Assessment of breeding habitat requirements and effects of anthropogenic disturbance upon Pallas's Fish Eagle in Mongolia

A report on field surveys June – August 2013

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Abstract

Virtually nothing is known concerning the habitat ecology of Pallas's Fish Eagle (*Haliaeetus leucoryphus*). This gap in knowledge is a significant issue, considering the species' declining population trend and the impending need for effective, and well-informed, conservation measures. The current study assessed various landscape characteristics, including land cover composition and availability of freshwater, in areas where Pallas's Fish Eagles were observed. In order to comprehend the potential influence of freshwater upon habitat selection, GPS data collected from a juvenile Pallas's Fish Eagle tagged with a 70 g GSM-GPS transmitter in Arkhangai, Mongolia were analyzed with a dynamic Brownian Bridge Movement Model (dBBMM). In addition, further analysis examined the probability of homogenous habitat utilization, in terms of temporal variation. Results suggested that freshwater availability was the key determinant of habitat utilization, and the highest probability of habitat utilization was concentrated along the shores of Boon Tsagaan Nuur, Ogii Nuur and the Orkhon River. However, only the areas without permanent anthropogenic disturbance were occupied. Furthermore, there was a significant difference in habitat utilization densities according to the time of day. The tagged individual frequently occupied freshwater habitat during the day, but retreated to elevated foothills to roost for the night. Results indicate the value of dBBMM in terms of fine- scale habitat ecological studies and aid in the correction of direct observation bias.

Introduction

The Pallas's Fish Eagle (*Haliaeetus leucoryphus*) is a large fishing eagle that occurs along inland seas, lakes, rivers, and arid steppe habitat (BirdLife International 2001, Ferguson-Lees and Christie 2001). The historical range encompasses a large portion of Asia, extending west to east from the Caspian Sea to China, and north to south from Russia to India and Myanmar (BirdLife International 2001). Past reports consider Pallas's Fish Eagles (PFE) to breed primarily within the Indian Subcontinent, China, and Mongolia. Early records from the late 1800's and early 1900's describe the occurrence of breeding pairs along northern India's rivers and lakes every few kilometers (BirdLife International 2001). However, the population has declined drastically in the last century, and a fraction of the population remains. Currently, the total population of PFE's in Asia have is estimated at 2,500 – 9,999 mature adults (BirdLife International 2015). However, Ferguson-Lees and Christie believe the population to be at the lower end of this range, based on the estimate of one breeding pair per 200 km^2 (2001). Mongolia has recorded a particularly troubling decline in numbers. Recent surveys found PFE's at eight (61.5%) of thirteen historical sighting locations and the latest estimated count stated that the country had less than 300 individuals (Gombobaatar and Monks 2005, Gilbert et al. 2009). Overall, there is a significant lack of quantitative data for this species throughout its range of over 1,000,000 km^2 in Asia (Ferguson-Lees and Christie 2001, BirdLife International 2015).

In the past decade, India and Mongolia were considered home to the species' two key breeding populations (BirdLife International 2001, Gilbert et al. 2009). However, recent surveys conducted by Gilbert et al. provided contradictory evidence, arguing that that Mongolia is not a current breeding stronghold for migrant Pallas's Fish Eagles and may have never actually bred in the country. Previous records of nesting behavior were reassessed and concluded to be misidentified White-tailed Eagles (*Haliaeetus albicilla)*. Population declines are believed to be due to habitat loss through drought-impacted wetlands, human disturbance, and water pollution, but there has never been a comprehensive study to assess these risks (BirdLife International 2001, Gombobaatar and Monks 2005). In order to properly assess conservation risks, researchers must first have a clear understanding of habitat utilization. Pallas's Fish Eagle habitat is considered restricted to freshwater sources and steppe, with nests overlooking freshwater in the canopy of trees, but there has never been a comprehensive study of habitat requirements (BirdLife International 2001). Therefore, the purpose of this study was to conduct surveys for Pallas's Fish Eagles in Mongolia, record any potential observations of breeding behavior, and to assess what landscape features may directly impact foraging and nesting habitat selection. Furthermore, in light of key habitat characteristics, we determined whether or not all qualifiying habitat was considered "ideal" or if the presence of anthropogenic disturbance deterred Pallas's Fish Eagles from occupying the area.

Study Area

Mongolia's land mass, approximately 1,565,000 km^2, is landlocked between Russia and China (52°06'−41°32'N, 87°47'−119°54'E) (Pyankov et al. 2000). The country exhibits high variability in geography and climate due to its continentality. Mongolia's climate is defined by harsh winters, with temperatures falling to -45° C, and warm, moist summers that can exceed 40°C (Fernández-Giménez 1999, Wingard and Zahler 2006). Mongolia claims one of the world's largest grasslands and makes up ~2.6% of the total global area (Tuvshintogtokh and Ariungerel 2013, Yu et al. 2003). 83.4% of the country's total land mass is steppe (Tuvshintogtokh and Ariungerel 2013). The remainder is taiga or desert, found along the Russian and Chinese national border respectively (Yu et al. 2003). Mongolia has a freshwater system of around 3,000 rivers that extend over 67,000 km (Wingard and Zahler 2006). Ogii Nuur (47°46'N, 102°46'E), is a freshwater, mesotrophic lake in Arkhangai Province, Mongolia with a surface area of approximately 25.1 km^2 and a maximum depth of 15.9 m. The Orkhon River, within the Orkhon River Valley, feeds directly into Ogii Nuur. Boon Tsagaan Nuur, (47°35'N, 99°10'E), is located within Bayan-Khongor Province, Mongolia in a region known as "Valley of Lakes." Boon Tsaagan Nuur is a saline lake with a water surface area of approximately 227.6 km^2 and a maximum depth of 16 m (Odonchimeg and Namkhai 1998).

Methods

Surveys were conducted 08:00 – 19:00 from June – August 2013 in Arkhangai and Bayan-Khongor Province, Mongolia. Survey sites were determined according to historical records (Gilbert et al. 2009). Eagle surveys were conducted by three researchers surveying the landscape via motor vehicle, foot, or horseback. GPS coordinates were collected with a Garmin GPS unit, with an accuracy of ±5 m, every time a Pallas's Fish Eagle was observed perched, as seen in Figure 2 and 3. Observed individuals were recorded as adult, subadult, or juvenile according to plumage. For every recorded eagle observation point, habitat data was collected along a 10 m transect line with 1x1 m subplots to estimate ground cover composition and diversity at each eagle-selected habitat site. Plant species within samples were recorded and percentages of bare ground, dung coverage, or vole burrows were estimated within each subplot using the Daubenmire cover class system, as seen in Figure 1 (Daubenmire 1959). The cover classes were determined according to the unique landscape. Nomadic animal husbandry is common to the region, so there is an extensive coverage of animal dung, which, in large quantities with cow and horse manure, removes any underlying vegetation. In addition, Ogii Nuur is home to a massive colony of Brandt's voles (*Lasiopodomys brandtii*). The colony exceeds over >500 breeding individuals and have visibly altered the landscape through extensive burrows and dirt mounds. Pallas's Fish Eagles may choose to linger in areas where voles are prevalent, as a potential prey base. Thus, it was also considered to be a landscape feature.

Perpendicular distances (m) from recorded eagle observation points to the closest freshwater source and the nearest anthropogenic disturbance (semi-permanent manmade structure) were calculated via GoogleEarth. In the event that an active nest was located, the point was subjected to the same data collection procedure as above. For every recorded eagle GPS position, another site was randomly chosen within 15 km of the site as a control and underwent sampling procedures identical to eagle-selected sites. Random sites were selected according to a numeric grid system overlaying a map of each survey region. Eagle-selected and randomly-selected habitat variable data were analyzed with Mann-Whitney-Wilcoxon tests to check for significant differences between samples. It is important to note that the survey observations were not independent and relatively infrequent. Therefore, results were compared to individual habitat utilization analyses from a juvenile Pallas's Fish Eagle fitted with a 70 g GSM-GPS transmitter that occurred within the same region as observed individuals from the field surveys.

Figure 1. Line transect sampling at Ogii Nuur, Arkhangai, Mongolia.

Figure 2. Adult and juvenile Pallas's Fish Eagle perched at the Baidraig River delta in Byan-Khongor, Mongolia.

During the summer of 2013, a juvenile Pallas's Fish Eagle, referred to as "Chinggis", was fitted with a 70 g GSM-GPS transmitter backpack. The GSM-GPS transmitter was limited in individual sample size (n=1); however, the overall GPS data set per individual was extensive, with over 30,000 GPS data points per month. Overall, data collected by the transmitters included GPS coordinates, time stamp (YYYY/MM/DD hh:mm:ss), altitude (m), flight speed (km/hr), orientation (°N), VDOP, HDOP, and total satellite count. In addition, transmitter conditions, such as external temperature (°F) and battery charge (volts), were also collected periodically. GPS data had an estimated accuracy of +/- 18 m horizontal and +/- 20 m vertical. Data was uploaded once a day when within range of a GSM cell tower and emailed to the principal investigator in a .txt and .kmz file format. Data was then uploaded to Movebank.org, a National Science Foundation funded database dedicated to the collection and utilization of animal movement and external environment conditions. GSM-GPS data were separated according to daily circadian periods and classified into one of two categories: migration and non-migration. Migration days were defined as days where the total distance traveled exceeds 100 km; otherwise, the day was classified as a non-migration day. For the purpose of this study, the habitat utilization of the tagged eagle that occurred in the same location as the observed individuals from the field survey, at Ogii Nuur, Arkhangai, Mongolia, over non-migratory periods were used for comparative analysis.

Traditionally, kernel analysis was used to assess home range location and size with varied confidence intervals, but produced poor results with large coordinate samples due to parameter estimation with least square cross-validation technique (Kraunstaber et al. 2012). In response, habitat utilization and heterogenous movements were described in terms of the probability of an eagle occupying an area at any given time with a dynamic Brownian Bridge Movement Model (dBBMM) in the computation program R with "Move" package (Kranstauber et al. 2014, R Core Team 2014). The output was an utililization distribution (UD) raster layer that illustrated the probability of a habitat being utilized at any given time (Kraunstauber et al. 2014).

Results

Surveys were conducted for twenty days over a period of three months, June – August 2013. In addition to habitat surveys, principal investigators were trapping Pallas's Fish Eagles to fit individuals with 70 g GSM-GPS transmitter backpacks. Baiting and trapping would actively alter natural behavior and habitat selection; therefore, surveys days preceded trapping efforts and were spread across the three-month field season. Overall, surveyors recorded 43 observations, as shown in Table 1. Furthermore, there were no observations of breeding activity. The majority of individuals observed were juveniles (76%), followed by subadults (15%) and adults (9%). Twenty-three observations were recorded in Bayan-Khongor (Figure 4) and twenty in Arkhangai (Figures 3 and 5). Throughout the survey period, there were no recorded observations of nests or breeding behavior. Man-Whitney-Wilcoxon tests showed no significant difference between eagle-selected habitat and randomly-selected habitat in regard to ground cover and composition. However, significance was reported for distance from perched individuals to the nearest freshwater source (mean=73.77 ±10.32, $p<0.0001$). To further investigate the potential relationship, a linear regression analysis was run to test for a potential correlation between the number of eagles and the distance from freshwater. However, results were not significant (R2=0.085405, $p>0.05$). Overall, the maximum distance eagles were observed away from water at any given survey time was 5.8 km.

Under the assumption that access to freshwater is the only key landscape feature that impacts Pallas's Fish Eagle habitat utilization, all river and lake shoreline would be considered sufficient. However, individuals were observed along less than 50% of the total available shoreline. Furthermore, some regions, such as Sangyn Dalai, had no recorded observations. A total of 5,158 recorded GPS coordinates from the GSM-GPS tagged juvenile, "Chinggis," was used to calculate a comparative habitat utilization distribution, as illustrated in Figure 3. The GPS data was further broken down into separate circadian periods, day and night, as shown in Figure 8. When the data was broken up according to circadian periods there was a noticeable variation in habitat utilization density probabilities. During the day, the tagged individual exhibited a higher degree of movement, and there was less concentration of habitat utilization in a few specific areas. Furthermore, the greatest UD occurred within the immediate vicinity (<1 km) of freshwater. In contrast, at night, the individual tended to remain in one of a few key areas located further away from the water (<12 km).

Survey Date	Survey site	Adult Observations	Subadult Observations	Juvenile Observations	Total Daily Observations
26-Jun-13	Ogii Nuur/Orkhon River Valley	-	-	6	6
27-Jun-13	Orkhon River Valley/Tamir River	-	1	1	2
28-Jun-13	Ogii Nuur/Orkhon River Valley	-	-	7	7
29-Jun-13	Old Orkhon River/Ogii Nuur	-	1	2	3
6-Jul-13	Orkhon River Valley	-	-	1	1
10-Jul-13	Ogii Nuur/Orkhon River Valley	-	-	2	2
20-Jul-13	Orkhon River Valley/Tamir River	-	-	-	0
21-Jul-13	Ogii Nuur/Old Orkhon River	-	1	-	1
25-Jul-13	Sangyn Dalai	-	-	-	0
27-Jul-13	Boon Tsagaan Nuur/Baidrag River	1	1	3	5
28-Jul-13	Boon Tsagaan Nuur	1	1	2	4
29-Jul-13	Boon Tsagaan Nuur	-	-	-	0
3-Aug-13	Boon Tsagaan Nuur/Baidrag River	2	2	8	12
15-Aug-13	Ulziit River	-	-	-	0
16-Aug-13	Baidrag River	-	-	-	0
17-Aug-13	Boon Tsagaan Nuur	-	-	2	2
20-Aug-13	Orkhon River Valley	-	-	-	0
22-Aug-13	Tuul River and Sangyn Dalai	-	-	-	0
25-Aug-13	Sangyn Dalai	-	-	-	0
26-Aug-13	Sangyn Dalai	-	-	-	0
	Totals	**4**	**7**	**34**	**45**

Table 1. Survey results for Pallas's Fish Eagles in Arkhangai and Byan-Khongor Province, Mongolia.

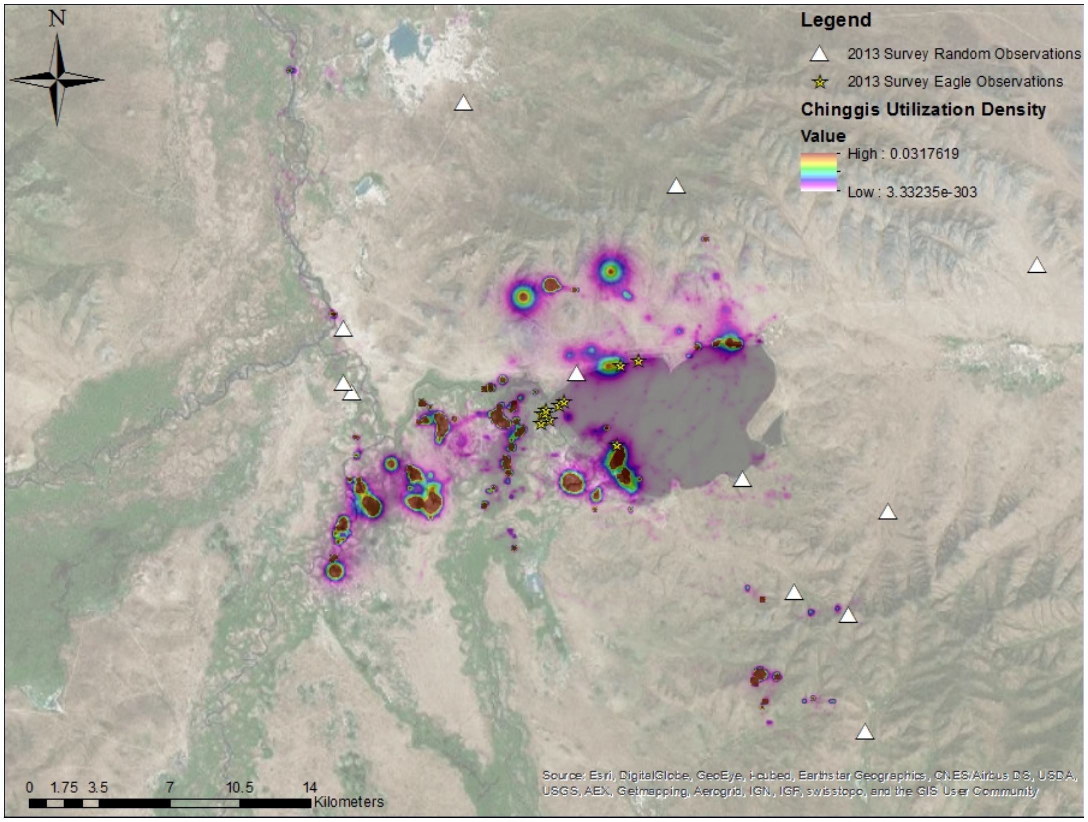


Figure 3. Chinggis's calculated UD and data collection sites at Ogii Nuur, Arkhangai for 2013 surveys.

Figure 4. Data collection points at Boon Tsagaan Nuur, Bayan-Khongor for 2013 surveys.

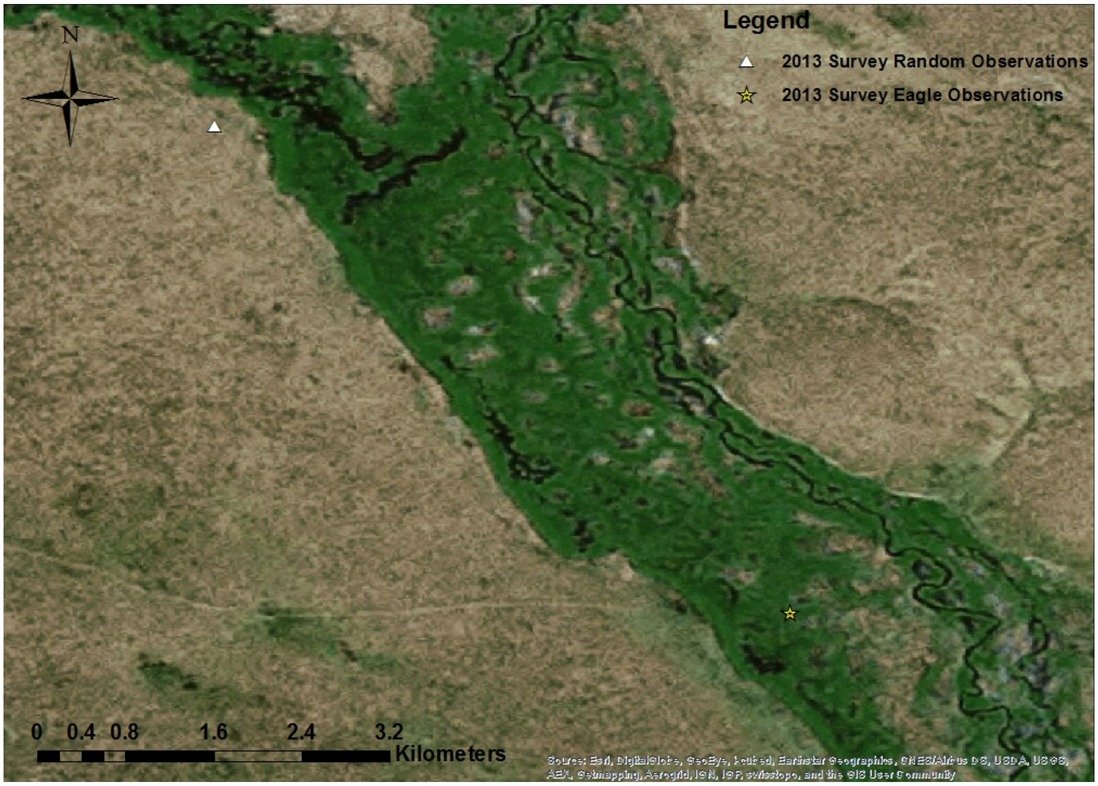
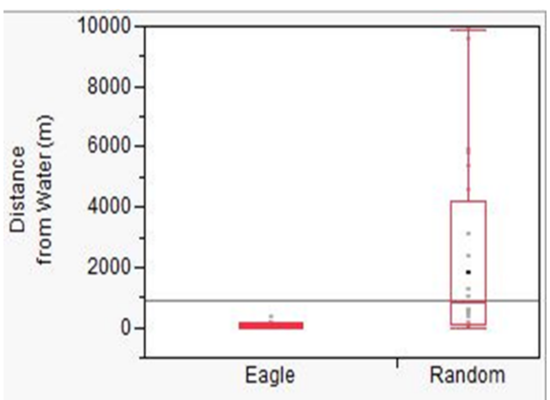


Figure 5. Data collection points at Orkhon River Valley, Arkhangai for 2013 surveys.



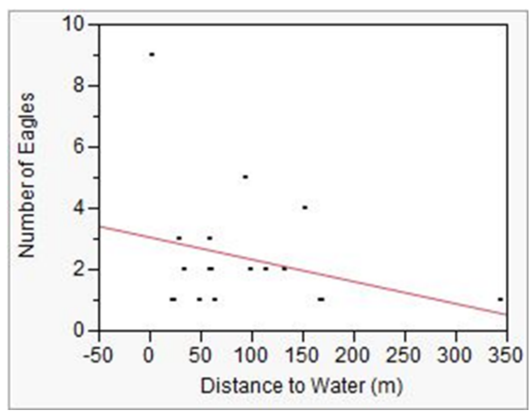


Figure 6 - 7. Quartile plot comparison distance from water (m) (mean=73.77 ±10.32, $p<0.0001$) and the linear regression analysis of number eagle observations as a function of distance from freshwater (m) ($R^2=0.085405$, $p>0.05$).

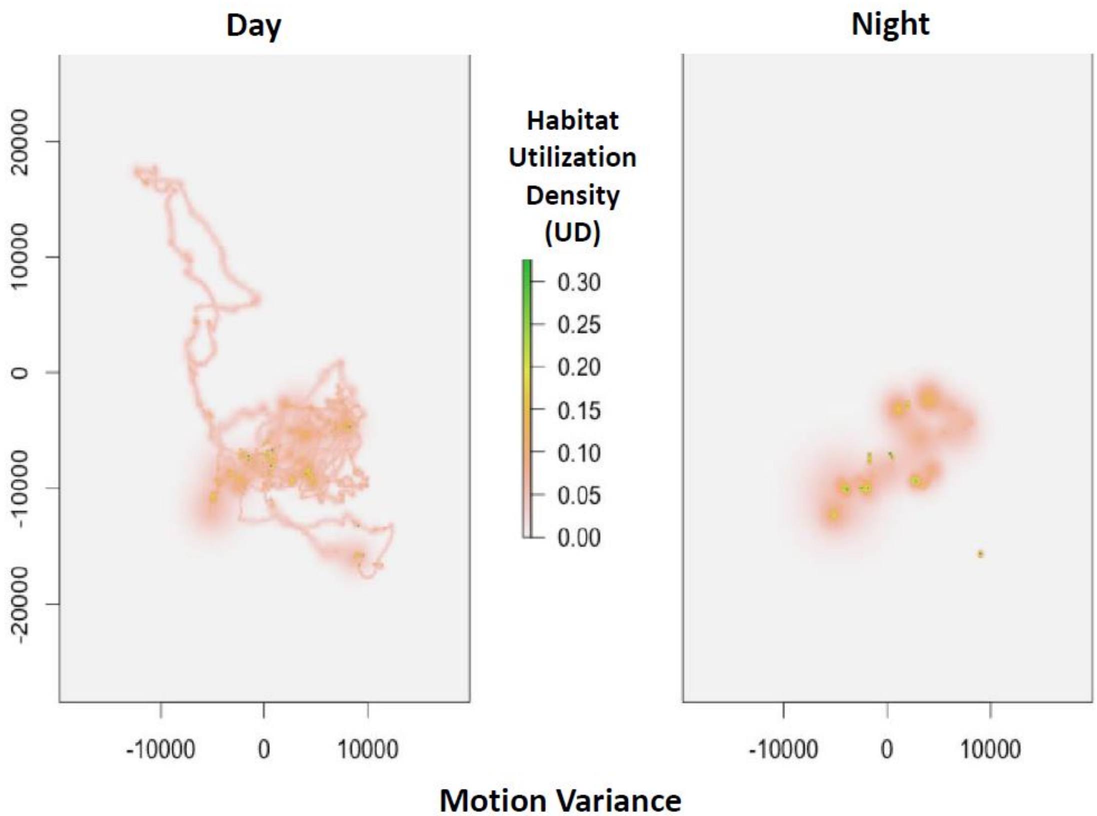


Figure 8. Chinggis's UD raster data separated according to circadian periods (day and night) at Ogii Nuur, Arkhangai, Mongolia.

Discussion

Pallas's Fish Eagle is a poorly-understood species in a precarious position, where the global population has been roughly estimated for over fifty years, despite its continuous declining trend, with no firm data to support its current status as "vulnerable" (BirdLife International 2015). As more attention is drawn to the significant gaps of knowledge concerning its current status and general ecology, the true severity of the situation may come to light. In the event that the species is re-listed as "endangered" by the IUCN, a comprehensive understanding of the species' habitat ecology will be vital for future conservation efforts. Thus, the purpose of the current study was to perform the first exploratory analysis of Pallas's fish eagle habitat utilization and address the following questions: "What landscape features impact habitat utilization?" and "Is all habitat with preferential landscape features considered equal?"

Overall, the only significant results from the Mann-Whitney-Wilcoxon test between eagle-selected habitat and randomly-selected habitat data sets were for one assessed landscape feature: distance from freshwater (m) ($p=0.0001<0.05$). Under the assumption that access to freshwater was the sole landscape feature to determine habitat utilization, eagles would be expected to be observed along all available freshwater sources. This scenario would closely reflect Pallas's Fish Eagle observations made along major freshwater sources throughout Asia, particularly in India and Pakistan, prior to the 1900's (BirdLife International 2001). However, eagles were observed at less than 50% of the immediately available habitat in both states. This indicates that the some factor is potentially rendering a portion of the habitat unsuitable.

For the dBBMM, Chinggis's GPS data recorded at Ogii Nuur, Arkhangai, Mongolia (July 4 – July 18, 2013) were analyzed, as a whole, to determine habitat utilization densities. The results provided supporting evidence for the original survey Wilcoxon-Mann-Whitney Test, which stated that the only assessed landscape feature with any significant impact upon habitat utilization was the proximity to freshwater. Habitat within the immediate vicinity of freshwater (<1 km) had the highest probability of utilization at any given time. Furthermore, results illustrated that, while water proximity was important, not all freshwater habitat was utilized. Thus, results suggest that not all available habitat can be considered "high quality." It is plausible that anthropogenic disturbance may serve as a significant deterrent to the tagged individual. The western range of Ogii Nuur and the Orkhon River Valley is protected as an undisturbed nature preserve by Mongolia's Ministry of Environment and Tourism with the occasional nomadic family with one to two gers. However, the south and southeastern shores of the lake are filled with permanent structures, including tourist camps, general stores, and public campgrounds. Therefore, if individuals were sensitive to anthropogenic disturbance, they would understandably avoid the region and remain within the protected, undisturbed reserve. During the few times that Pallas's Fish Eagles were observed near human settlements, it was always near nomadic structures, not permanent buildings.

After the dBBMM analysis was broken up into daily circadian periods (day and night), the habitat utilization densities shifted into two dissimilar raster plots over the range, an indication of temporally-dependent heterogeneous movements, as illustrated in Figure 8. During the day, the habitat utilization density was noticeably diverse with a high rate of movement. The plot illustrated several possible corridors between regions of higher UD probabilities within the immediate vicinity of freshwater (<1km). The increased rate of movement and highest concentrations of UD probabilities along freshwater indicates that the bird spends a large amount of time foraging along Ogii Nuur and the Orkhon River. However, at night the UD probabilities were primarily concentrated in eight different locations with almost no evidence of movement between concentrated points (Figure 8). Furthermore, the habitat with the highest UD at night occurred up to 12 km away from the nearest freshwater source in areas of higher elevation, the foothill peaks situated around the Orkhon River Valley. The lack of movement between sites indicate that the bird was not active at night and likely roosted for the entirety of the circadian period, unless disturbed. This behavior is plausible, because the Orkhon River Valley has virtually no trees, except for tiny groves of *Salix* sp. that do not exceed 10 ft. in height. Therefore, the safest night roost for an eagle would be a rugged peak in the foothills.

Overall, the analysis between the two circadian periods indicated heterogenous movements according to temporal variation, with the highest rate of movement occurring during the daytime. Furthermore, there was a sharp contrast in habitat utilization according to the time of day. The initial analysis that indicated the importance of freshwater, likely for foraging, as a key determinant of habitat utilization was correct in the daytime. However, regions of higher elevation appeared to be preferential as protective night roosts. Therefore, the assumption that freshwater availability was the only determinant of habitat utilization is biased according to in-person observations, because night surveys are infeasible. It is important to note that throughout the survey period, habitats occupied by Pallas's Fish Eagles were also filled with a large assortment of waterfowl. Thus, while the current study provides a baseline assessment of abiotic habitat features, it is important to consider other directly impacting factors, such as the availability of prey and presence of competition. Therefore, future studies should look at describing Pallas's Fish Eagle diet composition and prey bases.

It is important to note, as mentioned earlier, Mongolia was historically considered to be a major breeding population. However, Gilbert et al. argues against the presence of breeding pairs in the country (2014). The current study supports Gilbert et al.'s hypotheses (2014). Throughout the duration of all past fieldwork, in 2012 and 2013, there was never any sign of breeding behavior or fledglings. Furthermore, the majority of all Pallas's Fish Eagles observed were juvenile. In the event that the majority of the global Pallas's Fish Eagle population is migratory, this is a troubling trend that points to an unknown source of adult mortality. It is also important to note that virtually nothing is known about the seasonal movements of Pallas's Fish Eagles. India claims to have at least a partially sedentary population, but surveys do not occur during the summer monsoon season. Other historical observations in countries, such as Thailand, mention that the eagles tended to disappear right before the rainy season. Thus, the status of the “sedentary population” remains in question (BirdLife International 2001). In the event that the majority of the global population is migratory, then the current situation may be more severe than previously estimated. Further research on the species’ seasonal movements should be considered vital in the upcoming years.

Human-conducted surveys are a cost-effective method of collecting quantitative data and qualitative observations; however, it is not without its share of bias. Surveys can only be conducted during the day, and, in the event of heterogeneous movements, can lead to biased assumptions on habitat requirements. The use of GSM-GPS technology and the dynamic Brownian Bridge Movement Model served as an effective investigative tool to assess habitat utilization and provide greater insight to heterogenous movements according to temporal variation. Together, the two techniques have provided initial comprehensive insight into the behavior and habitat utilization of a cryptic and virtually unknown species.

Figure 9. Juvenile Steppe Eagles (*Aquila nipalensis*), White-tailed Eagles (*Haliaeetus albicilla*), and Pallas's Fish Eagles (*Haliaeetus leucoryphus*) perched along the Orkhon River, Mongolia.

Recommendations

Throughout the study, the principal investigator spent an extensive time in the field observing Pallas's Fish Eagles and the humans occupying the immediate area. During the time, a few concerning conservation issues were brought to light. The western shore of Ogii Nuur and the Orkhon River Valley are considered to be a protected national wildlife refuge and a RAMSAR wetland site, occupied only by temporary nomadic families relying upon animal husbandry as a source of income. However, there are no clear signs, fences, or general markers that mark the landscape as being closed to the public or illustrate the importance of the conservation area. Therefore, there were several instances of tourist groups illegally camping along the area. Furthermore, drivers needing to cross the Orkhon River had no clear indicator of the nearest road or crossing point, so they would drive randomly throughout the wetland, risking the vehicle getting stuck and causing further disturbance to the local flora and fauna. In an effort to reduce the flow of human traffic through protected habitat, I would recommend the installment of signs directing drivers away from the reserve and towards the nearest, safe crossing point. Preliminary efforts to address the issue were conducted by the surveyors during the study, as shown in Figure 10.

In addition to disturbing the wildlife and vegetation, trash was frequently left in the travelers' wake. At one point, the surveyors observed three juvenile eagles, two PFE and one white-tailed, fighting over a pile of trash in a plastic bag at the shoreline. The consumption of trash is a potentially lethal risk to the surrounding wildlife. It is important to note that trash receptacles within public-approved campsites are infrequent and easily accessible to the local wildlife. Most of the time, trash is simply piled together in plastic bags at the campsite for park employees to remove later. Therefore, I recommend the implantation of secure trash bins, similar to receptacles implemented by national parks within the United States, to reduce pollution from tourism.

Figure 10. Temporary sign to direct tourists to the Orkhon River road crossing.

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