ABSTRACT: Habitat quality for many wildlife populations has a spatial component related to the arrangement of habitat elements across large geographic areas. With remote sensing and GIS technology, this paper presents an approach to calculate Habitat Suitability Index (HSI) for Giant Pandas to evaluate the habitat quality. In this paper, a buffer of a given distance (30 km or more) to the Giant Panda distribution area estimated in three national surveys (1974, 1989 and 2002), which is located in Sichuan, Gansu and Shanxi provinces in western China, was used as the study area. In order to study different species group’s habitat quality, the study area is divided into five parts: the Qiling mountain systems, located in the southeast in Shanxi province, the Minshan mountain systems, located in the south in Gansu province and northwest in Sichuan province, the Qionglai mountain systems, the Xiangling mountain systems and the Liangshan mountain systems, located in the west of Sichuan province, conforming to the five big Giant Panda species groups. Three physical environmental factors (elevation, slope and aspect), one ecological factor (vegetation distribution) and several human-influence factors (distances to highways, general roads, inhabitants and rural areas) are selected as the influence factors to calculate HSI. Each factor was reclassified by grid-cell (30 × 30 m per cell) to the suitability index scale from 0 to 1 based on habitat affinities before final calculation. After analyzing the HSI values on the most Giant Panda distribution area, 0.0144 was considered as the threshold habitat quality. Then, HSI was calculated for five mountain systems for three periods conforming to three national surveys (1974, 1989 and 2002). Several benefits to the approach can be highlighted. Firstly, HSI can be used as the standard to evaluate the quality of Giant Panda habitat. Secondly, by using HSI maps from 1974, 1989 and 2002, we can see that the Giant Panda habitat was the largest in 1974, and was then reduced much before 1989. However, by 2002, it had recovered to some extent, which conforms to the habitat data from the three national surveys. Thirdly, the habitat changes in the five mountain systems examined in the study are different. Finally, nature reserves play an important role in the protection of Giant Panda habitat; there are more suitable habitats in nature reserves than non-protected areas.

KEY WORDS: Habitat Suitability Index (HSI), Giant Panda, remote sensing, wildlife habitat
1. INTRODUCTION

Effective conservation of threatened species requires knowledge of distribution and an understanding of the ecological factors determining habitat suitability (Gray et al. 2009). A Habitat Suitability Index (HSI) is such a conceptual model that relates measurable environmental variables to the suitability of a site for a species (Brooks 1997, Vinagre et al. 2006). HSI values are combinations of environmental variables, each represented by a suitability index (SI) and typically scaled from 0 (unsuitable habitat) to 1 (suitable habitat). HSI models are widely used in North America and allow wildlife to be represented with other natural resource information by recording or predicting the response of a species to its surroundings. Various factors, aside from habitat, may determine animal presence or abundance. Measures of habitat suitability may include only a limited number of factors that determine population levels. Thus, HSI models attempt to quantify habitat quality using habitat attributes considered important to the wildlife species (Rüger et al. 2005).

The Giant Panda (Ailuropoda melanoleuca, named by Armand David, literally meaning “cat-foot black-and-white”), a bear native to central-western and south western China (Wikimedia-contributors 2010-02-09), is a peculiar and endangered animal. It is the mark of the World Wildlife Foundation (WWF) and is considered a national treasure in China. Since the 1950s, it has been designated as top priority for species protection in China. The Giant Panda habitat was widely distributed in southwestern China, including Hunan, Hubei, Sichuan, Shaanxi and Gansu provinces in the 16th to 19th centuries (Zhu and Long 1983). But today, with the human population increase, agriculture expansion and transportation development, Giant Pandas (with a total number of 1596) only live in the Qinling mountain systems (with a total number of 61 on the area 1602 km²) and the Liangshan mountain systems (with a total number of 115 on the area 2204 km²), located in the west of Sichuan province (National Forest Ministry 2006).

Comparing the data from the third survey (1999–2003) with the data from the second survey (1985–1988), which were carried out by State Forestry Administration, (National Forest Ministry 1989; National Forest Ministry 2006), we can find that the panda distribution area expanded from 11 counties to 45 counties. Between these two surveys, the panda habitat also expanded by 43% from 13922 km² to 23050 km² and the panda population increased by 66% from 1114 to 1596 km² in 2002. The continuing decline in the panda population and habitat area has been preliminary curbed, and the survival environment is improving (National Forest Ministry 2006). Because of the large human population, recessive economy and poor facilities in the distribution area of the pandas, there remain many difficulties, problems and challenges to overcome and resolve in the process of panda protection in China. Maintaining and promoting panda habitat quality is the only way to go. Panda habitat quality is the degree of amenity of panda’s surroundings, which can be measured by panda habitat suitability. The HSI is therefore an excellent model to evaluate panda habitat quality.

By using the existing and potential panda habitats as the study area, along with the Landsat ETM data contemporary with the third national survey and the data from the third survey used as the main data source, this paper presents a HSI model to map the habitat quality in the study area. It provides a detailed view on the habitat quality and some new methods and ideas for habitat protection. This paper is significant for three reasons. First, it provides a scientific basis for strengthening the protection of existing nature reserves. Though many scholars have thoroughly studied the panda habitat, nobody has made a systematic analysis on the changes of panda habitat (Liu et al. 1999, An et al. 2001, Gong et al. 2005, Li et al. 2005, Li and Zhao 2005). Therefore, the changing dynamics of panda habitat remains unclear and the panda habitat quality is in dispute. Second, this paper is a guide to adjust and op-
Evaluating the habitat of Giant Panda using HSI

imize the existing nature reserves. Some nature reserves are too small to be effective and some adjacent nature reserves, due to separate local administration, are divided into several parts which degrades their function. Third, this paper provides a scientific basis for establishing new nature reserves. The new nature reserves can be established in the areas with a relative bigger HSI.

2. STUDY AREA

In this paper, a buffer of a given distance (30 km or more) to the Giant Panda distribution area from the three national surveys is used as the study area (shown in Fig. 1). The study area, which is located between 27°52´N–34°18´N and 101°19´E–109°10´E, covers all the distribution points of the four Giant Panda species groups, including three counties of Gansu Province, five counties of Shanxi Province, one county of Yunnan Province and more than thirty counties of Sichuan Province.

The study area is divided into five parts conforming to the five species groups: the Qinling mountain systems (1), the Minshan mountain systems (2), the Qionglai mountain systems (3), the Xiangling mountain systems (4) and the Liangshan mountain systems (5), shown as Fig. 1.

The study area is an expansion of the existing and historic habitat of the Giant Panda. It is located in the transition from the Sichuan basin to the Qinghai-Tibet Plateau, characterized by a mountain ravine area and a sparse human population. This area is suitable for the survival of the Giant Panda physiologically. Thus, we can study the existing panda habitats, the historical habitat, and the potential habitat, to provide a scientific basis for the expansion of Giant Panda habitat.

3. METHODS

3.1. Data collection

Landsat ETM data from 2002 of the study area, together with the Digital Elevation Model (DEM), road network maps, panda location, panda habitat area and settlement place of study area from the three national surveys data, which were carried out by State Forestry Administration, (National Forest Ministry 1989; National Forest Ministry 2006), are collected to study the

Fig. 1. The location of study area, the Giant Panda distribution area surveyed in years 1974–2002 in China and the five mountain systems (1 – Qinling mountain systems, 2 – Minshan mountain systems, 3 – Qionglai mountain systems, 4 – Xiangling mountain systems, 5 – Liangshan mountain systems).
habitat quality of Giant Panda. Also, Landsat MSS data from 1975 and Landsat TM data from 1989 are collected to validate the habitat quality of Giant Panda.

3.2. Selection of Panda habitat variables

According to the publications on the Giant Panda’s ecology and behavioral ecology, the three national surveys on Giant Panda population and habitat (National Forest Ministry 2006), and the analysis of the habitat characteristics (An et al. 2001, Zhang et al. 2004, Li and Zhao 2005), the influencing factors of Giant Panda’s habitat can be classified into three types: physical environmental factors, biological factors and human-influence factors (Peng et al. 2005, Yang et al. 2006, Zhang et al. 2006, Pasher et al. 2007, Zhang et al. 2007, Zhang et al. 2008).

(1) Physical Environmental Factors: physical environmental factors include elevation, geomorphic type, slope, etc. According to the data from the three national surveys, almost all the Giant Pandas lived in the area with the elevation from 1200 meters to 3800 meters with a slope less than 30 degrees (National Forest Ministry 2006, Ran et al. 2006).

(2) Biological Factors: biological factors include vegetation type, edulis bamboo (Fargesia or Bashania) distribution and richness, natural enemy distribution, etc. For Giant Panda, mountainous coniferous forest is the best habitat, broadleaf forest and shrubby forest are also suitable. In this paper, the vegetation types used to evaluate habitat are retrieved from Landsat remotely sensed data. The information on the distribution and richness of edulis bamboo came from the three surveys on the Giant Panda’s population and habitat.

(3) Human Influence Factors: human influence factors include logging, transportation, rural activity and daily life of local inhabitants. These activities either destroy the Giant Panda’s habitat or lead to a lower habitat quality.

3.3. HSI calculation

HSI models typically evaluate habitat quality by using weighted linear combinations and factors considered to be important to the wildlife species (Brooks 1997). Then the HSI model is scaled so that the HSI values range from 0 for unsuitable habitat to 1 for optimal habitat.

In this paper, we select elevation, slope and aspect as the physical environmental factors, vegetation distribution as the ecological factors and distances to highways, general roads, inhabitants and rural areas as the human-influence factors to calculate HSI. Each factor was reclassified by grid-cell to the suitability index scale (e.g. elevation in meters was converted to a 0–1 suitability scale) based on habitat affinities of panda derived from published sources on panda biology as well as on the survey data from the three national surveys. The evaluation standards of physical environmental factors and ecological factors are listed in Table 1. Suitable habitat was assigned to 1, less suitable was assigned to 0.6 and unsuitable was assigned to 0.1. The distribution of edulis bamboo was taken as a reference factor for the survey area. Because of human influence factors, four levels were classified according to the distance to the activity center. The evaluation standards of human influence factors are listed in Table 2, no influence was assigned to 1, weak influence was assigned to 0.7, middle influence was assigned to 0.4 and strong influence was assigned to 0.1.

Thus, we can get eight suitability indices for various factors:

\[
\begin{align*}
SI_{ele} &= B_{1100-1500} + 0.6B_{1500-2000} + 0.1B_{2000-3000} + 0.1B_{3000-3800} \\
SI_{type} &= B_{GT750} + 0.1B_{GT600} + 0.4B_{GT245} \\
SI_{aspect} &= B_{north, south, northeast} + 0.6B_{other} \\
SI_{veg} &= B_{shrubbery, broad leaf} + 0.6B_{shrub, other} \\
SI_{high} &= B_{GT245} + 0.4B_{300-720} + 0.1B_{LT110} \\
SI_{road} &= B_{GT245} + 0.4B_{300-720} + 0.1B_{LT110} \\
SI_{habin} &= B_{LT300} + 0.4B_{1450-1920} + 0.4B_{900-1410} + 0.1B_{LT300} \\
SI_{rural} &= B_{GT750} + 0.7B_{GT245} + 0.4B_{GT1920} + 0.1B_{LT300}
\end{align*}
\]

where: B represents “binary,” which means each degree is turned into binary before calculating the SI.

As all factors are the contributors to HSI, then, HSI for Giant Panda can be calculated as:

\[
HSI = SI_{ele} \times SI_{type} \times SI_{aspect} \times SI_{veg} \times SI_{high} \times SI_{road} \times SI_{habin} \times SI_{rural}
\]
Evaluating the habitat of Giant Panda using HSI overlaying the environmental maps. This resulted in a map of the composite Habitat Suitability Index value. The calculation process is shown in Fig. 2.

4. RESULTS

4.1. Determination of the threshold value

The Giant Panda is a non-social animal (Wang 2001, Zhang et al. 2004). Except for the rut and the vertical migration season, its movement distance is limited and relatively stable within a given period. Thus, there is little probability that a panda will appear outside a certain circle (always 2 km) around each active trace spot within a given period (National Forest Ministry 1989, National Forest Ministry 2006). From the third national survey data, Sichuan province has the largest Giant Panda population and habitat, about 75% and 77%, respectively. Thus, the locations of Giant Pandas in Sichuan province from the third national survey data are used to get the threshold value. In practice, we buffer every location within 5 km to create the actual territory map for all the Giant Pandas (Wang 2001, National Forest Ministry 2006). Then the map is used to overlay the HSI map of the study area to create a HSI map for the actual territory (Fig. 3). Supposing that 80% of the area is suitable for the Giant Panda, a threshold value of 0.0144 was got (Fig. 4; National Forest Ministry 2006). Therefore, a location with a HSI value larger than 0.0144 is considered being suitable for Giant Pandas.

### Table 1. Evaluation standards of physical environmental factors and ecological factors used in Habitat Suitability Index (HSI).

<table>
<thead>
<tr>
<th>Influence types</th>
<th>Suitable</th>
<th>Less suitable</th>
<th>Unsuitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical environmental factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>elevation (m)</td>
<td>1100–2800</td>
<td>1100–1500, 2800–3800</td>
<td>&lt;1100, &gt;3800</td>
</tr>
<tr>
<td>slope (degree)</td>
<td>&lt;30</td>
<td>30–45</td>
<td>&gt;45</td>
</tr>
<tr>
<td>aspect</td>
<td>south-east, south-west</td>
<td>west, north-west, north, north-east, east</td>
<td>–</td>
</tr>
<tr>
<td>Ecological factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vegetation bamboo</td>
<td>edulis bamboo</td>
<td>broad leaved forest and shrubby</td>
<td>others</td>
</tr>
<tr>
<td></td>
<td>no bamboo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Evaluation standards of human-influence factors used in Habitat Suitability Index (HSI).

<table>
<thead>
<tr>
<th>human influence types</th>
<th>Strong influence</th>
<th>Middle influence</th>
<th>Weak influence</th>
<th>No influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to national highway and province highway (m)</td>
<td>&lt;180</td>
<td>180–300</td>
<td>300–720</td>
<td>&gt;720</td>
</tr>
<tr>
<td>Distance to general road (m)</td>
<td>&lt;60</td>
<td>60–210</td>
<td>210–720</td>
<td>&gt;720</td>
</tr>
<tr>
<td>Distance to inhabitants (m)</td>
<td>&lt;900</td>
<td>900–1410</td>
<td>1410–1920</td>
<td>&gt;1920</td>
</tr>
<tr>
<td>Distance to rural area (m)</td>
<td>&lt;90</td>
<td>90–240</td>
<td>240–750</td>
<td>&gt;750</td>
</tr>
</tbody>
</table>

Fig. 2. HSI Calculation diagram.
With the HSI calculation model listed in section 2.4, HSI maps of the study areas in 1974, 1989 and 2002 are created (Fig. 5). The distribution plots for the three maps are shown in Fig. 6. We can see that the areas with HSI less than 0.0144 are 22% of the whole study area in 1974 (about 32338 km²), 23% in 1989 (about 34300 km²) and 23% in 2002 (about 33925 km²). This means that the area suitable for the Giant Panda in 1974 is larger than that in 2002, and the area in 2002 is larger than that in 1989, which corresponds to the data from the three national surveys.

### 4.3. HSI map for five mountain systems

Due to the expansion of human activities, the Giant Panda habitat is divided into several parts (mountain systems of Qinling, Minshan, Qionglai, Xiangling and Liangshan) and each part has its own level of development and protection. Thus, in order to protect and expand the habitat with corresponding actions, it is necessary to evaluate the quality of each part. Table 3 shows the HSI statistical results for all parts in 1974, 1989 and 2002. Fig. 7 presents the HSI maps in 1974, 1989 and 2002, respectively. The table and figures indicate that few changes have taken place in Minshan, Qionglai and Qinling mountain systems, although they have experienced a decline and then a steady improvement. Liangshan mountain system has a similar situation, but the change is much more prominent, which show serious disturbance in this area. Xiangling mountain system is also improving steadily.

The situations of all the mountain systems at the time of 2002 can be retrieved from Table 3. The average HSI in the Minshan mountain systems is 0.0649, which is lower than the study area average. However, the areas with a HSI larger than 0.0144 cover 52% of the whole Minshan mountain system and have an average HSI of 0.123. The average HSI in Qinling is 0.131, which is still lower than the study area average. The areas with a HSI above 0.0144 occupy 64% of the whole, with an average HSI of 0.202. The average HSI in Qionglai is 0.131, which is lower than the study area average. The area with HSI above 0.0144 includes 64% of the whole system, with an average HSI of 0.211. The average HSI in Xiangling is 0.059, which is lower than the study area average. The area with HSI above 0.0144 covers 51% of the whole system and have an average HSI of 0.199.

With these statistical results, the quality of all mountain systems can be evaluated with the panda population density calculated by
Evaluating the habitat of Giant Panda using HSI

Fig. 4. Plot of HSI in Minshan, Qionglai, Xiangling and Liangshan mountain systems’ panda distribution area.

Fig. 5. Calculated HSI-map for study area (A – 1974, B – 1989, C – 2002).

Fig. 6. Plot of calculated HSI in 1974, 1989 and 2002 for the study area.
kernel density estimation method from the panda distribution (Wang 2001, National Forest Ministry 2006). Qinling and Qionglaishan mountain systems have the best quality and the largest percentage of habitat, hence the highest population density (with 0.078 per km² and 0.072 km² from the third national survey data, respectively). Xiangling mountain system bears the worst quality and the smallest percentage of habitat. While Liangshan mountain systems hold a medium percentage, it has the smallest area among the five mountain systems, hence the smallest area for the pandas. Thus, both systems have a relatively low density (with 0.040 per km² and 0.052 per km² from the third national survey data, respectively). Minshan mountain system has a different situation. It has been divided into two species groups by the highways. Moreover, it has the largest human population and has a relatively low HSI. However, due to its large area, Minshan mountain system provides more suitable habitat for the pandas leading to a relatively high density (with 0.074 per km² from the third national survey data) (National Forest Ministry 2006). Fig. 7C indicates that Qinliang and Qionglaishan mountain systems have the best quality habitat in 2002. Xiangling mountain system has the worst quality habitat, demanding special protection. Liangshan mountain system has a medium quality habitat, but due to the smallest area, special protection is still needed. Minshan mountain system has the largest habitat, but Fig. 7C indicates that the panda habitat is being depleted due to the fast development of the economy. Therefore, habitat protection in this area requires much attention.

4.4. HSI map for nature reserves

Nature reserves are the primary base for biodiversity protection (Wang 2001, National Forest Ministry 2006). They play a significant role in maintaining biological function, strengthening the regional eco-capacity and sustainable development capacity, encouraging international communication and scientific research, and implementing the scientific development outlook comprehensively (National Forest Ministry 2006). As the Giant Panda is a protected species, panda habitat protection becomes the main concern of the nature reserves where pandas are distributed (National Forest Ministry 2006). These nature reserves also become the major base for panda protection. Thus, it is necessary to evaluate the quality of the nature reserves where pandas are distributed. The nature reserves in Sichuan province were selected to evaluate because this province has the most natural reserves, the widest distribution and the most variety.

Compared with other areas, nature reserves have a higher percentage of suitable habitats. Wolong Nature Reserve, as an example, has a suitable habitat percentage in the reserve (83% in 2002), but the percentage of the whole Qiongla mountain system, where it is located, only reaches 63%. Xiaozaizigou and Huanglong Nature Reserves have a relatively small percentage of suitable habitat (63% and 57%, respectively), while the percentage only reaches 52% for the whole Minshan mountain system where they are located. The establishment of the two nature reserves is relatively late (National Forest Ministry 2006). Thus, we can infer that nature reserves play an essential role in the protection of pandas.

<table>
<thead>
<tr>
<th>Mountain systems</th>
<th>1974</th>
<th>1989</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HSI</td>
<td>HSI&gt;0.0144</td>
<td>HSIAvg.</td>
</tr>
<tr>
<td>Minshan</td>
<td>0.07</td>
<td>53.57</td>
<td>0.12</td>
</tr>
<tr>
<td>Qinling</td>
<td>0.16</td>
<td>64.63</td>
<td>0.24</td>
</tr>
<tr>
<td>Qiongla</td>
<td>0.14</td>
<td>62.42</td>
<td>0.22</td>
</tr>
<tr>
<td>Xiangling</td>
<td>0.06</td>
<td>35.95</td>
<td>0.15</td>
</tr>
<tr>
<td>Liangshan</td>
<td>0.09</td>
<td>55.08</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Table 3. Statistics (HSI Avg. – average value of HSI; HSI>0.0144 (%) – the percentage of the area covered with HSI greater than 0.0144; HSI Avg. (>0.0144) – it’s average value of HSI) for five mountain systems (see Fig. 1) years 1974, 1989 and 2002 (with threshold value = 0.0144).
5. DISCUSSION AND CONCLUSIONS

5.1. Changing tendency of the panda habitat quality

Intuitively, large-bodied species, assumed to have the greatest spatial requirements, should be most prone to suffering the effects of habitat loss (Hockey and Curtis 2009). Thus, to make clear of the changing tendency of the panda habitat quality is important to protect panda. With the HSI calculated above, the changing tendency of the panda habitat quality can be deduced: the panda habitat quality hits an all-time high in 1974 (with the largest area and best quality), and then declines in 1989 (with a smaller area and worse quality), but has started to rebound steadily since then. Though the rise has not reached the highest point in 1974, the ascending trend continues due to the national policies and the contribution of local people in the later years. This changing tendency corresponds to the data from three national surveys and other published sources. However, the habitat changes vary among the five mountain systems. In Qionglai and Qinling mountain systems, the change was steady and
minor. The situation in Minshan mountain system fluctuated during the period 1974 to 2002, while Liangshan and Xiangling mountain systems suffered a major change, which also corresponds to the data from the three national surveys and other literature. Thus, the HSI can be used as an essential parameter to evaluate the quality of panda habitat (Kliskey et al. 1999). Meanwhile, because the land cover status is retrieved from remote sensing data, the human-induced factor, which was used to be the main factor impacting the evaluated result, is reduced to a controlled level. From the calculation process of HSI, we can see that the major driving factors of habitat change are land cover and elevation. Highways and roads are the second major driving factors of habitat change because they cause fragmentation of the habitat (National Forest Ministry 2006).

5.2. Role of nature reserves in quality assurance of Giant Panda habitat

There are 40 nature reserves in China that function to protect Giant Panda. These nature reserves cover 45% of the area of the total panda distribution area, and contain 62% of the total panda population. This means that nature reserves are playing an essential role in panda habitat protection, not as that habitats had become worse because of the establishment of the nature reserve (Liu et al. 2001). Using the HSI maps from 1974, 1989 and 2002, we can see that the nature reserves have a higher percentage of habitats suitable for pandas than that of other areas. Though the quality and quantity of Giant Panda habitat have recovered in recent years, in the view of species group protection, the Giant Panda habitat needs to be further expanded. Thus, HSI can be used to evaluate the quality of panda habitat as well as to provide scientific-based information to expand existing nature reserves and support the foundation of new nature reserves.

5.3. Merits and deficiencies of HSI

HSI models are based on the assumptions that a species will select and use areas that are best able to satisfy its life requisites, and consequently, greater use will occur in higher quality habitat (Brooks 1997, Ray and Burgman 2006). Thus, HSI models have their own limitations. Limitations of HSI models include the lack of linearity between wildlife density and individual habitat parameters, the inferiority of simple indices to those based on multivariate analysis, the variability of habitat use regardless of life stage or season, and inadequacy of a species’ observed density as an indicator of habitat quality (Brooks 1997, Kliskey et al. 1999, Vinagre et al. 2006, Vincenzi et al. 2007).

In addition to the above limitations, the HSI model presented in this paper has its own limitations. First, HSI maps are unable to indicate the fragmentation of habitats. In future research, HSI should be combined with landscape features to evaluate the fragmentation of the habitats. Second, others factors, which may have some impact on the quality of habitats, such as logging, harvesting herbs, picking bamboo shoots, and bamboo flowering, have not been taken into account. Third, the distribution of panda-edible bamboo has not been taken into consideration, yet it is a crucial factor for the distribution of pandas. In the future, distribution and changes of edible bamboos for pandas will be combined with HSI to improve the precision of the panda habitat evaluation.

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6. REFERENCES

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Vinagre C., Fonseca V., Cabral H., Costa M. J. 2006 – Habitat suitability index models for the juvenile soles, Solea solea and Solea senegalensis, in the Tagus estuary: Defining variables for species management – Fish Res. 82: 140–149.


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