Oryx Vol **40** No 1 January 2006

Planning the conservation of the breeding population of cinereous vultures *Aegypius monachus* in the Republic of Georgia

Alexander Gavashelishvili, Mike J. McGrady and Zura Javakhishvili

Abstract Occupied and potential nesting areas of Near Threatened cinereous vulture *Aegypius monachus* in the Republic of Georgia were examined to model its nesting habitat. The intention is to support its conservation within the context of the ongoing establishment of a system of protected areas. Data were manipulated and analysed using a geographical information system, univariate statistical analysis and logistic regression. The best model suggested that in Georgia plots were more likely to contain a cinereous vulture nest if the slope was >30° and faced north, was situated in rugged terrain away from unprotected and populated areas, and was relatively dry. North-facing slopes were where suitable nest trees could be found, whereas ruggedness, protected areas and remoteness from populated areas made access to the nest trees by humans difficult. Low annual rainfall provided better soaring and breeding conditions. The model suggested that the breeding range of cinereous vulture in Georgia could expand if seasonal grazing, which is the primary source of disturbance, is properly managed. Because neither nesting places nor food availability appeared to be limiting, human disturbance and climate seem to best explain the current distribution of nesting cinereous vultures in Georgia, and probably elsewhere in the Caucasus.

Keywords *Aegypius monachus*, cinereous vulture, Georgia, GIS, grazing, logistic regression, protected area.

Introduction

The cinereous vulture or Eurasian black vulture *Aegypius monachus* is categorized globally as Near Threatened (BirdLife International, 2004; IUCN, 2004). Its distribution extends from Spain in the west to Mongolia and Russia in the east, although the Spanish population is somewhat isolated (del Hoyo *et al.*, 1994). In most places except for Spain the range extent and abundance of cinereous vulture has declined. Where population declines have been observed they are linked to indirect persecution (e.g. poisoning) and changes in nesting habitat (Hiraldo, 1974; Donázar, 1993, 2002; Donázar *et al.*, 2002).

Cinereous vultures feed on dead animals and nest in loose knit groups, although in some clusters pairs are >3 km apart (Cramp & Simmons, 1980). However, it is not known if relatively close-nesting is important to cinereous vultures and therefore whether small areas of habitat suitable for cinereous vulture nesting are not used because they would not support some minimum cluster size. Distance between nests within colonies varies, and may be determined by the availability of suitable nest trees (Fargallo *et al.*, 1998). In addition, high nesting density may cause productivity to decline (Donázar *et al.*, 2002). Cinereous vultures prefer areas that support pines (*Pinus* spp.), junipers (*Juniperus* spp.) and oaks (*Quercus* spp.) (Cramp & Simmons, 1980).

The cinereous vulture has been poorly studied outside Europe. In Georgia cinereous vulture breeding (20–30 pairs) is restricted to the south-east (Gavashelishvili & Javakhishvili, 2002; Gavashelishvili *et al.*, 2004), where they nest in mature juniper trees. Historical data are generally lacking, but earlier surveys reported breeding elsewhere in the country (Abuladze, 1983). However, no breeding has been seen in these areas in recent years (A. Gavashelishvili, unpubl. data).

Because of their semi-colonial nesting behaviour and because nesting areas are used over many years, understanding the characteristics of these areas is important to their conservation. To our knowledge there have been no quantitative analyses of nesting habitat requirements of cinereous vulture in the Caucasus. This study examines breeding site selection by cinereous vulture in Georgia. Our main objective was to construct a model that would facilitate the planning and zoning of Vashlovani National Park in Georgia, and more broadly the conservation of the species in the Caucasus. Vashlovani National Park is being established as an enlargement of

---

Alexander Gavashelishvili* (Corresponding author) 3420, 16th St. NW#404 Washington, DC 20010, USA. E-mail kajiri2000@yahoo.com

Mike J. McGrady Natural Research Ltd., Perth, Scotland, UK.

Zura Javakhishvili Georgian Center for the Conservation of Wildlife, Tbilisi, The Republic of Georgia.

*Also at: Georgian Center for the Conservation of Wildlife, Tbilisi, The Republic of Georgia.

Received 21 July 2004. Revision requested 25 January 2005. Accepted 22 April 2005.

© 2006 FFI, *Oryx*, **40**(1), 76–83 doi:10.1017/S0030605306000081 Printed in the United Kingdom

the Vashlovani Nature Reserve, which includes *c.* 50% of the cinereous vulture breeding pairs in Georgia. Maps derived from our model will help conserve and manage cinereous vulture in Georgia by identifying places where previously unknown occupied sites may be located, and highlighting areas where vultures may nest in the future if the breeding range expands.

Study area

The study area was the entire territory of the Republic of Georgia (70,000 km^2), where the current distribution of breeding cinereous vultures comprises 1,993 km^2 at 100–900 m above sea level in the south-east (hereafter, the breeding range) (Fig. 1). The breeding range is bounded to the south by Azerbaijan and to the north by a fertile, relatively moist, populated area dominated by crops and woodland. It is semi-arid ($<$500 mm annual rainfall and $<$150 mm annual snowfall; Dzotsenidze, 1964; Khatiashvili *et al.*, 1989) and is comprised mostly of steppe (dominated by *Bothriochloa ischaemum*) and semi-desert (dominated by *Artemisia fragrans*) habitats, but includes areas of arid woodland (dominated by *Juniperus, Paliurus* and *Pistacia* spp.) and tugai-type riparian forest (dominated by *Populus, Quercus, Alnus* and *Salix* spp.). There are no permanent human settlements, but it is a wintering (October – April) ground for large flocks of domestic sheep, and at that time shepherds' camps are established across the area at intervals of *c.* 2 km. At other times grazing is almost nil. Part of the breeding range is covered by four protected areas: Korugi, Iori and Chachuna Sanctuaries and Vashlovani Nature Reserve, of which only the Reserve (40 km^2) is free from grazing and hunting throughout the year. The establishment of the Vashlovani National Park is in progress, and its core area will be the existing Vashlovani Nature Reserve. We surveyed the study area for nesting cinereous vultures in 1994–2002, and recorded habitat variables that may affect the distribution of breeding cinereous vultures.

Methods

Habitat variables

Variables related to nest site availability, climate, terrain and human disturbance were considered (Table 1). Tree species and size were linked to nest site availability. Annual rainfall was used as a climatic variable. Elevation, slope, aspect and the length of elevation contours per area unit (ruggedness) characterized terrain. Aspect values (north = 0°, increasing clockwise) were sine and cosine transformed to see whether nest distribution had any directional biases. Distances to unprotected areas, roads and populated areas were used as a measure of human disturbance. Because the Vashlovani Nature Reserve is the only protected area that excludes grazing and hunting, the rest of the study area was considered unprotected.

Analytical approach

Nest locations were mapped using a global positioning system. Terrain data were extracted from updated 1:50 000 topographic maps (original source: Headquarters of Geodesy and Cartography under the Council of Ministers of the USSR. 1978, Facility No. 11) using the geographical system ArcView v. 3.3 (ESRI Inc., Redlands, USA). We derived 20 m square grids of habitat variables,

Fig. 1 The present breeding range of cinereous vulture in Georgia and the sampling plots used in the analysis.

Table 1 Explanatory variables used in the analysis of cinereous vulture nesting site selection.

Variable	Description
DBH	Diameter (cm) at 1.5 m above ground level of a nested tree or the thickest tree in a 20 m plot
Tree height	Height (m) of a nested tree or the thickest tree in a 20 m plot
Rainfall	Total annual rainfall (mm)
Elevation	Elevation (m) above sea level of a 20 m plot
Slope	Slope (degrees) of a 20 m plot
CosAspect	Aspect of a 20 m plot, cosine-transformed (i.e. increasing from south (–1) to north (+1)
SinAspect	Aspect of a 20 m plot, sine-transformed (i.e. increasing from west (–1) to east (+1)
Ruggedness	Total length (m) of 100 m elevation contours within a 500 m radius of the centre of a 20 m plot
DstRoad	Distance (m) to the nearest road
DisPop	Distance (m) to the nearest hut, house, or any building occupied by humans
DstGraze	Distance (m) to the nearest point of unprotected areas that were exposed to grazing (i.e. distance from inside Vashlovani Nature Reserve to its border)

Table 2 Characteristics of occupied cinereous vulture nest sites in the Republic of Georgia. All variables (Table 1) except DBH and tree height were used to define potential nesting plots (n = 31).

Habitat variable	Minimum	Maximum	Mean	SD
DBH (cm)	20	53.30	30.96	10.95
Tree height (m)	2	8	4.9	1.7
Rainfall (mm)	397.68	432.14	412.05	16.46
Elevation (m)	220	545.372	395.72	92.15
Slope (degrees)	30	60	44.89	9.26
CosAspect	–0.99	0.97	0.720	0.380
SinAspect	–0.97	0.87	–0.14	0.575
Ruggedness (m)	3,987.70	9,972.22	6,755.62	940.68
DstRoad (m)	2,330.06	3,596.10	2,983.86	444.28
DisPop (m)	7,204.55	16,996.94	13,270.03	3,264.61
DstGraze (m)	0	1,000	600.12	211.02

as follows. Elevation contours at 100 m intervals were vectorized and used to interpolate an elevation grid, which was then used to derive grids of slope and aspect. A rainfall grid was interpolated from the 200 mm annual rainfall contours in Khatiashvili *et al*. (1989). To create a ruggedness grid each square was assigned the value of the total length of 100 m elevation contours within a radius of 500 m of the grid square centre. Finally, we created grids of distances to unprotected areas, roads and populated areas.

We examined and modelled nest site selection within the breeding range by comparing habitat variables at 20 m plots that were occupied by cinereous vultures (n = 12) to those at 100 randomly selected potential but unoccupied 20 m plots. Ranges of the habitat variables measured at all nests found during 1998–2002 were used to identify 20 m potential nesting plots within the breeding range (Table 2), and included requirements that potential plots were >440 m apart from each other and from occupied plots. This distance limitation was based on the minimum nearest-neighbour distance for cinereous vultures in the breeding range, and minimized autocorrelation effects. To create a model of plot occupancy and ensure a sample of independent cases, we used nest sites occupied by individual cinereous vulture pairs in 2002.

We also examined variables that may limit cinereous vulture nesting outside the current breeding range. To do this we first applied the model derived from the breeding range (above) to the rest of Georgia, then compared habitat variables (that were not included in the original model) at plots outside the breeding range where the model predicted nest presence to those at occupied plots. For this comparison we used 70 randomly selected plots from outside the breeding range that the model predicted would have potential for holding nesting cinereous vultures. These plots were distributed relatively evenly across the country, in all regions (Fig 1). Limiting the proximity of predicted plots reduced spatial autocorrelation, and the relatively even coverage ensured diversity in the sample.

Statistical treatment

Statistical analyses were performed using SPSS v. 11 (SPSS Inc., Chicago, USA). Student's *t*-tests examined differences in the distribution of variables between occupied and potential nesting plots within the breeding range. Levene's test was used to determine whether the assumption of equal variances could be made for the Student's *t* test.

Binomial logistic regression was used to predict nesting habitat requirements for cinereous vulture, because the dependent variable (occupied plot = 1, potential nesting plot = 0) was dichotomous (Hosmer & Lemeshow, 1989; Menard, 2002). Logistic regression estimates parameters (coefficients) after logit transformation of the dependent variable as $\ln[p/(1-p)] = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots$, where ln is the natural logarithm, p is the probability of obtaining a positive response (i.e. nest presence), B_0, B_1, B_2, . . . are parameters to be estimated from the observed data, and X_1, X_2, . . .are the independent (i.e. explanatory) variables.

The forward stepwise likelihood ratio method was used to select variables that were included, using P = 0.05 for inclusion and P = 0.10 for exclusion. Models produced by the initial logistic regression procedure were improved through residual analysis, and distilled into a best-fit model using a model evaluation procedure, both of which are described below.

Residual analysis was performed using scatter plots of standardized residuals against the independent variables, which were examined to see if the independent variables in the model were linearly related to the logit of the dependent variable. Quadratic, cubic, square root, logarithmic and inverse transformations were tested to eliminate non-linearity. Scatter plots of leverage values (a measure of how much a case influences the regression) and Cook's distances (a measure of how much the coefficients change when a case is removed from the model) were examined to reveal possible errors in the data. Cases with leverage values $>2p/n$, where p is the number of independent variables in the model, and n is the number of cases, were examined more closely, as were cases with Cook's distances >1.

Additionally, best-model selection and optimization of its classification cut-off value were tested using the ROC (Receiver Operating Characteristic) Curve or the Area Under the ROC Curve (AUC). AUC values of 1 suggest the classification to be correct, values of 0 suggest it to be incorrect, and values of 0.5 suggest that the scheme is no better than guessing. To evaluate a measure of the agreement between the observed values and predicted group values at an optimal cut-off value, Cohen's kappa was used, in which a value of 1 indicates perfect agreement and a value of 0 indicates that agreement is no better than chance. In the final evaluation procedure we used the Leave-One-Out cross-validation (i.e. fitting the model with all observations minus one and then using the model to predict the excluded observation, and doing this for all observations).

Results

In all, 31 nests were found, all in junipers. The shortest distance between nests was 20 m. The mean nearest-neighbour distance among pairs that we were able to identify (n = 12) in 2002 was 1,104.41 ± SD 795.54 m (range, 440–2,469 m). Six of the existing pairs were in the Vashlovani Nature Reserve. Aspect had a northerly bias: 30 nests had aspects between 289.5° (WNW) and 66.4° (NE); the aspect of one nest was 186° (SSW) (Fig. 2). Table 2 summarizes all other nest site features. Northern bias of aspect and distance to unprotected areas were significantly greater in occupied than potential plots; no other significant difference in variables occurred between occupied and potential plots (Table 3).

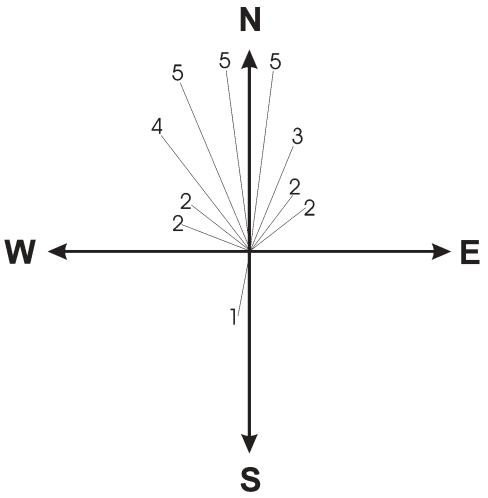

Fig. 2 Aspect (in 15° intervals) of cinereous vulture nests in the Republic of Georgia, with the number of nests found in each aspect.

The best model of cinereous vulture nesting site selection produced by the logistic regression procedure within the breeding range included ruggedness, distance to unprotected areas and south-north direction of aspect: $\ln[p/(1-p)] = 11.925 \ln(Ruggedness) + 1.948 \ln(DstGraze + 1) + 4.310\ CosAspect - 109.692$, where p is the probability of a 20 m plot containing a cinereous vulture nest (Table 4).

Table 3 Comparison of nest site characteristics (mean ± SD) between occupied and potential cinereous vulture nesting plots within the breeding range. Levene's test was used to make corrections to df.

Variable	Plots with a pair (n = 12)	Plots without a pair (n = 100)	df	Student's t^1
DBH (cm)	30.27 ± 11.05	30.93 ± 10.89	110	0.197
Tree height (m)	4.50 ± 1.73	4.9 ± 1.69	110	0.811
Rainfall (mm)	416.72 ± 16.57	416.22 ± 19.63	110	0.085
Elevation (m)	367.991 ± 187.40	367.780 ± 170.53	110	0.005
Slope (degrees)	43.00 ± 11.12	44.45 ± 9.31	110	0.499
CosAspect	0.703 ± 0.544	–0.264 ± 0.706	15.813	5.619***
SinAspect	–0.068 ± 0.498	–0.002 ± 0.663	110	0.334
Ruggedness (m)	6,690.90 ± 2,397.27	5,592.91 ± 1,161.09	11.627	1.565
DstRoad (m)	2,945.13 ± 443.889	2,948.71 ± 423.265	110	0.027
DisPop (m)	1,2210.5 ± 3,097.6	13,036.9 ± 3,055.0	110	0.884
DstGraze (m)	225.00 ± 313.70	7.5 ± 23.93	11.015	2.401*

^{1}*$0.01 < P < 0.05$, ***$0 < P < 0.001$

Table 4 Binomial logistic regression models of cinereous vulture habitat requirements in Georgia within and outside the breeding range.

Model	Parameter estimate	SE	Wald	P
Within the breeding range				
ln(Ruggedness)	11.925	4.074	8.569	0.003
ln(DstGraze + 1)	1.948	0.701	7.710	0.005
CosAspect	4.310	1.713	6.330	0.012
Constant	−109.692	36.532	9.016	0.003
2 Log likelihood	−17.030			
Nagelkerke R^2	0.832			
df	1			
Outside the breeding range				
ln(Rainfall)	−15.980	6.343	6.347	0.012
DisPop	0.001	3.456×10^{-4}	8.370	0.004
Constant	88.919	35.017	6.448	0.011
2 Log likelihood	−20.024			
Nagelkerke R^2	0.835			
df	1			

Residual analysis did not reveal any overly influential points. An ROC plot test suggested the model performed better than guessing (AUC ± SE, 0.973 ± 0.026, $P < 0.001$), and the optimal classification cut-off was 0.3. At this cut-off the model classified 91.7% of occupied plots correctly and 99.0% of potential nesting plots. Overall, the model classified 98.2% of all plots correctly and 96.4% of the cross-validated cases. The model performed better than chance at its optimal classification cut-off (Cohen's kappa = 0.906, $P < 0.001$).

Application of the model to the rest of Georgia at the cut-off of 0.3 generated many plots of predicted nest presence in areas where they did not occur (Fig. 3a). The comparison of these plots ($n = 70$) to those with nests ($n = 12$) within the breeding range resulted in a model that suggested a negative response to annual rainfall and positive correlation with distance to populated areas (Table 4): $\ln[p/(1 - p)] = 0.001\ DisPop - 15.980 \ln(Rainfall) + 88.919$.

Residual analysis of this model did not reveal any overly influential points. The ROC plot test suggested that the model performed better than guessing (AUC ± SE, 0.980 ± 0.013, $P < 0.001$), and the optimal classification cut-off was 0.5. At this cut-off the model classified 97% of occupied plots correctly and 95.5% of potential nesting plots. Overall, the model classified 96% of all plots correctly and 94% of the cross-validated cases. The model performed better than chance at its optimal classification cut-off (Cohen's kappa = 0.96, $P < 0.001$). Interpretation of the model onto a map at its optimal cut-off value considerably limited the distribution of breeding cinereous vulture (Fig. 3b). The combination of the original model and this one further refined the species distribution in Georgia (Fig. 3c).

Discussion

Cinereous vultures in Georgia nested in rugged semi-arid landscapes in mature juniper trees on steep slopes, and in general these nest site features do not distinguish them from tree nesting cinereous vultures elsewhere (Cramp & Simmons, 1980; del Hoyo *et al.*, 1994; Fargallo *et al.*, 1998). It is likely that cinereous vultures also nested in pine trees *Pinus eldarica* in the breeding range before these trees were extirpated. Other tree species (*Paliurus, Pistacia, Populus, Quercus, Alnus* and *Salix* spp.) probably provide poor support for the large nests of cinereous vulture, and in the breeding range these species grow mostly on gentle slopes, which are less advantageous in terms of wind-generated updraughts and protection from nest predators. Most nests were on north-facing slopes, perhaps because south-facing slopes are poorly wooded, mostly with *Paliurus* and *Pistacia* spp..

It seems unlikely that cinereous vultures were competitively excluded from potential nesting plots because elsewhere they nest on cliffs (Cramp & Simmons, 1980), and whether in trees or cliffs they can nest in close proximity to other raptors, including griffon vulture *Gyps fulvus* (M. Ghasabian, pers. comm.). Imperial eagle *Aquila heliaca*, the only likely competitor for tree nest sites, is not numerous in Georgia and nests mostly in riparian and flatland forest patches.

In Georgia cinereous vulture nesting trees were always on steep slopes. However, they will nest in flat areas (Hiraldo & Donázar, 1990), especially where food is available (Cramp & Simmons, 1980). Our results suggest that in Georgia cinerous vultures are selecting nesting sites that provide protection from nest predators and are less accessible to humans. Also, for large raptors, nest sites that facilitate take off and landing (sometimes with prey) may be selected (Newton, 1979). The absence of nests in areas with higher annual precipitation, including snow, may be linked to nests collapsing under the weight of snow, or possibly springtime snow build-up on nests preventing vultures from breeding. Also, cinereous vultures are heavy, soaring birds and areas of low annual rainfall, and therefore low soil moisture, produce strong thermal updraughts (Stull, 1988).

Nest site selection and occupancy by cinereous vultures are most likely affected by either loss of nests and nesting habitat due to human activities or disturbance during the pre-laying and laying period, especially if these occur consistently over time (Donázar, 2002). Reproductive success is more likely to be affected by relatively short-lived disturbance during the nesting period (Hiraldo, 1983; Fargallo *et al.*, 1998; Donázar, 2002).

A variety of factors that could affect nesting cinereous vulture distribution, including prey availability, poisoning, densities of nest predators and nest collapse are, we believe, of secondary or minor importance in Georgia.

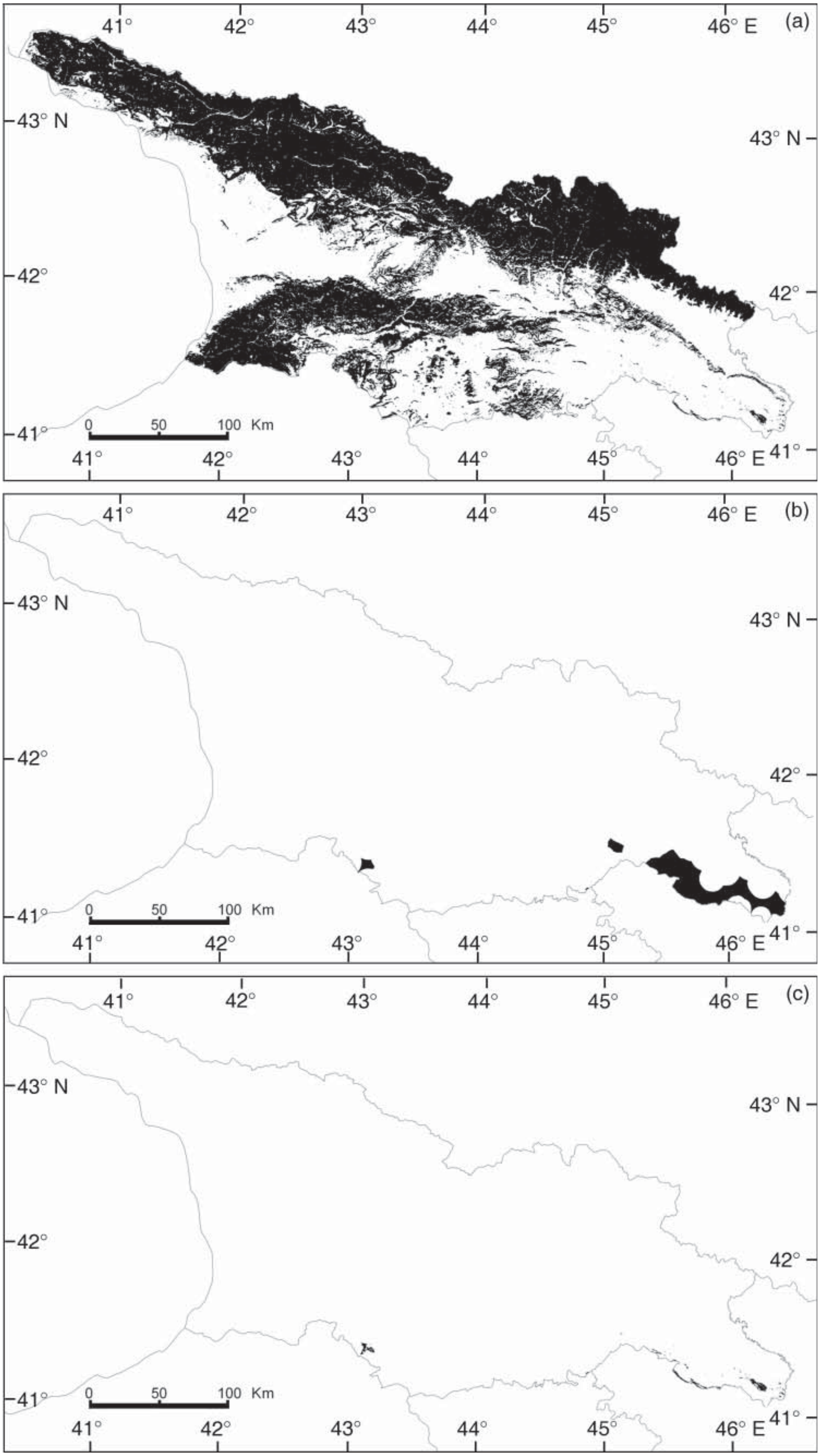

Fig. 3 Models predicting the occurrence of cinereous vulture nests (shaded areas) at optimal classification cut-off values (see text for details) derived by (a) considering habitat requirements inside the breeding range, (b) considering habitat requirements outside the breeding range, and (c) combining (a) and (b). The final model (c) predicted nest presence in a small area in the south-west where cinereous vultures do not, however, nest, probably because of a lack of trees.

Here and elsewhere local prey availability is less critical for cinereous vultures than for other raptors because cinerous vultures can forage over large areas. This and the occurrence of colonies of griffon vulture (whose foraging behaviour is similar to that of cinereous vulture) near potential cinereous vulture nesting plots suggest that some other factor (e.g. human disturbance) is more closely linked to cinereous vulture distribution in Georgia. A similar line of argument excludes poisoning as a major influence upon cinereous vulture distribution. The relatively high densities of both cinereous vulture nests and tree-climbing predators, including bear *Ursus arctos*, leopard *Panthera pardus*, lynx *Felis lynx* and jungle cat *Felis chaus*, which occur in the Vashlovani Nature Reserve (NACRES and Ministry of Environment of Georgia, pers. comm.) exclude these potential nest predators as a primary influence in determining cinereous vulture distribution in Georgia. Cinereous vulture nesting places can be identified even if they have been vacant for some time because their nests are large and persist over many years in the semi-arid climate, and even nests that collapse under their own weight (Bernis, 1966) are detectable. That there were no potential, yet unoccupied plots that contained nests from earlier nesting attempts suggests either that the factor restricting nesting occurs during the pre-nest building period or, more likely, nests disappear because of human disturbance.

Human disturbance during winter herding, including direct persecution, destruction of nest trees for firewood, and unintentional disturbance are the factors most likely to affect cinereous vultures in Georgia, in particular because their nests are built in low trees. Thus, cinereous vultures were found nesting in protected areas where grazing was controlled, and in areas where the terrain was rugged and access by sheep and humans was difficult. The presence of griffon colonies in high cliffs near potential but unoccupied cinereous vulture nesting plots seems to be a result of their nests' relative inaccessibility. The importance of protected areas for providing secure nesting opportunities for cinereous vulture can also be seen in other parts of the Caucasus. In Armenia cinereous vultures have been extirpated from unprotected areas, and the Khosrov Nature Reserve is the only place they breed (M. Ghasabian & K. Aghababian, pers. comm.).

Donázar (2002) suggested that direct disturbance by humans (not including poisoning) is relatively unimportant in causing declines in cinereous vulture populations, and suggested that loss of nesting habitat was the main cause. This may only be the case, however, for the more westerly populations. Our results suggest the main cause of the restricted nesting distribution of cinereous vulture in Georgia are changes in nesting habitat related to grazing and disturbance by shepherds and their sheep, and that enforcement of the status of existing protected areas and the establishment of new or enlargement of existing protected areas could play an important role in increasing the numbers of breeding pairs. However, increased enforcement in protected areas where damage has occurred may not result in immediate re-occupancy because the mature trees in which they nest may have been removed. Also, the negative effects of human persecution and disturbance may persist because individual evasive behaviour may have developed and cinereous vultures are long-lived (Donázar *et al*., 2002).

Most potential cinereous vulture nesting habitat in eastern Georgia predicted by our models lies within the Vashlovani Nature Reserve. This not only highlights the importance of the Reserve, but also suggests that the establishment of protected areas outside the Reserve (especially a buffer zone) is likely to increase the number of nesting pairs, both within and outside the Reserve.

The expansion of existing, small, strictly protected areas including the Vashlovani Nature Reserve is in progress in accordance with the 1996 Law on Protected Areas System in Georgia. One of the main goals of the expansion is enhancement of range and forest management through conservation-sensitive grazing in the support zones of the developing national parks. As part of this, planning the relocation of seasonal pastures is underway within eastern Georgia, and our results could help in the design of the zones of the planned Vashlovani National Park, to increase the amount of protected potential cinereous vulture nesting habitat and minimize conflict between the management of grazing and the conservation of cinereous vulture.

Acknowledgements

Amiran Kodiashvili of Vashlovani Nature Reserve facilitated this work. Mamikon Ghasabian and Karen Aghababian of the Armenian Society for the Protection of Birds provided information on cinereous vulture in Armenia. The COBASE program of the National Academy of Science, USA, Office of Central Europe and Eurasia and the Eppley Foundation for Research provided partial financial support. Two anonymous referees helped improve the manuscript.

References

Abuladze, A. (1983) Distribution and numbers of cinereous vulture in eastern Georgia. In *Proceedings of the 5th Scientific Conference of Young Scientists of the Institute of Zoology of the Academy of Sciences*, pp. 22–27. Metsniereba Publishers, Tbilisi, Republic of Georgia. [in Russian]

Bernis, F. (1966) El Buitre Negro (*Aegypius monachus*) en Iberia. *Ardeola*, **12**, 45–99.

BirdLife International (2004) *Threatened Birds of the World 2004. CD-ROM*. BirdLife International, Cambridge, UK.

Cramp, S. & Simmons, K.E.L. (1980) *Handbook of the Birds of Europe, the Middle East and North Africa*. Oxford University Press, Oxford, UK.

del Hoyo, J., Elliot, A. & Sargatal, J. (1994) New World vultures to guineafowl. In *Handbook of the Birds of the World, Volume 2*, pp. 52–205. Lynx Edicions, Barcelona, Spain.

Donázar, J.A. (1993) *Los buitres ibéricos*. Quercus, Madrid, Spain.

Donázar, J.A. (2002) *Tendencias recientes de la población española de buitre negro: evaluación de factores limitantes y medidas de consevación*. Terceras Jornadas Científicas del Parque Natural de Peñalara y del Valle de El Paular, **40**, 81–87.

Donázar, J.A., Blanco, G., Hiraldo, F., Soto-Largo, E. & Oria, J. (2002) Effects of forestry and other land-use practices on the conservation of cinereous vultures. *Ecological Applications*, **12**, 1445–1456.

Dzotsenidze, G.S. (ed.) (1964) *Georgian SSR Atlas*. Main Administration of Geodesy and Cartography under the USSR Geological Committee, Tbilisi, The Republic of Georgia & Moscow, Russia. [in Georgian]

Fargallo, J.A., Blanco, G. & Soto-Largo, E. (1998) Forest management effects on nesting habitat selected by Eurasian black vultures (*Aegypius monachus*) in central Spain. *Journal of Raptor Research*, **32**, 202–207.

Gavashelishvili, A. & Javakhishvili, Z. (2002) *Raptors of Georgia*. GCCW/BirdLife International, Tbilisi, The Republic of Georgia.

Gavashelishvili, A., Javakhishvili, Z. & Gokhelashvili, R. (2004) *Birds in Europe II. BirdLife International's World Bird Database*. Http://www.birdlife.info/wbdbeurope [accessed 20 April 2004].

Hiraldo, F. (1974) Colonias de cría y censo de los Buitres Negros (*Aegypius monachus*) en España. *Naturalia Hispanica*, **2**, 1–31.

Hiraldo, F. (1983) Breeding biology of the cinereous vulture. In *Vulture Biology and Management* (eds S.R. Wilbur & J.A. Jackson), pp. 197–213. University of California Press, Berkley, USA.

Hiraldo, F. & Donázar, J.A. (1990) Foraging time in the cinereous vulture *Aegypius monachus*: seasonal and local variation and influence of weather. *Bird Study*, **37**, 128–132.

Hosmer, D. & Lemeshow, S. (1989) *Applied Logistic Regression*. Wiley & Sons, New York, USA.

IUCN (2004) *IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland [http://www.redlist.org, accessed 5 July 2005].

Khatiashvili, N.M, Ushveridze, G.A. & Kobakhidze, E.D. (eds) (1989) *Resorts and Resort Resources of Georgian SSR*. Main Administration of Geodesy and Cartography under the Council of Ministers of the USSR, Moscow, Russia. [in Georgian with English summary]

Menard, S. (2002) *Applied Logistic Regression Analysis*. 2nd edition. Sage Publications, Thousand Oaks, USA.

Newton, I. (1979) *Population Ecology of Raptors*. T. & A.D. Poyser, Berkhamsted, UK.

Stull, R.B. (1988) *An Introduction to Boundary Layer Meteorology*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Biographical sketches

Alexander Gavashelishvili's research interests are focused primarily on the Caucasus. He studies vultures using satellite-received radio-telemetry, remote sensing, and habitat modelling of Caucasian turs, bezoar goat, argali, leopard and Caucasian grouse.

Mike McGrady has a particular interest in birds of prey, with projects in Europe, Asia, North America, Africa and Central America. His research includes work on peregrine falcon migration and demography, dispersal and ranging of golden eagles, the potential impact of windfarms on golden eagles, movements of vultures, and the ecology of Steller's sea eagles.

Zura Javakhishvili conducts research on the ecology, demography, and conservation of various bird species, including field surveys of birds in Georgia, radio-telemetry of Caucasian grouse, and assistance in coordination of the IBA network in Georgia.