HABITAT EVALUATION OF SMOOTH-COATED OTTER (*Lutrogale perspicillata*) IN INDUS PLAINS OF PAKISTAN USING REMOTE SENSING AND GIS

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ABSTRACT:

The smooth-coated otter (*Lutrogale perspicillata*), a semi-aquatic species, is one of the two species of otters in Pakistan. It is reported as Near Threatened (NT) according to IUCN Red List of Mammals of Pakistan. The species is distributed throughout the Indomalayan eco-zone and occurs along the Indus River and its tributaries in Pakistan. Current study was conducted to evaluate the habitat of the smooth-coated otter in Indus Plains of Pakistan using Habitat Suitability Model (HSM) by incorporating topographic and environmental layers along with species sighting data. ALOS-AVNIR-2 satellite images were used to develop land cover maps of entire study area leading to the development of digital layers in accordance to key habitat features of the species. Within each layer, different variables were assigned suitability values according to the relationship of that indicator with otter habitat. Combining all these layers we derived the suitability of habitat for smooth coated otter in the study area and Habitat Suitability Index (HSI) was calculated. Patches with a suitability value ranging 0.7-1.0 (highly suitable habitat) occupied 13.81% area and suitability value ranging 0.4-0.7 (moderately suitable habitat) occupied 10.71% area while unsuitable habitat for otter (0.1-0.4) is 75.48% of the total study area.

1. INTRODUCTION

The smooth-coated otter (*Lutrogale perspicillata*) is a semi-aquatic species belonging to the Mustelidae family of order Carnivora and is one of the two species of otters in Pakistan (Roberts, 2005). It is reported as Near Threatened (NT) according to IUCN Red List of Mammals of Pakistan (Sheikh & Molur, 2005). The species is distributed throughout the Indomalayan eco-zone and its distribution in Pakistan is along the Indus River and its tributaries in Punjab Province (Roberts, 1997).

The smooth-coated otters are found in lowlands, mangroves, freshwater wetlands, riverine forest, lakes and rice fields (Chanin, 1985). Rice fields in Malaysia have also been regarded as an important habitat for the species. In these rice fields and other adjoining rural areas, they are adaptable to live in close association with the people and have even been found more tolerant against the human activities than other otter species such as Eurasian otter and Hairy-nosed otter. (Foster-Turley, 1992). Unlike Common otter, the Smooth otter prefers plain area in Punjab and Sindh Provinces of Pakistan and is found near rivers, canals, lakes and fish ponds surrounded by thick vegetation especially *Typha* spp., *Fragmites* spp. and *Saccharum* spp. (Khan & Hasnain, 2008; Khan et al. 2008, 2009).

Otters are considered as an indicator species for the health of wetland ecosystems due to being sensitive to degradation, when considering the food chain (Roberts, 1997). Overall population of this species is on decline. Various threats to the species identified during the field surveys included hunting for fur, habitat degradation, water pollution, weak enforcement of wildlife laws, increasing tourism and competition and conflicts between otters and fishermen. (Khan et al., 2008).

Wildlife management is much more than the preservation of certain plant and animal species; it involves management of a complete ecosystem (De Wulf et al., 1988). Quantification and analysis of current impacts on wildlife habitat such as logging agriculture, road developments etc. are vital phases in the process of formulating sound wildlife management policies. Until recently many conventional techniques have been applied for collecting data on natural resources. Relatively large number of ground-based studies have been carried out on habitat and corridor use by the wild animals (Johnsingh and Joshua, 1994; Mishra and Johnsingh, 1996; Johnsingh, 1991 & 1992; Bhat and Rawat, 1995; Rodgers, 1990) The role of remote sensing has been emphasised in quick appraisal of habitat attributes, identification of new sites for protected areas and current status of corridors (Panwar, 1986; Kamat, 1986). Ground survey methods such as counting animals, trapping, collection of droppings, investigations of feeding sites as well as ground mapping of habitats (Lamprey, 1963; Giles, 1978; Kotwal and Parihar, 1988) will always be useful. However, in a number of cases other techniques can supplement or partially replace tedious ground survey methods. Moreover, it is felt that ground methods have limitations as whole area can not be accessed in one go in many of the cases and the information collected may not be as accurate as is possible through remote sensing aided by limited ground survey (Ashraf et. al., 2004).

The utility of GIS and Remote Sensing for the present purpose is particularly apparent in the development of models for

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application over extensive temporal and spatial scales. Further, analytical tools to model wildlife-habitat relationships are a fundamental part of this GIS enabling it to integrate spatial data and evaluations of the external parameters such as forest management actions on habitat supply for specific species or groups of species. Similarly, simulating changes to habitat variables in GIS can illustrate how habitat supply temporally changes (van Manen and Pelton 1993).

Habitat models, in general, and habitat suitability index (HSI) models, in particular, are among the most widely used wildlife management tools in the world (Verner et al. 1986, Van Horne and Wiens 1991, Brooks 1997). In Europe, habitat models are receiving increasing attention (Storch 1996, Kuhn 1998) as the need for practical evaluation methods for land management and conservation practice has become recognized (Link et al. 1996). Typically, habitat models are used to assess the suitability of an area as a habitat for one or several target species. A HSI model summarizes the conceptual understanding of the habitat relationships of the target species, based on literature reviews, expert opinion, or research studies. A set of habitat variables is identified and combined into a series of simple equations. The resulting HSI score ranges between 0 for unsuitable and 1 for optimal habitat suitability. The procedures of HSI model development and testing have been summarized by Schamberger and O'Neil (1986), Van Horne and Wiens (1991), Morrison et al. (1992), and Brooks (1997).

Current study was conducted to evaluate the habitat of the smooth-coated otter in Indus Plains of Pakistan (Fig. 1) using Habitat Suitability Models (HSM).

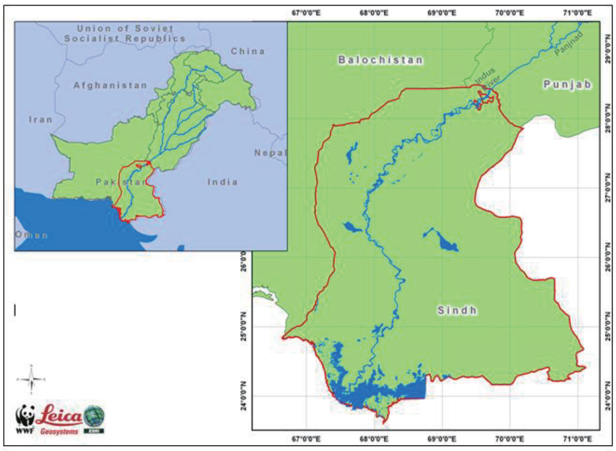

Figure 1. Map showing the extent of the study area

2. METHODS

Topography, forest boundaries, rivers, reservoirs, canals, roads, settlements etc. were digitized using ArcGIS (Version 9.3) on the basis of Survey of Pakistan's topographic maps (1:50000). Data and information on the occurrence and distribution of the smooth-coated otter was collected from previous field survey reports conducted by WWF – Pakistan (Waseem et. al., 2008) and from a recent field visit in 2010.

Extensive field surveys were conducted to collect ground data for land cover mapping and also habitat parameters of otter with their sightings. A total of 14 different field investigation trips were made covering 37 sampling sites (Fig. 4). A-2 sized field maps of ALOS satellite data (False Color Composites (FCC) of band 4 3 2 RGB) at 1:25,000 with Geographic grid of 1 minute intervals, were used during the survey. A total of 53 sample plots and 170 GPS-linked descriptive data points from all locations were collected and were used in land cover mapping using ALOS data.

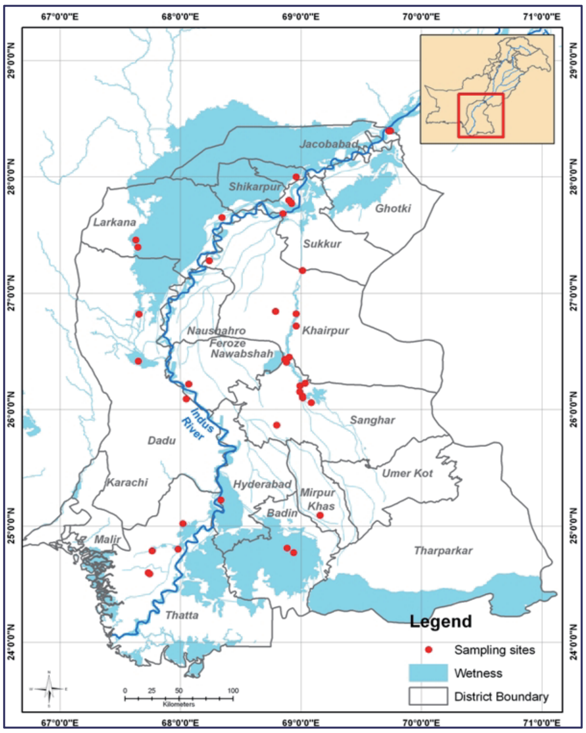

Figure 2. Sighting data collected during different surveys

Development of accurate landcover map has a primary importance in habitat mapping of fauna species. For developing the landcover of the study areas recent ALOS satellite images were acquired from JAXA and Object Based Image Analysis (OBIA) was performed based on the ground truth data collected during the field surveys, digital photographs and information of the local forest and vegetation types

- Landcover
    - Typha, Phragmites, Saccharum
    - Water bodies
    - Mud flats
- Distance from the water
- Sighting data
- Vector data layer

Deductive approach was used to develop HSM for the otter species. A priori information is used to produce a categorical and discrete classification of habitat suitability for the species. (Rondinini et al., 2006). The HSM was built for the whole study area by using the Arcview GIS software (version 9.3) based on previous suitability models for otters and crested ibis (Boitani et al., 2002; Ottaviani, 2004 & Li et al., 2002). Within each layer, different habitats were assigned different suitability values ranging from 0-4 according to the relationship of the indicator with otter habitat. Vector layers were then transformed into raster layers and every individual cell was assigned a habitat suitability index (HSI) value. Combining all these layers we derived the suitability of habitat for smooth coated otter in the study area (HSI ranging from 0 to 1). The model was built within 1000 m buffer of the riparian habitat or of water bodies. This buffer represents the extent of probable area where otter species can be found.

3. RESULTS AND DISCUSSION

Suitable habitat for smooth-coated otter in the study area appears to be severely fragmented (Fig. 6). Patches with a suitability value ranging 0.7-1.0 (highly suitable habitat) occupied 13.81% area and suitability value ranging 0.4-0.7 (moderately suitable habitat) occupied 10.71% area while unsuitable habitat for otter (0.1-0.4) is 75.48% of the total study area (Table 1). The distribution of smooth-coated otter (Fig. 6, 7) revealed that they were found almost exclusively in areas where the habitat suitability was > 0.7.

Table 1. The area of patches of different habitat suitability for smooth-coated otter in Sindh Province, Pakistan

HSI	Suitability	Area (km^2)
0.0-0.4	Unsuitable	4,308
0.4-0.7	Moderately suitable	611
0.7-1.0	Highly suitable	788

Artificially assigned Habitat Suitability Index (HSI) was used to evaluate the habitat quality of smooth-coated otter. This method is a fast and convenient method for estimating habitat availability with spatial explicitness in a heterogeneous landscape (Li, et. al., 2002) irrespective of any changes to habitat preference of this species.

Smooth-coated otter presence probability increases with the decrease in the distance to water and riparian vegetation (Fig. 3, 5) (Waseem et. al., 2008). While the increase of otter presence probability with the distance to major urban centers and to highways, points to the negative influence of these indicators of human activity on this species. The proximity to major towns is often suggested as harmful for otters, especially due to the water contamination they generate downstream (Delibes and Rodrı´guez, 1990; Ruiz-Olmo and Delibes, 1998).

Presence probability values can be used to define favourable or unfavourable areas for a species, which could be taken into account when implementing specific conservation programs. For example, areas where the probability of presence is four times higher than that of absence could be considered as environmentally favourable and areas where the probability of absence is four times higher than that of presence could be considered as environmentally unfavourable for a species. Determining a cut-off point above which the species is more likely to be present than expected at random can be useful to correct the probability thresholds defining these favourable or unfavourable areas (Rojas et al., 2001). The fact that the cut-off point for the otter is lower than 0.5 indicates that it is probably necessary to lower the probability values considered for determining favourable or unfavourable areas for this species in Pakistan.

Many factors affect wildlife habitat selection and no single theory is suitable for every animal (Rosenzweig, 1985). Smooth-coated otter live in a patchy habitat and move between patches to gain the most food for the least energetic cost. Meanwhile, human disturbance, competition and the risk of being captured negate the benefits of feeding in what might otherwise be a suitable habitat.

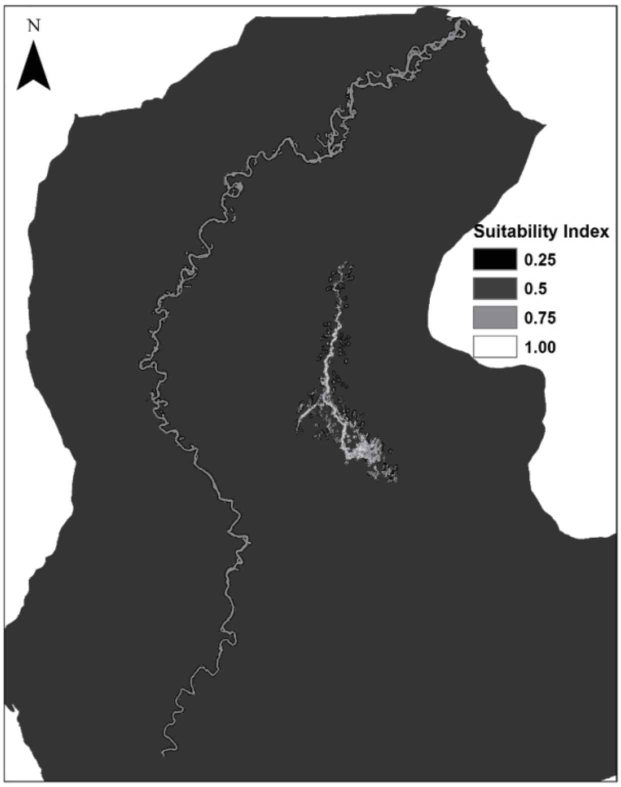

Figure 3. The suitability of distance from water for smooth-coated otter.

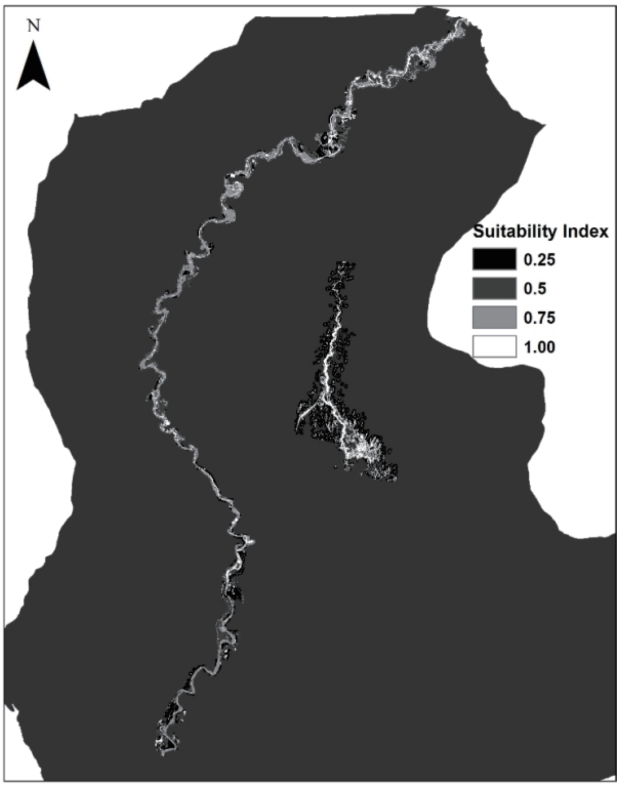

Figure 4. The suitability of land cover classes for smooth-coated otter.

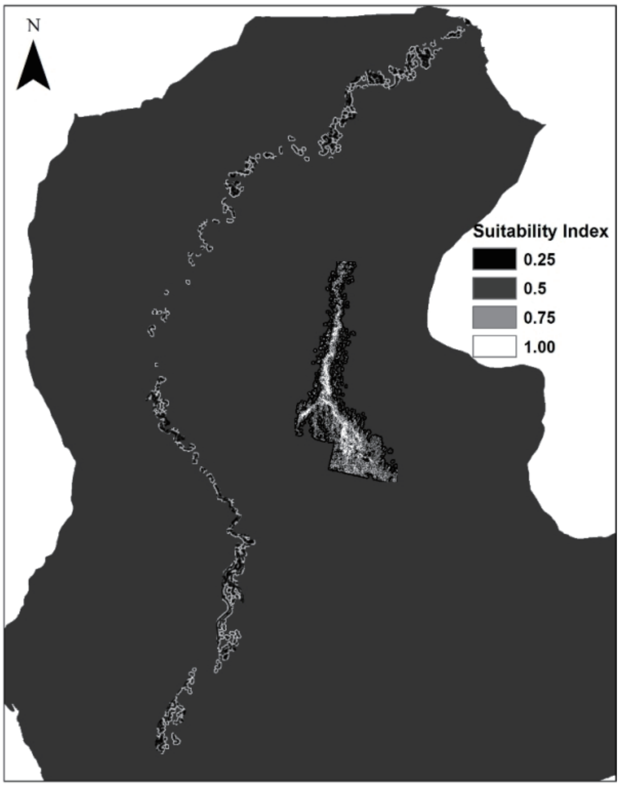

Figure 5. The suitability of distance from riparian vegetation for smooth-coated otter.

We selected what we determined to be the most relevant factors to evaluate habitat for these otters. Wetlands are the most important food source for this species, vegetation types determine hiding site quality, roads and towns restrict habitat suitability because of human disturbance. Because the habitats that smooth-coated otter select are highly correlated with the calculated suitability index, the four factors we considered appear to be important in determining the distribution of this species. We also found that some areas with a high suitability index were never visited by smooth-coated otter (Fig. 7) therefore, some other factors must limit their distribution. In conclusion, overall habitat quality (Fig. 6) provides an important base for determining potential habitats of smooth-coated otter and provides information on how to rehabilitate other habitats to support adequate populations of the species, including potential areas for their reintroduction.

Species–habitat relationships include several hierarchical levels of spatial scale, and different habitat features may be relevant to a species at different scales (Bissonette, 1997). Thus, habitat variables used successfully to predict a species' response at one scale may fail at another. Habitat models, however, rarely consider the potential effects of scale (Laymon and Reid 1986, Van Horne and Wiens 1991). The spatial resolution underlying HSI models depends on the resolution of the species–habitat concept used for model development. Being planning rather than research tools, most HSI models are not built on direct investigations, but on whatever information is at hand. Therefore, resolution will often result from the available data set rather than from purposeful design. Hence, many HSI models are applied with the underlying assumption that wildlife–habitat relationships are consistent throughout all levels of scale (Hamel et. al., 1986).

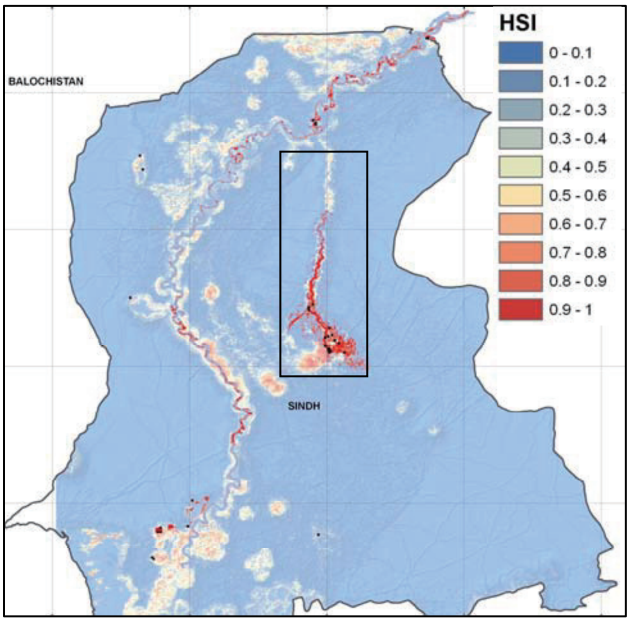

Figure 6. The calculated integrated suitability of the habitat for smooth-coated otter in Sind, Pakistan

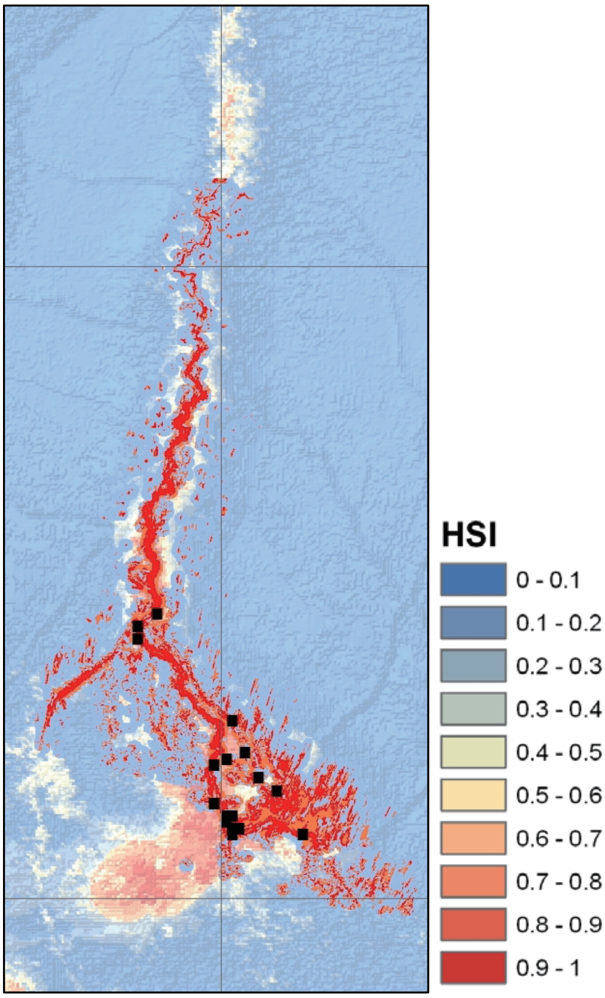

Figure 7. Suitable habitat of smooth-coated otter in Nara canal, indicated in Fig. 3.

Since otters are territorial, an otter population needs a considerable longitude of suitable habitat to keep a number of individuals large enough to maintain its viability. In areas where otter presence is restricted to the main course of a river and there is no connection with a nearby suitable territory, any intervention in the river is more likely bound to fragment the local otter population and could make it become nonviable. On the other hand, in regions where otter presence probability is also high outside the main courses of rivers, otters are predicted to have a greater mobility along the territory. Overall, this study will help *in-situ* conservation and management of the smooth-coated otters in Pakistan.

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5. REFERNCES

Ashraf, S., R. Nawaz., A. Daud and Qamer, F. M., (2004): Mapping western tragopan Tragopan melanocephalus habitat and distribution pattern in the Palas Valley, Pakistan using landcover, terrain and field survey data. In proceedings of International Symposium on Galliformes, April 2004, Deradun, India.

Bhat, S.D. and Rawat, G.S. 1995. Habitat use by chital (Axis axis) in Dhaulkhand, Rajaji National Park, India. Tropical Ecology, 36(2), 177-189.

Bissonette, J. A. 1997. Scale-sensitive ecological properties: historical context, current meaning. Pages 3-31 *in* J. A. Bissonette, editor. Wildlife and landscape ecology: effects of pattern and scale. Springer-Verlag, New York, USA.

Boitani, L., Corsi, F., Falcucci, A., Maiorano, L., Marzetti, I., Masi, M., Montemaggiori, A., Ottaviani, D., Reggiani G., Rondinini, C., 2002. Rete Ecologica Nazionale. Un approccio alla conservazione dei vertebrati italiani. Sapienza University of Rome Italian Ministry for Environment Territory and Sea, Institute of Applied Ecology Rome.

Brooks, R. P. 1997. Improving habitat suitability index models. 25:163-167.

Chanin, P. 1985. The natural history of Otters. Christopher Helm, London. 179 pp.

Delibes, M., Rodrı´guez, A.1990. La situacio´ n de la nutria en Espan˜ a: una sı´ntesis de los resultados. In: Delibes, M. (Ed.), La Nutria (Lutra lutra) en Espan˜ a. Serie Te´cnica, Ministerio de Agricultura, Pesca y Alimentacio´ n / ICONA, Madrid, pp. 157–167.

Foster-Turley, P., Macdonald, S. and Mason, C. 1990. Otters; An Action Plan for their Conservation. Kelvyn Press, Inc., Broadview, Illinois, USA 126 Pp.

Foster-Turley, P.A. 1992. Conservation aspects of the ecology of Asian Small Clawed and Smooth Coated Otters on the Malay Peninsulas. IUCN Otter Specialist Group Bulletin. 7:26-29.

Giles, R.H. 1978. Wildlife Management. Freeman & Co., San Francisco. Hamel, P. A., N. D. Cost, and R. M. Sheffield. 1986. The consistent characteristics of habitats: a question of scale. Pages 121-128 in J. Verner, M. L. Morrison, and C. J. Ralph, editors. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin, USA.

Johnsingh, A.J.T. and Joshua, J. 1994. Conserving Rajaji and Corbett National Parks – the elephant as flagship species. Oryx, 28(2), 135-140.

Johnsingh, A.J.T. (1991). Rajaji. Sanctuary, 11, 14-25.

Kamat, D.S. 1986. An integrated approach to remote sensing studies for wildlife habitat evaluation. . Proc. Seminar-cum-Workshop, Wildlife Habitat Evaluation using Remote Sensing Techniques, 22-23 October, 1986, Dehradun, pp. 165-182.

Khan, W.A. & Hasnain, S.A. 2008. Large Mammals at Indus for All Programme Sites (Unpublished Report). WWF-P, Karachi. 88 pp.

Khan, W.A., Qasim, M., Ahmad, E. and Bhaagat, H. B. 2008. Distribution of Smooth coated otter (Lutrogale perspicillata) in Sindh, Pakistan (Unpublished Report). WWF-P, Islamabad and Sindh Wildlife Department. 41 pp.

Khan, W. A., Qasim, M., Ahmad, E., Akbar, G., Habib, A. H., Ali, H., Mueen, F., Chaudhry, A. A., Iqbal, S., Bhaagat, B. H., Akhtar, M., Ahmad,. M. S., 2009. A survey of smooth coated otters (lutrogale perspicillata sindica) in the Sindh province of Pakistan. IUCN Otter Spec. Group Bull. 26(1) 2009. http://www.otterspecialistgroup.org/Bulletin/Volume26/Khan_et_al_2009.html

Kotwal, P.C. and Parihar, J.S. 1988. Management plan of Kanha National Park and Project Tiger Kanha for the period 1989-90 to 1998-99, Mandla, M.P.

Lamprey, H.F. 1963. Ecological separation of large mammal species in the Tarangire Game Reserve, Tanganyika. East African Wildlife Journal, 5, 151-166.

Laymon, S. A., and J. A. Reid. 1986. Effects of grid-cell size on tests of a spotted owl HSI model. Pages 93-96in J. Verner, M. L. Morrison, and C. J. Ralph, editors. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin, USA.

Li, X., Dianmo, L., Yiming, L., Zhijun, M., & Tianqing, Z. 2002. Habitat Evaluation of crested ibis: A GIS-based approach. Ecological Research 17, 565-573.

Link, F.-G., H. Reck, and M. Theis. 1996. Bewertungen im Naturschutz. Beiträge der Akademie für Natur- und Umweltschutz Baden-Württemberg 23, Stuttgart, Germany.

Mishra, C. and Johnsing, A.J.T. 1996. On habitat selection by the goral (Nemorhaedus goral) Bovidal, Artio dactyla. Zool. London, 240, 573-580.

Morrison, M. L., B. G. Marcot, and R. W. Mannan. 1992. Wildlife–habitat relationships. University of Wisconsin Press, Madison, Wisconsin, USA.

Ottaviani, D., 2004. I modelli di distribuzione delle specie animali in Italia: opportunità e limiti della loro utilizzazione per la conservazione della biodiversità. Ph.D. Thesis, Sapienza University of Rome (in Italian with English summary), 240 pp.

Panwar, H.S. 1986. Forest cover mapping for planning tiger corridors between Kanha and Bandhavgarh – a proposed project. Proc. Seminar-cum-Workshop, Wildlife Habitat Evaluation using Remote Sensing Techniques, 22-23 October, 1986, Dehradun, pp. 209-212.

Roberts, T.J. 1997. The Mammals of Pakistan. Revised Edition, Oxford University Press, Karachi. 525 pp.

Roberts, T.J. 2005. Field guide to the large & small sized mammals of Pakistan. Oxford University Press, Karachi. 259 pp.

Rodgers, W.A. 1990. Grassland production and nutritional implications for wild grazing herbivores in Rajaji National Parks, India. Tropical Ecology, 31(2), 41-49.

Rojas, A.B., Cotilla, I., Real, R., Palomo, L.J., 2001. Determinacion de las areas probables de distribucion de los mamferos terrestres en la provincia de Malaga a partir de las presencias conocidas. Galemys 13 (NE), 217–229.

Rondinini, C., Wilson, K.A., Boitani, L., Grantham, H., Possingham, H.P., 2006. Tradeoffs of different types of species occurrence data for use in systematic conservation planning. Ecology Letters 9, 1136–1145.

Rosenzweig M. L. (1985) Some theory aspects of habitat selection. In: Habitat Selection in Birds (ed. M. L. Cody) pp. 517–540. Academic Press, New York.

Ruiz-Olmo, J., Delibes, M. (Eds.), 1998. La nutria en Espan˜ a ante el horizonte del ano. 2000. Sociedad Espanola para la Conservacion y Estudio de los Mamı´feros, Malaga, Spain.

Schamberger, M. L., and L. J. O'Neil. 1986. Concepts and constraints of habitat-model testing. Pages 5-10 inJ. Verner, M. L. Morrison, and C. J. Ralph, editors. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin, USA.

Schulz, T. T., and L. A. Joyce. 1992. A spatial application of a marten habitat model. Wildlife Society Bulletin20:74-83.

Sheikh, K.M. & Molur, S. 2005. (Eds.) Status and Red List of Pakistan’s Mammals. Based on Pakistan’s Conservation Assessment and Management Plan for Mammals. 344 pp. IUCN, Pakistan.

van Horne, B., and J. A. Wiens. 1991. Forest bird habitat suitability index models and the development of general habitat models. Fish and Wildlife Research 8. U.S. Fish and Wildlife Service, Washington, D.C., USA.

van Manen, F.T. and M.R. Pelton. 1993. Data-based modeling of black bear habitat using GIS. pp.323-329 in I.D. Thompson (ed.). Proc. 21st Congress IUGB, Halifax, NC. Vol. 1. 379pp.

Verner, J., M. L. Morrison, and C. J.Ralph, editors. 1986. Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison, Wisconsin, USA.