure + Fel_Period)	816.24	0	0.297	0.297
2	ρ (.), ψ (Avgprec_mean + Open.forest + Slope_mean + TreeHeight_mean + Dom_Tree + Cavities + AL_Anth_Pressure + Fel_Period)	817.29	1.046	0.176	0.473
3	p(Open.forest + Slope_mean), ψ (Avgprec_mean + Open.forest + Slope_mean + TreeHeight_mean + Dom_Tree + Cavities + AL_Anth_Pressure + Fel_Period)	817.4	1.158	0.167	0.64
4	p(Slope_mean), ψ (Avgprec_mean + Open.forest + Slope_mean + TreeHeight_mean + Dom_Tree + Cavities + AL_Anth_Pressure + Fel_Period)	817.74	1.497	0.141	0.78
5	p(Cropland), ψ (Avgprec_mean + Open.forest + Slope_mean + TreeHeight_mean + Dom_Tree + Cavities + AL_Anth_Pressure + Fel_Period)	818.2	1.956	0.112	0.892
6	p(Open.forest), ψ (Avgprec_mean + Open.forest + Slope_mean + TreeHeight_mean + Dom_Tree + Cavities + AL_Anth_Pressure + Fel_Period)	818.27	2.025	0.108	1
	Multi-state Forest Owllet Occupancy				
1	ψ 1(.), ψ 2(.), p(Slope_mean + Cropland), δ (Slope_mean + Cropland)	1197.747	0	0.324	0.324
2	ψ 1(.), ψ 2(.), p(Slope_mean), δ (Slope_mean)	1197.752	0.005	0.323	0.648
3	ψ 1(.), ψ 2(.), p(Slope_mean + Open.forest), δ (Slope_mean + Open.forest)	1198.458	0.711	0.227	0.875
4	ψ .1(.), ψ 2(.), p(.), δ (.)	1200.539	2.791	0.08	0.955
5	ψ 1(.), ψ 2(.), p(Cropland), δ (Cropland)	1202.806	5.058	0.026	0.981
6	ψ 1(.), ψ 2(.), p(Open.forest), δ (Open.forest)	1203.414	5.666	0.019	1

Of a set of 14 candidate models (**Table 3**), the best model estimated an occupancy probability ($\hat{\psi}$) of 0.786 (± 0.038 SE), which is a slight improvement from a naïve occupancy of 0.75. While, the number of cavities (Cavities) was by far the most important predictor for the forest owlet occupancy (AICwt = 0.320) and Cropland with Cavities received almost the same support (AICwt = 0.305), the Slope received the less (AICwt = 0.145) support among the top three models. Our single-state occupancy analysis suggests that the number of cavities and the Cropland percentage had positive influence on the forest owlet occupancy while the slope degree value has a negative influence on the forest owlet occupancy (please see **Figure 12 and Table 5**).

Table 3. Summary of top ranked Single-state occupancy models in explaining probability of the forest owlet occupancy in the Dang, Gujarat in the northern Western Ghats, India.

	Models	AIC	delta	AICwt	cumltvWt
1	p(Slope_mean + Cropland), ψ (Cavities)	811.02	0	0.32	0.32
2	p(Slope_mean + Cropland), ψ (Cropland + Cavities)	811.12	0.09	0.305	0.624
3	p(Slope_mean + Cropland), ψ (Slope_mean)	812.6	1.58	0.145	0.769
4	p(Slope_mean + Cropland), ψ (Cropland)	815.56	4.54	0.033	0.802
5	p(Slope_mean + Cropland), ψ (.)	815.82	4.8	0.029	0.831
6	p(Slope_mean + Cropland), ψ (Open.forest + Slope_mean + Cavities)	816.04	5.02	0.026	0.858
7	p(Slope_mean + Cropland), ψ (Closed.forest)	816.27	5.25	0.023	0.881
8	p(Slope_mean + Cropland), ψ (TreeHeight_mean)	816.47	5.45	0.021	0.902
9	p(Slope_mean + Cropland), ψ (Cropland + Agr_Period)	816.58	5.55	0.02	0.922
10	p(Slope_mean + Cropland), ψ (Cropland + Fel_Period)	816.58	5.55	0.02	0.941
11	p(Slope_mean + Cropland), ψ (Alt_Mean)	816.82	5.79	0.018	0.959
12	p(Slope_mean + Cropland), ψ (Dom_Tree + Al_Anth_Pressure)	816.96	5.94	0.016	0.975
13	p(Slope_mean + Cropland), ψ (Avgprec_mean)	817.35	6.32	0.014	0.989
14	p(Slope_mean + Cropland), ψ (Open.forest)	817.77	6.74	0.011	1

RESULTS: MULTI-STATE OCCUPANCY

Consistent with single-state occupancy model, the Slope (Slope_Mean) and Cropland model received more than 30% of the Akaike weight ($AICwt = 0.324$, **Table 2**) as the best of six models. The model estimated an Occupancy probability ($\hat{\psi}_1$) of $0.787 (\pm 0.037 \text{ SE})$ and Reproduction probability ($\hat{\psi}_2$) of $0.628 (\pm 0.079 \text{ SE})$ given present.

Following a step-wise procedure for multi-state occupancy, we first investigated the top predictors of occupancy of forest owlet ($\hat{\psi}_1$). The best supported model for the forest owlet occupancy included number of cavities and cropland percentage in a grid ($AICwt = 0.731$ in a set of 14 models, **Table 4**). Consistent with single-state occupancy modelling, number of cavities and the Cropland percentage had positive influence on the forest owlet occupancy while the slope degree value had a negative influence on the forest owlet occupancy (please see **Figure 13 and Table 5**).

We held forest owlet occupancy variables constant (Cropland + Cavities), as we evaluated specific predictors for the reproduction ($\hat{\psi}_2$). The best model for the probability of reproduction given occupied ($\hat{\psi}_2$) was of $0.660 (\pm 0.070 \text{ SE})$ which was improved from the naïve probability of reproduction of 0.44 and the occupancy of forest owlet ($\hat{\psi}_1$) was close to 1 ($0.974 \pm 0.044 \text{ SE}$). The multi-state occupancy model predicted higher estimates compared to both the naïve occupancy of 0.75 and the occupancy probability ($\hat{\psi}$) of $0.786 (\pm 0.038 \text{ SE})$ from the single-state occupancy model. The best model ($AICwt = 0.731$ in a set of seven models, **Table 5**) had a single predictor - number of cavities - which had a positive influence on the probability of reproduction given occupied (please see **Figure 13, Table 5**). Please see **Figure 14** for the variation in the occupancy probability and **Figure 15** for the breeding probability in the landscape. Predicted values of occurrence and reproduction from the multi-state occupancy models were overlaid on the surveyed grids.

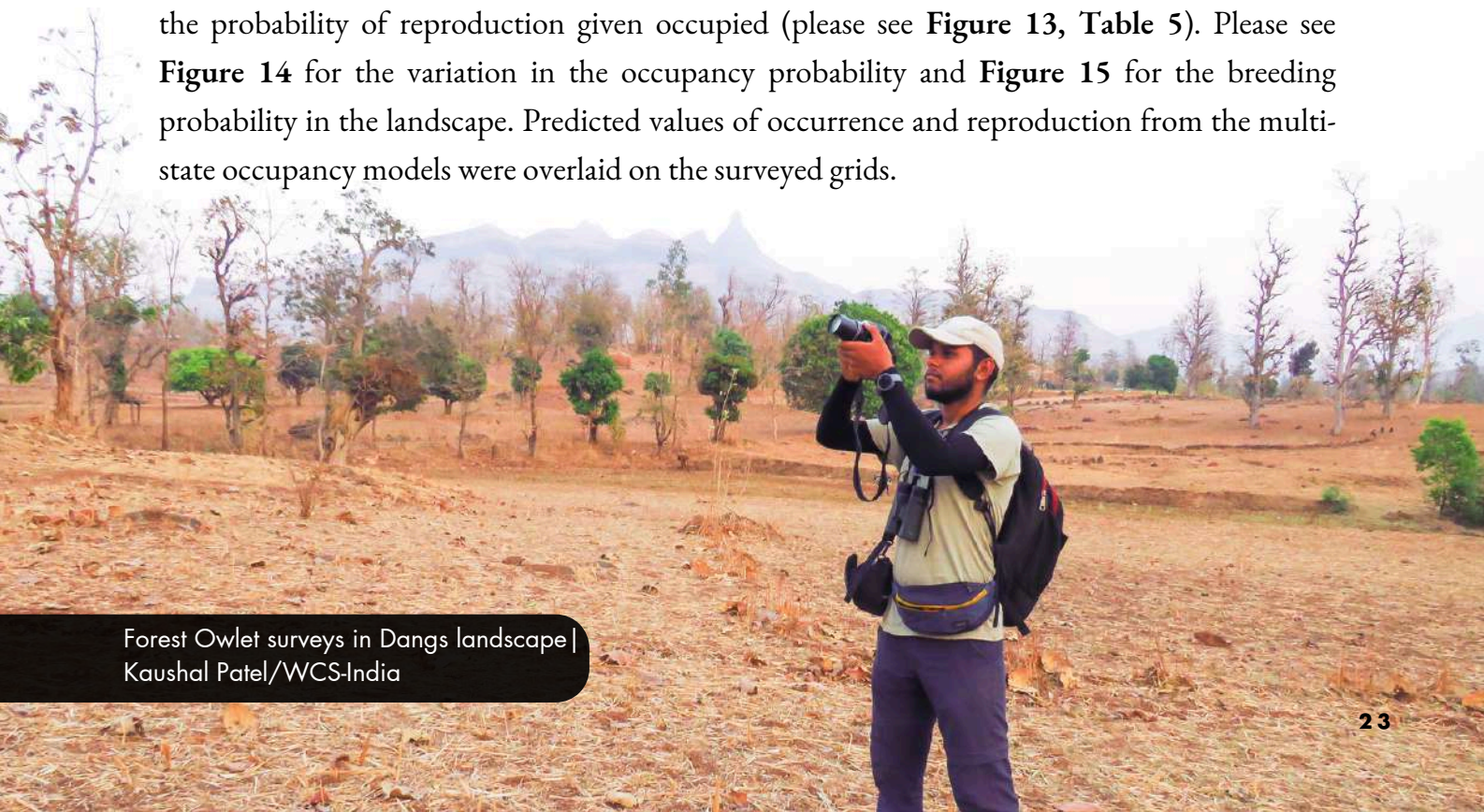


Table 4. Summary of top ranked Multi-state occupancy models in explaining probability of the forest owlet occupancy (ψ_1) while keeping the probability of reproduction given present (ψ_2) constant in the Dangs, Gujarat in the northern Western Ghats, India.

	Models	AIC	delta	AICwt	cumltvW t
1	$\psi_1(\text{Cropland} + \text{Cavities}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1189.16	0	0.731	0.731
2	$\psi_1(\text{Cavities}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1192.59	3.42	0.132	0.864
3	$\psi_1(\text{Slope_mean}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1194.39	5.23	0.054	0.917
4	$\psi_1(\text{Cropland} + \text{All_Anthro_Pressure}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1197.27	8.11	0.013	0.93
5	$\psi_1(\text{Cropland}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1197.41	8.25	0.012	0.942
6	$\psi_1(.), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1197.75	8.58	0.01	0.952
7	$\psi_1(\text{Closed.forest}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1198.23	9.06	0.008	0.96
8	$\psi_1(\text{Cropland} + \text{Agr_Period}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1198.39	9.23	0.007	0.967
9	$\psi_1(\text{Cropland} + \text{Fel_Period}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1198.39	9.23	0.007	0.974
10	$\psi_1(\text{TreeHeight_mean}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1198.57	9.4	0.007	0.981
11	$\psi_1(\text{Dom_Tree} + \text{All_Anthro_Pressure}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1198.93	9.76	0.006	0.986
12	$\psi_1(\text{Alt_Mean}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1199.08	9.92	0.005	0.991
13	$\psi_1(\text{Avgprec_mean}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1199.2	10.04	0.005	0.996
14	$\psi_1(\text{Open.forest}), \psi_2(.), p(\text{Cropland} + \text{Slope_mean}), \delta(\text{Cropland} + \text{Slope_mean})$	1199.7	10.54	0.004	1



Table 5. $\hat{\beta}$ - coefficient estimates indicating slopes and associated standard errors (SE) of covariates from top models used to explain forest owllet occupancy in the Dangs, Gujarat in northern Western Ghats, India. Here, Ψ and Ψ_1 is the probability of occupancy by the forest owllet, and Ψ_2 , the probability of reproduction given occupied.

	Models	States	$\hat{\beta}_{\text{Intercept}}$ (SE)	$\hat{\beta}_{\text{Cavities}}$ (SE)	$\hat{\beta}_{\text{Cropland}}$ (SE)	$\hat{\beta}_{\text{Slope_mean}}$ (SE)
Single-state model for Occupancy	Model 1	Ψ	1.301 (0.224)	0.691 (0.341)	--	--
	Model 2	Ψ	1.304 (0.232)	0.642 (0.323)	0.272 (0.198)	--
	Model 3	Ψ	1.299 (0.224)	--	--	-0.435 (0.188)
Multi-state model for Occupancy	Model 1	Ψ_1	2.969 (1.122)	2.107 (1.033)	0.919 (0.495)	--
		Ψ_2	0.662 (0.266)			
	Model 2	Ψ_1	1.624 (0.462)	1.085 (0.661)	--	--
		Ψ_2	0.563 (0.379)			
	Model 3	Ψ_1	1.568 (0.509)	--	--	-0.675 (0.376)
		Ψ_2	0.676 (0.326)			
Multi-state model for Reproduction	Model 1	Ψ_1	3.599 (1.727)	0.666 (0.311)	--	--
		Ψ_2	0.560 (0.254)			

Figure 12. The relationship between occupancy and habitat covariates predicted by the top single-state model for the forest owllet (a) Numbers of Cavities observed in a grid, (b) Percentage of cropland in a grid and (c) Mean value of the Slope in degree for a grid. The predicted probability of occupancy is plotted over the observed range of values of each predictor. Grey colored bands represent 95% confidence interval.

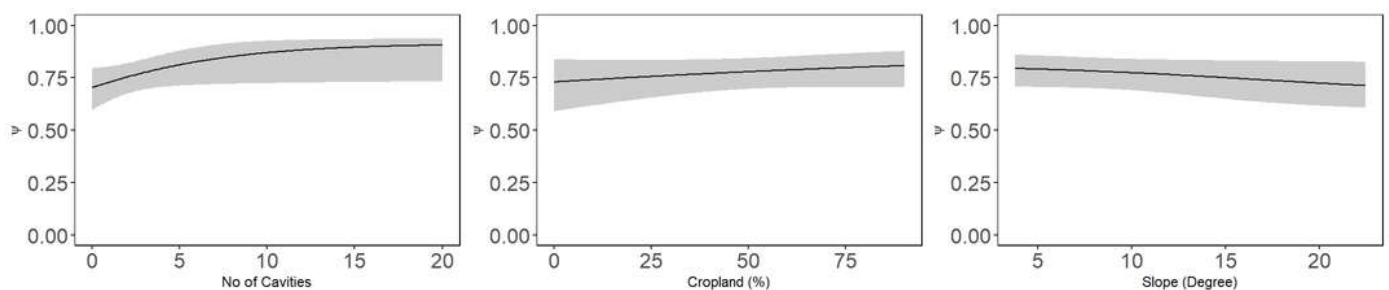


Figure 13. Number of cavities best predicted (a) occupancy probability (ψ_1) and (b) probability of breeding given present (ψ_2) - as seen by slope estimates from the Multi-state occupancy models. Grey colored bands represent 95% confidence interval.

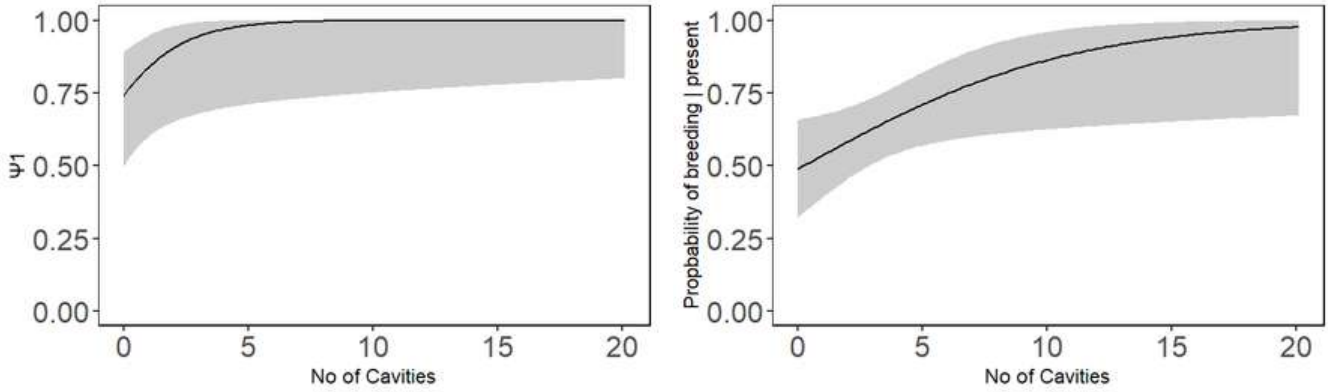


Figure 14. Estimated forest owllet occupancy probability (2024-25) in the Dangs, northern Western Ghats landscape in the State of Gujarat, India. Occupancy probabilities have been divided into five classes to show variation in the landscape.

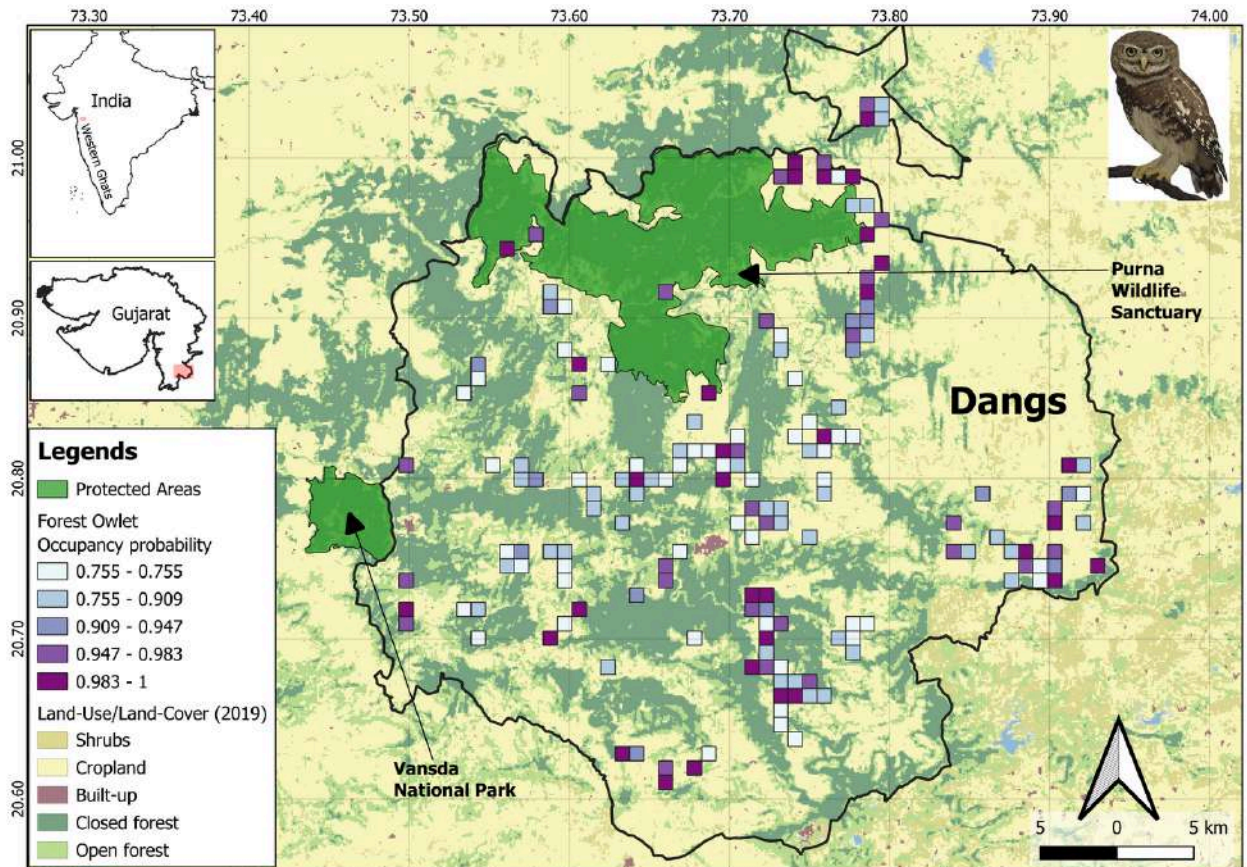
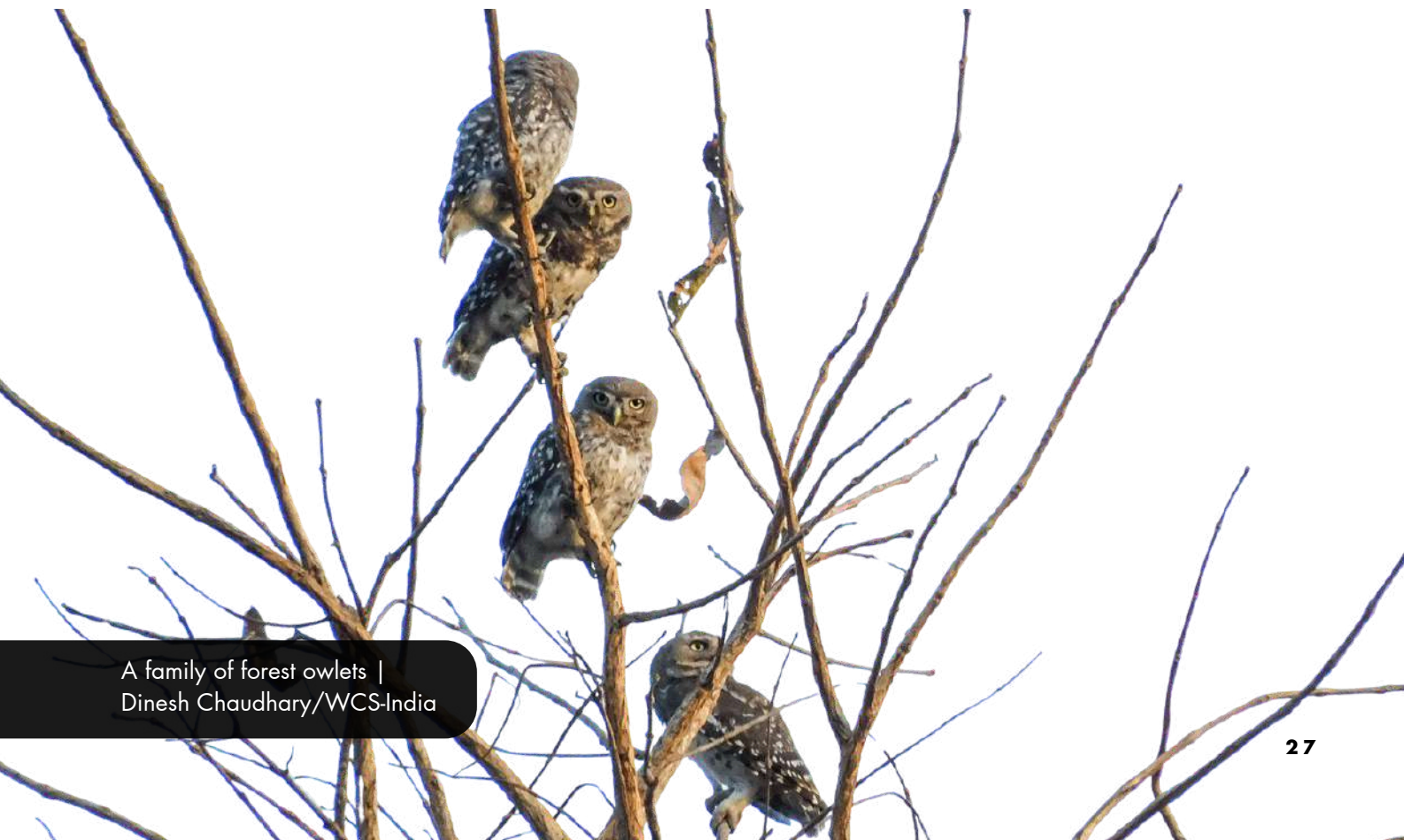
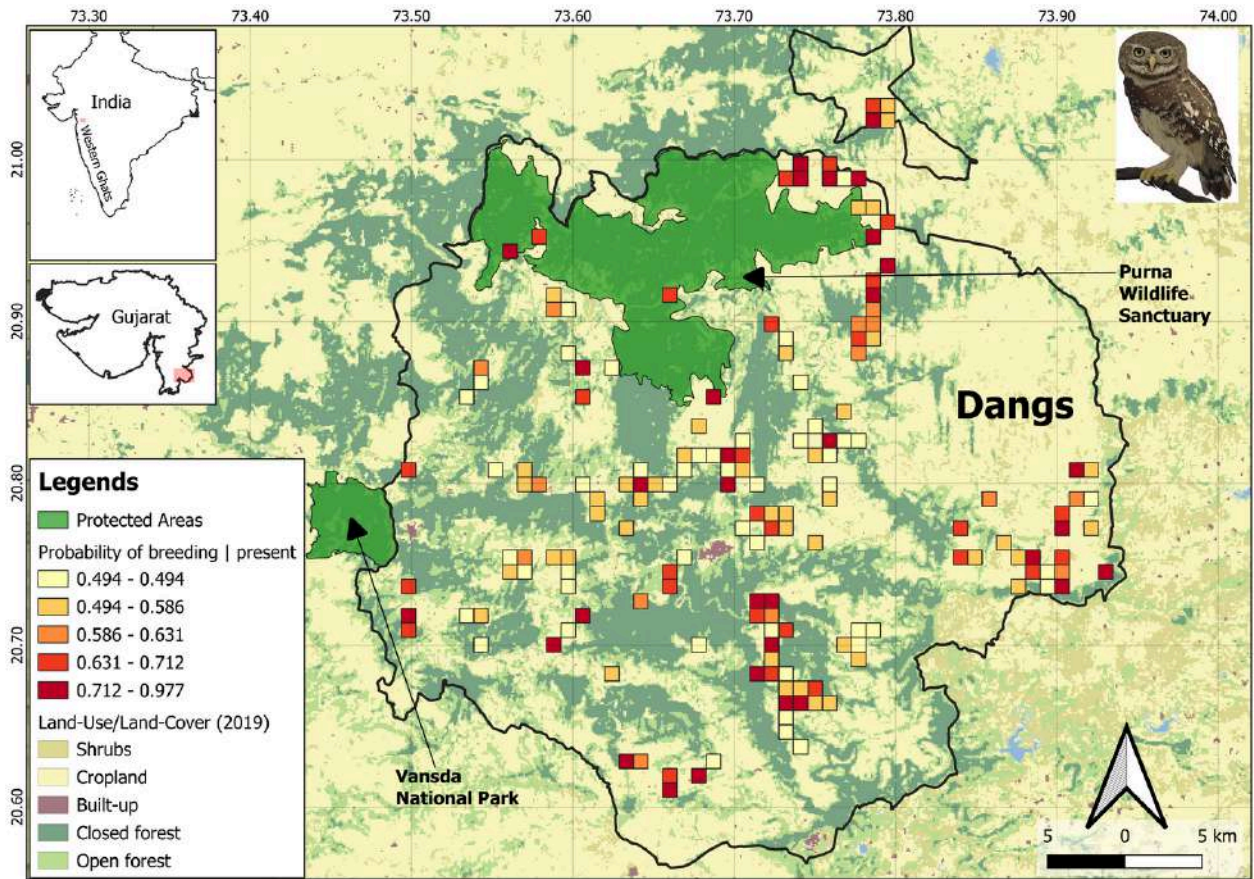


Figure 15. Estimated forest owlet probability of breeding given present (2024-25) in the Dangas, northern Western Ghats landscape in the State of Gujarat, India. Breeding probabilities have been divided into five classes to show variation in the landscape.



A family of forest owlets |
Dinesh Chaudhary/WCS-India

DISCUSSION: OCCUPANCY AND REPRODUCTION SUCCESS USING OCCUPANCY MODELS

Role of prior knowledge and a well-designed study

The occupancy surveys for the breeding season 2024–25 were designed using information from positive locations and insights from prior studies (Jambu & Patel 2021; Khan et al. 2023). Before conducting the main surveys and also due to time limit constraint, we conducted pilot surveys in April–June 2024 which helped us in gaining additional knowledge on habitat features and the natural history of adults and juveniles, among other factors. We then overlaid 1 sq.km grids to delineate the final survey units. We also selected the sites (non-random) or the grids which had the potential of being occupied by the species.

Prior knowledge of location aided detections, allowing us to refine sighting probabilities. Consequently, occupancy estimates during 2024-25 are informed by this preparatory information, in contrast to earlier surveys conducted without such knowledge. For example, Jambu & Patel (2021) reported a naïve occupancy of 0.28 for the 2015-16 surveys, and Khan et al. (2023) estimated an average occupancy of 0.27 for the 2018-19 surveys in Dang, where prior knowledge of species locations was not incorporated in their study design.

Natural history knowledge of the forest owlet juveniles

Several studies have addressed the natural history of the forest owlet (Ishtiaq & Rahmani 2005; Jathar & Rahmani 2004; Mehta et al., 2017). During pilot surveys conducted in April–June 2025, five sightings of juveniles provided valuable insights into their plumage development relative to adults (**Figure 4 and 11**), as well as juvenile behavior and vocalizations. The juveniles remained largely inconspicuous within the habitat, often motionless until they emitted a distinctive call (**Figure 5**). Juveniles gradually developed the adult plumage through the season; however, knowledge of behavior helped us distinguish juveniles from adults. Recognizing this call facilitated the detection of a total of 104 juveniles across 54 grids in 2024–25. Consequently, we were able to estimate reproduction probability in an occupancy framework.



Role of replicates surveys

To address imperfect detection, replicates (repeated visits to the same site or area over a short period) are essential for the occupancy surveys, although they may introduce biases in occupancy estimates. The study employed a four-replicate survey design within a multi-state occupancy framework to detect both adults and juveniles across life-history stages. The numbers of sightings per replicate were 89, 117, 182, and 177, respectively. This pattern suggest that after February, habitat openness increased due to deciduous-forest phenology and agricultural field management (e.g., lopping), which likely elevated detection rates. During the first visit, adult pairs may have been preoccupied with care, potentially reducing detectability. Observer proficiency also likely improved over time, further enhancing detections of the species. By covering the full breeding season (October–June), the study obtained a greater number of juvenile observations, facilitating their incorporation into the multi-state occupancy analysis.

Role of Multi-state occupancy in our study

Single-state occupancy models, having only two states (state 0-unoccupied, state 1-occupied) are limited to estimating the probability of occupancy. Considering this, multi-state occupancy models have the additional capability of incorporating another state - for example in our case (state 2- reproduction given presence). When we compared the results from the single-state and multi-state occupancy models using our dataset, we were able to improve the estimate of probability of occupancy from 0.79 to nearly 1 in multi-state occupancy models. The best predictors for the detection probability - Slope and Cropland percentage and the probability of occupancy-number of cavities, cropland and slope remained same for both the models. We were able to estimate the probability of reproduction given presence, which improved from the naïve estimate of 0.44 to 0.66. We were also able to identify number of cavities as the best predictor for reproduction using the multi-state occupancy model, which can be used to highlight the importance of cavities and develop conservation strategies accordingly.



Role of Tree Cavities for the forest occupancy and reproduction

Approximately 18% of the global avifauna (at least 1,878 species) depend on tree cavities for breeding and roosting (van der Hoek et al. 2017). Among these, only about 19% consistently excavate their own cavities - woodpeckers, with an additional ~7% (e.g., barbets, parakeets, trogons) being facultative excavators (Varghese 2002; van der Hoek et al. 2017). Consequently, at least 72% of cavity-users, including owls, cannot excavate their own cavities and rely on natural decay holes or cavities created by other excavators (Cockle et al. 2011; van der Hoek et al. 2017). This makes cavities an invaluable resource for cavity-nesting birds, including the forest owlet. Previous studies have reported that forest owlets use both natural cavities and those excavated by woodpeckers (Jathar & Rahmani 2004; Ishtiaq & Rahmani 2005; Mehta et al. 2019). In Dangs, our direct observations and indirect evidence (pellets from 32 sites) show that forest owlets utilize woodpecker-excavated cavities, exclusively on live trees, with 4 -10 cavities per tree. The high cavity abundance in this area likely reflects the diversity and activity of woodpeckers (at least nine woodpecker species, Jambu and Patel 2021), which play an indirect but crucial role in provisioning the roosting and nesting resources that forest owlets require.

Our results indicate a positive relationship between the availability and abundance of tree cavities and both occupancy and reproduction of forest owlets. Therefore, any conservation strategy for the forest owlet must prioritize the protection of cavity-bearing trees and the ecological processes that generate cavities, particularly the activity of primary excavators such as woodpeckers. Cavity as covariates have not been used in many previous studies (Khan et al. 2023, Kulkarni et al. 2022, Jathar and Rahmani 2004, Kulkarni and Mehta 2020). We recommend including cavities as one of the habitat covariates in the upcoming studies when evaluating the most important predictors for the occupancy as well as reproduction of Forest Owlets. Mukardamwala et al. (2024) baseline study in Purna Wildlife Sanctuary, Dangs found 6.4% of 843 trees had cavities, with 48% of cavities excavated. Larger-girth trees bore cavities more often, especially Teak. Their study also suggests prioritizing the preservation of large trees and cavity-bearing species to safeguard cavities as a landscape resource.



A white-naped woodpecker with a tree cavity |
Kaushal Patel/WCS-India

Role of Cropland and slope

Our analysis, employing both single- and multi-state occupancy models, identified two key predictors of detection, and occupancy probability: the proportion of cropland or agricultural fields and the slope of the terrain. Forest owlets were observed in and around agricultural fields, consistent with edge-specialist behaviour, which helps explain the relatively high detection and occupancy rates in our study area. The negative relationship between slope and forest owllet occupancy probability is likely driven by the fact that agricultural fields predominantly occur at lower slopes, while higher-slope areas tend to be less feasible for agriculture and therefore remain more forested. The positive association with agricultural-field presence should not be interpreted as fields being essential habitat per se; rather, in our study area, fields are in close proximity to forests and form a matrix that interfaces with forested habitat, potentially facilitating movement and edge-related resources for the species. Similar to Kulkarni and Mehta (2020) in central India, the forest owllet in Dangs was seen to prefer agricultural areas adjacent to forests. Likewise, in East Kalibhit, Madhya Pradesh, the species was reported from plain terrain and gentle slopes (Mehta et al. 2017). In contrast, the forest owllet preferred hilly terrains in Melghat, Nandurbar and Tansa Wildlife Sanctuary (Mehta et al. 2016, Kulkarni and Mehta 2020). Khan et al. (2023) also showed that the forest owllet occupancy is positively influenced by agricultural fields, possibly because the open fields attract rodents, which comprise a major proportion of its diet (Mehta et al. 2018). There has been no study to date on the dietary requirements of the forest owllet in the northern Western Ghats. Investigating the hypothesis that agricultural fields support a large portion of the forest owllet's diet, particularly through rodent prey, would be worthwhile for future research.



Role of Forest Cover

Our model did not identify forest cover percentage as an important predictor in our area, but agricultural fields consistently occurred in close proximity to forests. The forest cover in Dangs appears to help maintain the diversity and abundance of woodpeckers (Jambu and Patel 2021), which in turn indirectly facilitates the availability of nest cavities for forest owlets and other bird species and owls. During the surveys, we also observed forest owlets foraging in forested areas as well as along field edges. It remains unclear from the occupancy surveys alone how habitat use across micro-habitats (forested vs. edge vs. open areas) is partitioned. The use of radio telemetry could provide deeper insights into habitat use and foraging ground selection.

OTHER BREEDING BIOLOGY RELATED OBSERVATIONS



During the occupancy surveys, we were also able to identify 32 roost or nest sites through observations of forest owlet activity and indirect signs, such as pellets (**Figure 16**). All identified sites were located on live trees with secondary cavities - those excavated by other species like woodpeckers, with 4–10 cavities per tree (**Figure 16**), at heights ranging from 9 to 15 meters. Notably, this range exceeds previous reports of nest heights in the Central Indian landscape, which were documented at 7.57 ± 2.73 m (Mehta et al., 2022) and 6.97 ± 1.10 meters (Jathar and Rahmani, 2004) 8.0 ± 1.04 m (Ishtiaq & Rahmani 2005). We also experimented different methods to determine if nesting had occurred in these sites (**Figure 17**).

Figure 16: One of the actively used nest sites by forest owlet on a live *Albizzia procera* tree, excavated by a Woodpecker (on left), was further confirmed by the presence of pellets on the opposite side of tree from the active cavity, serving as indirect evidence (bottom). Photo Credits: Kaushal Patel/WCS-India





Figure 17: Team members inspecting a cavity using a 15-foot (4.5m) telescopic pole fitted with an endoscope camera for an inside view of the nest to understand breeding status, However, all cavities were not accessible | Harsh Patel/WCS-India

We identified 55 breeding pairs with 104 juveniles, ranging from one to three per pair. The average brood size per pair was observed to be 1.89 (SE \pm 0.10). Due to the greater height of nests in the Dangs forests, we were unable to directly assess clutch size, hatchling success, or fledgling success. However, when comparing estimates from Toranmal - based on a clutch size of 2.5 and a fledgling success rate of 0.41% (Jathar and Rahmani 2004)- the average number of fledglings per pair was estimated at 1.02. This figure is nearly double the fledgling count estimated for the Dangs forests. Formula: fledglings per pair = (clutch size x fledging success rate).

Unlike Mehta et al. (2022), we observed that forest owlet nests and trees are reused by jungle and spotted owlets after forest owlet fledglings have left the cavity. In fact, we also observed the forest owlet being chased on a few occasions by a pair of spotted owlets or jungle owlets that were newly inhabiting the area.

Grid ID: 20849 - Chinchali: We discovered a deceased forest owlet (**Figure 18**), while another individual from the pair was observed nearby in January 2025. We continued monitoring this site and the site was confirmed as breeding after the sighting of a juvenile. Since the forest owlets in the Dangs are not banded with color identifiers (or marked), we are unable to determine whether the surviving individual paired with another bird, or if the site was overtaken by a different pair. However, we presumed that the surviving individual had paired with another bird and mated successfully.

Site Fidelity: Consistent with the findings of Jathar & Rahmani (2004) and Mehta et al. (2017), we observed notable nest site fidelity in forest owlets during this breeding season. Specifically, we identified four out of five nesting sites that housed juveniles, corroborating previous reports of juvenile presence at these sites or grids during the 2023-24 breeding season.



A jungle owlet in a tree cavity |
Dinesh Chaudhary/WCS-India

Re-nesting: Ishtiaq and Rahmani (2004), in Toranmal, observed that a pair re-nested, with the fledgling stage persisting until May. Similarly, Jathar & Rahmani (2004), over a three-year study period, documented that three out of nine breeding attempts involved re-nesting, with the fledgling stage extending until May. In the Dangs, we also observed juveniles with their parents (fledgling stage) until June, which could indicate re-nesting or perhaps a delay in breeding activity and egg-laying dates. Such variability in breeding timing may be influenced by environmental factors or anthropogenic disturbances and therefore needs long-term monitoring of the population.

POTENTIAL THREATS IDENTIFIED

We discovered a dead forest owlet in one of the grids (**Figure 18**). Upon closer inspection, we noticed that its head was twisted, and there was a wet substance on the head and neck. The body was remarkably fresh, and notably, no parts were missing (for superstition or rituals). Although the cause of death was unclear, it did not appear to be natural. We promptly notified the ranger, forester, and watcher responsible for that area, as the forest owlet is a Schedule I species. After completing the necessary paperwork, they proceeded to incinerate the body.

We identified the removal of wild animals from their nests for use as pets as a direct threat to the species, while hunting small mammals for bushmeat represents an indirect threat to the population. Additionally, some individuals misunderstand hunting regulations, believing they only apply to certain species like wild ungulates and parrots, and are unaware that owls are also classified as Schedule I species. Raising awareness about this classification and informing the community that hunting or harming these owls and other species is a punishable offense will be a key focus in our future outreach efforts. A comprehensive assessment of threats to the forest owlet and its habitat is essential for guiding future conservation efforts.

Figure 18: A dead forest owlet from grid 20849-Chinchali (N) with unknown cause of death. **A.** Dorsal view, **B.** Ventral view. | Dinesh Chaudhary/WCS-India



MAPPING STAKEHOLDERS AND INITIATING AWARENESS CAMPAIGNS

Important key stakeholders in the Dangs district

1. Local Communities: Residents around forest owl habitats play a crucial role in conservation efforts. Most negative interactions and threats to the species and its habitat can be mitigated by working with these communities.
2. Gujarat Forest Department: Our team maintains regular communication with the Divisional Forest Officers (DFOs) of North and South Dangs for fieldwork planning and updates on species sightings. During the last summer survey (April–June 2024), officials from South Dangs, including the Deputy Conservator of Forests (DCF), Assistant Conservator of Forests (ACF), and Range Officer of Ahwa, visited the project site and were apprised of the project activities.
3. Education Department: We engaged with officials from the Education Department in Ahwa, presenting our project and its significance. They expressed interest in raising awareness and requested a formal proposal to facilitate educational outreach programs in schools.
4. Eco-Development Committees (EDCs): These local organisations, operating under Forest Department oversight, focus on sustainable development and conservation initiatives. The DCFs of both divisions have encouraged involving EDC members in awareness campaigns for the forest owl.
5. Local Bird Guides: Several individuals serve as bird guides in the region. Training about 25 local individuals in bird identification and ethical birding practices can enhance conservation efforts and foster community engagement.
6. Private Landowners and Village Heads: Many forest owl nest and roost sites are on private lands. Engaging landowners and village heads is essential for monitoring and protecting these sites from threats such as logging and hunting.
7. Other Research Institutes: Collaborations with institutions such as IISER-Tirupati, SACON, and Navsari Agricultural University provide valuable insights into past and ongoing research in the landscape.





Figure 19: Involvement of local bird guides during Forest Owlet Conservation Day on 24th Oct 2024 at Kilad eco-tourism site, Waghai, Gujarat | WCS-India



Figure 20: Mr. Dinesh Chaudhary delivering a presentation on forest owlet ecology and other important birds and their conservation in the landscape during an event on sustainable lifestyle practices on 29th January 2025 at Mahal ecotourism site | WCS-India



Figure 21: Mr. Kaushal Patel explaining the concept of the food web in ecosystems and its importance for maintaining ecological balance, with a focus on the Dangs forests (on the left). He also shared insights on the history of the forest owl's rediscovery, detailing what current research has revealed about this species, both in the Dangs landscape and in other areas, while emphasising the significance of conserving the forest owl and its habitat in this region (on the right).
 Photo Credits: Forest Owllet Project | WCS-India



Figure 22: Involvement of local students and forest staff during the event on sustainable lifestyle practices on 29th January 2025 at Mahal ecotourism site | WCS-India



Figure 23: A field visit with one of our key stakeholders, the Gujarat Forest Department. From left to right – the Range Forest Officer (Ahwa Range), Principal Investigator - Mr. Kaushal Patel, Field intern - Mr. Harsh Patel, the Deputy Conservator of Forests - South Dangs Division, and the Assistant Conservator of Forests - South Dangs Division | WCS-India

Stakeholder Engagement and Awareness Activities

1. Forest Owlet Conservation Day (October 24, 2024): Organised in collaboration with the South Dangs Forest Department, this event brought together forest personnel, bird guides, and conservationists to discuss community-driven conservation strategies. An outreach poster and brochure on "Owls of Surat Dangs" were released.
2. Sustainable Lifestyle Practices Workshop (January 29, 2025): Hosted by the North Dangs division at the Mahal ecotourism site, this event featured participation from forestry officials, students, and researchers. Our team delivered a presentation on forest owlet ecology and distributed educational brochures.
3. Dang Bird Festival (18th and 19th March, 2025): We organized the "Dangs Bird Festival 2025" at Kilad Ecotourism campsite. The event saw the participation of 120 individuals, including fifty students from five schools, five teachers, forest staff, and local bird guides. In collaboration with the South Dangs division, participants gained valuable insights into bird identification, their habitats, and the conservation of raptors, including the forest owlet. This initiative aimed to foster awareness and promote active involvement in ecological preservation. A brochure on "Raptors of Surat-Dangs" was released and distributed amongst the participants during the event.



Figure 24: Celebration of Forest Owlet Conservation Day with the South Dang Division of the Gujarat Forest Department | WCS-India

Learnings from the Stakeholder Engagement

Interacting with a diverse group of stakeholders provided valuable insights into their knowledge, interests, and challenges.

- While we engaged with several local bird-guides who expressed strong interest in pursuing an alternative livelihood, they also demonstrated enthusiasm for formal training, viewing national and international programs as essential steps toward establishing bird-guiding as a legitimate career. Currently, birding tour operations lack formal institutionalization, with no established rules, regulations, or ethics. So, formalizing a structured birding club could be instrumental in elevating bird-guiding as a credible livelihood option.
- The Gujarat Forest Department plays a crucial role in preserving the forest owlet habitat, including monitoring timber depot operations, and preventing both legal and illegal logging of cavity-bearing trees is essential to habitat conservation; sustained engagement with the department and targeted capacity-building workshops will be beneficial in the coming years.
- The district education department responded positively to collaborating with school students to raise awareness about wildlife, including birds and insects, though there is concern about hunting birds with catapults among students during their free time; we plan to initiate awareness programs in selected schools to promote wildlife conservation and humane coexistence.
- Previous surveys conducted by IISER Tirupati and SACON provided valuable secondary information for occupancy survey planning, and we intend to sustain and expand collaborations with these institutes in the future.
- Our Phase-I project did not include interactions with private landowners or village heads, but going forward we aim to involve them to disseminate forest owlet conservation messages and monitor nest sites. Exposure visits to Community Conservation Areas will offer practical lessons for local leaders to implement context-specific conservation strategies in the region.

Overall, our next steps include establishing a formal birding club with a code of ethics, designing formal training programs for bird-guiding as a sustainable livelihood. We also plan to strengthen collaborations with the Gujarat Forest Department and the education department to support habitat conservation and community awareness. In addition, we will initiate school-based awareness campaigns, monitoring breeding sites, and expand stakeholder engagement to private landowners and village heads through exposure visits to conservation areas.



Blooming of milk and wine lily (*Crinum zeylanicum*) in the Dangs landscape | Kaushal Patel/WCS-India

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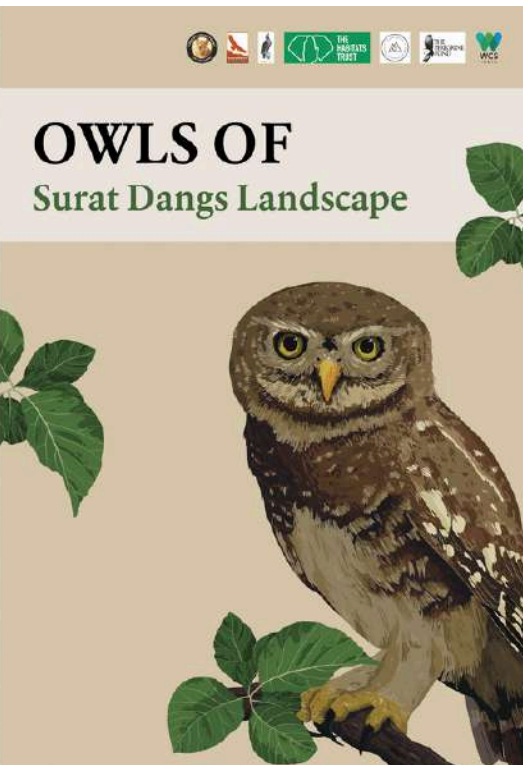
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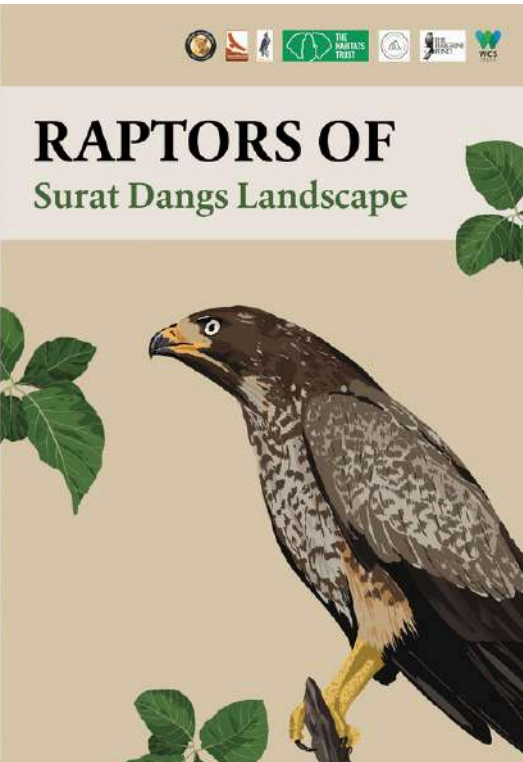


ANNEXURE

Awareness Material: Multilingual brochure on the “Owls of Surat-Dangs Landscape” covering 14 species of owls from the landscape | Rucha Bhave/WCS-India



Awareness Material: Multilingual brochure on the “Raptors of Surat-Dangs Landscape” covering 32 species of raptors from the landscape | Rucha Bhave/WCS-India



RAPTORS OF Surat Dangs Landscape



- NT Pallid Harrier**
Circus macrourus
ઉજળો પટ્ટાઈ
Schedule I | WLP
Appendix II
- VU Tawny Eagle**
Aquila rapax
દેશી જુમ્મસ
Schedule I | WLP
Appendix II
- LC Bonelli's Eagle**
Aquila fasciata
સેસાબર
Schedule I | WLP
Appendix II
- LC White-eyed Buzzard**
Buteo teesa
શ્વેતનયન તોસો, ટોસો,
શ્વેતનેશ ટોસો
Schedule I | WLP
Appendix II
- LC Long-legged Buzzard**
Buteo rufinus
મોસમી ટોસો
Schedule I | WLP
Appendix II
- VU Greater Spotted Eagle**
Clanga clanga
ટપકાવાળો જુમ્મસ,
મોટો કાવો જુમ્મસ
Schedule I | WLP
Appendix II
- LC Shikra**
Accipiter badius
શિકરો બાજ
Schedule I | WLP
Appendix II
- LC Eurasian Marsh Harrier**
Circus aeruginosus
પાન પટ્ટાઈ
Schedule I | WLP
Appendix II
- LC Common Buzzard**
Buteo buteo
નાનો ટોસો, રૂન ટોસો
Schedule I | WLP
Appendix II
- LC Short-toed Snake Eagle**
Circus galicus
સામાર
Schedule I | WLP
Appendix II
- LC Eurasian Sparrowhawk**
Accipiter nisus
બાદશાહ શિકરો
Schedule I | WLP
Appendix II
- LC Montagu's Harrier**
Circus pygargus
પટ્ટી પટ્ટાઈ
Schedule I | WLP
Appendix II

- CC Black Kite**
Milvus migrans
સામડી, ચોલ, દેશી
સામડી, શિખાળુ સામડી
Schedule II | WLP
Appendix II
- CC Egyptian Vulture**
Neophron percnopterus
ખેરો ગીધ, સફેદ ગીધ
Schedule I | WLP
Appendix II
- LC Brahminy Kite**
Haliaeetus indus
ભરાવો સામડી,
બાદશાહી સામડી
Schedule I | WLP
Appendix II
- NT Red-Necked Falcon**
Falco chicquera
તુરુમ્બી
Schedule I | WLP
Appendix II
- LC Pergrine Falcon**
Falco peregrinus
શાહીન, કાવો શાહીન
Schedule I | WLP
Appendix I
- CC White-rumped Vulture**
Gyps bengalensis
મોત પેઠ ગીધ
Schedule I | WLP
Appendix II
- LC Oriental Honey-Buzzard**
Pernis ptilorhynchus
મધિધો બાજ
Schedule I | WLP
Appendix II
- LC Crested Serpent Eagle**
Spheniscus cheela
ચોટવીંધો માછીપાર
Schedule I | WLP
Appendix II
- LC Eurasian Hobby**
Falco subbuteo
મોટી પોતી
Schedule II | WLP
Appendix II
- LC Common Kestrel**
Falco tinnunculus
મોટી ધરજી
Schedule II | WLP
Appendix II
- LC Besra**
Accipiter virgatus besra
બેસરો શિકરો
Schedule I | WLP
Appendix II
- NT Grey-Headed Fish Eagle**
Ichthyophaga ichthyophaga
રાખોડી શિર માછીપાર,
રાખોડી શિર પ્રત્યે ગરુડ
Schedule I | WLP
Appendix II
- LC Booted Eagle**
Hieraaetus pennatus
જિપાળુ સેસાબર
Schedule I | WLP
Appendix II
- CC Indian Vulture**
Gyps indicus
ભુખરો ગીધ, ઘિરનારી ગીધ
Schedule I | WLP
Appendix II
- LC Black-eared Kite**
Milvus lineatus
સમડી, મીલ, દેશી સમડી,
જિપાળુ સમડી
Schedule II | WLP
Appendix II
- LC Black-winged Kite**
Elanus caeruleus
કાવસો
Schedule I | WLP
Appendix II
- LC Changeable Hawk-Eagle**
Niiaetus cirrhatus
મોરબાજ
Schedule I | WLP
Appendix II
- LC Black Eagle**
Ichneutes malayanus
શ્યામ ગરુડ
Schedule I | WLP
Appendix I
- CC Amur Falcon**
Falco amurensis
વાલપગ શાહીન
Schedule I | WLP
Appendix II
- LC Barbary Falcon**
Falco (peregrinus) peregrinoides
શાહીન
Schedule I | WLP
Appendix I

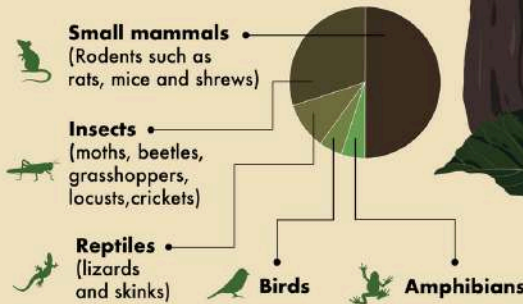
Forest Owlet (*Athene blewitti*)

EX EW CR **EN** VU NT LC Schedule I | The Wild Life (Protection) Act, 1972

Characteristics

- A unique **diurnal** owl endemic to India, rediscovered after > 100 years
- Has **distinct calls** (phonetic)
- Breeding season: **October to May**
- Tree-cavity nesting**, both parents take care of fledgeling(s)

Diet¹



Habitat

Open-dry deciduous forests dominated by teak trees, close to agriculture fields and forest patches.

Existing exclusively in the pockets of Central India - Satpura hill range and the Northern Western Ghats (Birdlife International 2023).

Historically, the species was documented from the eastern range in Chhattisgarh and Odisha, with specimens collected in 1872 and 1877 (Rasmussen and Collar, 1998). However, a more recent rapid survey conducted by Mehta et al. (2007) found no evidence of its existence in these states.

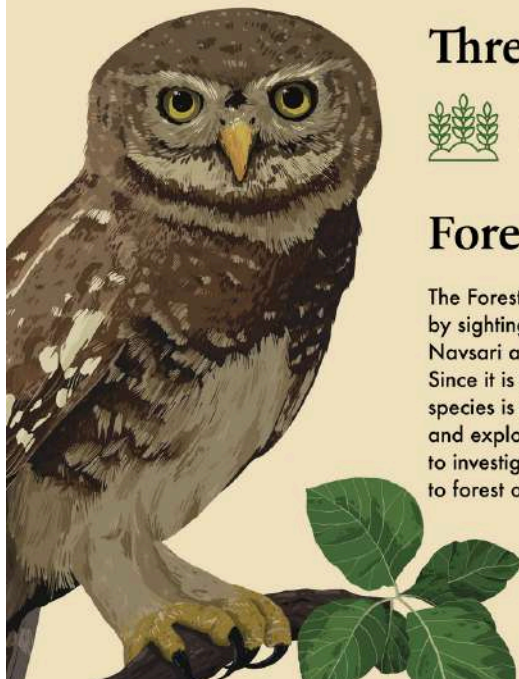
Threats

- Agricultural expansion
- Forest land encroachment
- Hunting for bushmeat and rituals

Forest Owlet in Western Ghats

The Forest Owlet was first reported in the Dang district of Gujarat in 2014, followed by sightings in parts of Maharashtra such as Tansa Wildlife Sanctuary and Nashik, Navsari and Valsad in Gujarat state and Dadra and Nagar Haveli union territory. Since it is found mostly outside Protected Areas in the Northern Western Ghats, the species is highly vulnerable to threats such as hunting, logging, habitat degradation, and exploitation for superstitious practices. WCS-India's Forest Owlet project aims to investigate the fine-scale distribution, breeding biology and threats to forest owlets in the region to inform conservation measures.

¹Ishfaq et al. (2002), Jathar & Rahmani (2004), Mehta et al. (2018)







ડાંગી થીબરી (*Athene blewitti*)

EX EW CR EN VU NT LC Schedule I | વાઇલ્ડ લાઇફ પ્રોટેક્શન એક્ટ, ૧૯૭૨

લાક્ષણિકતાઓ

-  ભારત માટે એક અનન્ય દૈનિક ધ્રુવડ સ્થાનિક, 100 વર્ષ વધુ પછી પુનઃ શોધાયેલ
-  અલગ અવાજ (ધ્વન્યાત્મક)
-  પ્રજનન ઋતુ: ઓક્ટોબર થી મે
-  વૃક્ષની બખોલ માં માળો બનાવે, બંને માતા-પિતા બચ્ચાં(ઓ)ની ઉછેર માં સંભાળ રાખે છે

આહાર¹

-  નાના સરતન પ્રાણીઓ (જેવા કે ઉદર અને છછુંદર)
-  જંતુઓ (શલભ, ભૂંગ, તિત્તીધોડા, તીડ)
-  સરિસૃપ (સરડો / કાચિડો અને સાપ બમણી)
-  પક્ષીઓ
-  ઢેડકા



નિવાસસ્થાન




ખુલ્લા-સૂકા પહોળા પાંદડાવાળા જંગલો જ્યાં સાગના વૃક્ષોનું વચસ્વ છે, ખેતીના ક્ષેત્રો અને જંગલની નજીક ત્યાં જોવા મળે.

મધ્ય ભારતના માત્ર કેટલાક જ ભાગોમાં વિશિષ્ટ રીતે - સતપુરા પર્વતમાળા અને ઉત્તરી પશ્ચિમ ઘાટ માં અસ્તિત્વ ધરાવે છે (Birdlife International 2023).

ઐતિહાસિક રીતે, 1872 થી 1877 માં એકત્રિત નમુનાઓ પ્રમાણે, છત્તીસગઢ અને ઓડિશામાં પૂર્વીય ભારતમાં આ પ્રજાતિનું નોંધ કરવામાં આવ્યું હતું. (Rasmussen and Collar, 1998). જો કે, Mehta et al. (2007) દ્વારા હાથ ધરવામાં આવેલ તાજેતરના સર્વે દરમિયાન આ રાજ્યોમાં તેના અસ્તિત્વના કોઈ પુરાવા મળ્યા નથી.



સત્તામણી/તાકીદ

-  કૃષિ વિસ્તરણ
-  વન જમીન અતિક્રમણ
-  માંસ અને ધાર્મિક વિધિઓ માટે શિકાર

પશ્ચિમ ઘાટમાં ડાંગી થીબરી

સૌપ્રથમ ડાંગી થીબરી ૨૦૧૪ માં ગુજરાતના ડાંગ જિલ્લામાં નોંધાયું હતું, ત્યારબાદ મહારાષ્ટ્રના કેટલાક ભાગો જેમ કે તાનસા વન્યજીવ અભયારણ્ય અને નાસિક, ગુજરાતમાં નવસારી અને વલસાડ અને દાદરા નગર અને હવેલી યુનિયન ટીતોરી માં નોંધાયું. ડાંગી થીબરી ઉત્તરી પશ્ચિમ ઘાટમાં સંરક્ષિત વિસ્તારોની બહાર જોવા મળે છે, તેથી આ પ્રજાતિ શિકાર, લોગિંગ (લાકડા કાપવા), એના વસવાટની અધોગતિ અને અંધશ્રદ્ધાળુ પ્રથાઓ જેવા જોખમો ને લીધે અત્યંત સંવેદનશીલ છે. WCS- India નો ડાંગી થીબરી સંરક્ષણ પ્રોજેક્ટ (ફોરેસ્ટ ઓવરવેટ પ્રોજેક્ટ)નો ઉદ્દેશ્ય સંરક્ષણને લાગતા જરૂરી પગલાંની માહિતી આપવા માટે આ પ્રદેશમાં આ પ્રજાતિનું વિસ્તરણ, સંવર્ધન જીવવિજ્ઞાન અને ડાંગી થીબરીને લાગતા જોખમોની તપાસ કરવાનો છે.

¹Ishiaq et al. (2002), Jathar & Rahmani (2004), Mehta et al. (2018)



Table A1. Summary of adult and juvenile forest owlet per grid and per replicate.

* indicates two pairs in a grid with two and three juveniles each.

Grid ID	Localities	Sightings of adults per grid				Juveniles
		1st rep	2nd rep	3rd rep	4th rep	Total per grid
13596	Borigavtha (Bhilya Dunger)	-	1	2	2	3
13604	Gira Waterfall Road	-	1	1	2	-
13606	Dokpatal (N)	-	2	2	2	1
13607	Dokpatal (S)	-	4	4	3	-
14235	Shiv Mandir (Kusmal)	-	-	-	2	-
14250	Rambhas (W)	-	-	1	2	-
14394	Kusmal	1	1	-	-	-
14395	Dhodhalpada	-	-	-	-	-
14411	Rambhas (E)	-	1	1	2	1
14413	Baaj	-	-	-	-	-
14562	Chichinagaontha	-	-	-	-	-
14708	Bhujad (W)	1	1	2	2	1
14729	Dagadiamba (W)	-	-	1	-	-
14730	Borpada	2	1	2	2	2
14884	Bhawadi	-	-	-	-	-
14885	Malin (N)	-	-	2	2	-
14890	Dagadiamba (E)	-	-	1	-	-
14891	Dagdiamba (s)	-	-	-	-	-
15029	Bhujad (E)	-	1	4	1	-
15046	Pimpari (Selvas Athal)	2	2	2	1	2
15194	Koshmal	-	-	1	-	-

15195	Godadiya	-	-	2	-	-
15212	Malin (S)	1	1	2	2	-
15218	Lahandabdar	-	2	2	1	2
15356	Godadiya (S)	-	2	2	2	1
15359	Gunjpeda	2	1	-	-	-
15373	Kalam Dunger	-	-	-	-	-
15374	Bhendmal (N)	-	-	-	-	-
15375	Bhendmal (S)	-	-	-	-	-
15378	Moti Dabdar (S)	1	4	4	3	-
15521	Kalamkhet	1	1	2	2	1
15523	Sarwar	-	-	-	-	-
15529	Pimpri	-	-	2	2	-
15538	Moti Dabdar (N)	2	2	4	3	-
15691	Dhulchond (N)	1	1	2	2	3
15692	Dhulchond (S)	-	-	-	-	-
15843	Sodmal	-	-	1	1	-
15864	Nanapada	-	-	1	1	3
16012	Gaurya (W)	-	1	3	4	3
16015	Mulchond (S)	1	-	2	2	-
16031	Supdahad (W)	-	-	-	-	-
16172	Gaurya (N)	-	-	-	-	-
16173	Gaurya (S)	-	2	1	2	-
16174	Mulchond (N)	1	-	1	-	-
16181	Khapri	-	-	-	-	-
16192	Supdahad	-	-	-	-	-
16334	Isdar (W)	-	1	3	2	2

16482	Mahal	2	1	1	1	-
16495	Isdar (E)	-	-	-	-	-
16501	Sunda (N)	-	-	1	-	-
16502	Sunda (S)	1	-	-	-	-
16515	Nadakchond (N)	2	2	2	-	1
16516	Nadakchond (S)	1	2	2	2	-
16654	Diwan Tembrun	2	2	1	2	2
16655	Isdar (N)	-	-	-	-	-
16661	Kasavdahad	-	-	-	-	-
16813	Diwan Tembrun (N)	1	1	1	2	1
16815	Jamanvahir (N)	-	-	-	-	-
16828	Wasurna	-	-	-	1	-
16837	Morambi	1	1	-	2	2
16972	Gadhvi	-	2	4	4	5*
16976	Jamanvahir (W)	-	-	-	-	-
16997	Bhapkhal	-	-	-	-	-
17137	Jamanvahir (E)	2	2	2	2	-
17138	Chankhal (W)	-	-	-	-	-
17139	Nilsakiya	2	-	2	2	-
17297	Sukmal (N)	1	1	2	2	-
17298	Sukmal (S)	1	-	-	-	-
17299	Chankhal (N)	-	-	-	-	-
17303	Borkhet Hellipad	1	-	2	2	3
17461	Chankhal	-	-	-	-	-
17463	Pipalyamal	-	2	1	2	1
17465	Borkhet	-	-	-	2	-

17469	Gaykhas (N)	1	2	2	1	2
17470	Gaykhas (S)	2	1	1	1	-
17474	Umarpada(W)	1	1	2	3	3
17611	Moti Kasad	-	1	2	-	3
17624	Gondalvahir (W)	-	-	-	-	-
17625	Gondalvahir (CC)	1	-	-	-	-
17630	Gaykhas (E)	-	-	2	-	-
17631	Borkhal (E)	-	-	1	2	3
17632	Borkhal	1	-	-	2	3
17633	Temburgartha	1	-	1	2	-
17634	Umarpada (N)	1	-	4	2	2
17635	Umarpada (S)	-	1	1	1	3
17762	Gavdahad (W)	-	4	3	-	-
17773	Ghana (N)	-	2	3	-	2
17774	Ghana (S)	1	1	1	1	-
17785	Gondalvahir (E)	2	-	-	2	-
17786	Bhisya	-	-	-	-	-
17793	Lingaroad	1	-	2	2	-
17796	Taklipada (N)	-	-	-	-	-
17797	Taklipada (S)	-	2	-	2	2
17798	Moti Dabhas	1	1	1	1	1
17799	Lahandabhas (N)	-	-	-	2	-
17800	Lahandabhas (S)	-	-	2	-	-
17922	Burthadi	-	3	-	2	2
17923	Gavdahad	2	2	3	2	2
17937	Gaygothan	1	1	2	-	1

17941	Kotba	-	-	1	1	-
17958	Vihiramba	-	-	-	-	-
17959	Nirgudmal	-	-	2	2	2
17962	Jakhana	1	2	2	2	2
18101	Sita Ni Tekri	1	1	2	1	-
18103	Dhavalidod (W)	2	-	-	-	-
18109	Pipalghodi (S)	-	-	-	2	-
18119	Kamad	-	-	-	1	-
18120	Kahandolghodi	-	-	1	3	1
18244	Jamnyamol (N)	-	-	-	-	-
18245	Jamnyamal	1	1	-	-	2
18263	Dhavalidod (N)	1	2	4	-	-
18264	Dhavalidod (S)	1	1	-	-	-
18266	Sendriamba Road	-	1	-	1	-
18267	Sendriamba	-	2	8	8	-
18281	Lahancharya	-	1	-	1	-
18406	Jamnyamal (E)	-	-	-	-	-
18422	Chikhli	1	-	2	2	1
18424	Dhavalidod (E)	-	1	1	2	2
18438	Linga (W)	-	-	3	3	-
18567	Golan	-	-	-	-	-
18569	Singana	2	-	2	2	3
18577	Kangariyamal (S)	1	-	2	-	-
18578	Karanjda (W)	-	1	2	3	1
18579	Ghubadia	-	3	4	2	-
18585	Chikhli (S)	-	1	-	-	-

20525	Waidun (E)	2	2	-	-	3
20526	Madalbari (N)	2	2	-	-	2
20687	Waidun (S)	-	-	1	2	2
20688	Madalbari (E)	-	-	-	-	-
20844	Chinchdhara (W)	1	2	-	2	3
20845	Karadiamba	-	1	1	2	-
20847	Hanwatpada	-	-	-	-	-
20848	Chinchli (N)	-	-	-	-	1
20849	Chinchli	2	2	2	2	-
21002	Wadiawan (W)	-	-	-	-	-
21004	Wadiawan (S)	1	1	1	1	-
21163	Wadiawan (N)	2	-	2	2	-
21165	Wadiawan (E)	-	-	-	3	-
21167	Chinchdhara (E)	1	2	2	-	-
21331	Mahardar	-	1	4	4	-
Total sightings		89	117	182	177	104



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