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Landscape factors affecting relative abundance of gray foxes
*Urocyon cinereoargenteus* at large scales in Illinois, USA

Susan E. Cooper, Clayton K. Nielsen & Patrick T. McDonald

Evaluation of wildlife-habitat relationships at the landscape level provides insight into how habitat connectivity, fragmentation and land-use changes may affect wildlife populations. Although previous studies have demonstrated that habitat composition and configuration at large scales may affect the presence, survival and movement of carnivore species, no such analyses have been conducted for the gray fox *Urocyon cinereoargenteus*. We used a generalized correlative mapping approach to investigate the relationship of gray fox relative abundance to landscape variables at the county scale in Illinois, USA. Relative abundance of gray foxes was high in 37 of 102 (36%) counties. Four models were competitive based on $\Delta AIC_c$ scores, and these models indicated that standard deviation of the perimeter-area ratio of agricultural patches, interspersion and juxtaposition index of grassland patches, coefficient of variation of the proximity index of forest patches and relative patch richness of the landscape affected gray fox relative abundance. The variables occurring in our competing models indicate that the relative abundance of the gray fox is higher in counties containing a high level of fragmentation of preferred habitat types (i.e. forests and grasslands) and lower dispersion of less preferred habitat types (i.e. agriculture). Our results reflect gray fox habitat use at smaller scales, and at the landscape scale, gray fox abundance is influenced by how cover-type patches are configured.

Key words: carnivores, FRAGSTATS, gray foxes, habitat model, landscape, *Urocyon cinereoargenteus*

Analysis of habitat at multiple spatial scales is widely recognized as important, as habitat affects the distribution of wildlife geographically, regionally and locally (Donovan et al. 1997, Gehring & Swihart 2003, Ecke et al. 2006). At large scales, more effective evaluation of habitat connectivity, complexity and fragmentation, as well as changes in land use can be made (Donovan et al. 1997, Guisan & Zimmermann 2000, Osborne et al. 2001, Kie et al. 2002), and these factors affect presence, survival (Sovada et al. 2000, Rohm et al. 2007) and movements of wildlife (Knick & Dyer 1997, Dijak & Thompson 2000, Constible et al. 2006, Ecke et al. 2006). Habitat analyses at large scales typically utilize animal information, a geographic information system (GIS) and remotely-sensed satellite imagery (Knick & Dyer 1997, Carroll et al. 1999, Osborne et al. 2001, Woolf et al. 2002). Oftentimes, the goal of such analyses is to predict habitat suitability or potential colonization of previously unused areas (Buckland & Elston 1993, Corsi et al. 1999, Mladenoff et al. 1999, Osborne et al. 2001). Many of these studies use a correlative approach that relates species occurrences to predictor variables available across the entire study area (Osborne et al. 2001:459).

Habitat analyses at large scales have been con-
ducted for many carnivore species in North America (LaRue & Nielsen 2008, McDonald et al. 2008, Zielinski et al. 2010, Scheller et al. 2011). These analyses have employed various approaches in model building. Researchers oftentimes select landscape predictor variables based on information and data acquired from local or smaller-scale studies (Osborne et al. 2001, Woolf et al. 2002). The expectation that predictor variables at one scale would relate to those at another scale makes biological sense but could overlook variables that, while less ecologically intuitive, actually predict species occurrence at larger scales better.

Habitat analyses for gray foxes *Urocyon cinereoargenteus* have occurred primarily at the home-range scale (Haroldson & Fritzell 1984, Sawyer & Fendley 1994, Chamberlain & Leopold 2000, Temple 2007). These studies characterize gray foxes as habitat generalists with some preference for wooded cover. Constible et al. (2006) attempted to relate home-range size to landscape patterns using variables selected on assumed ecological importance for gray foxes, bobcats *Lynx rufus* and coyotes *Canis latrans*, but only found this useful for bobcats. This finding may indicate that habitat patterns at the home-range scale for gray foxes do not predict patterns at a large scale.

Gray foxes are widely distributed throughout North America (Cypher 2003), and although the International Union of Conservation of Nature and Natural Resources lists the gray fox as a species of least concern (Fuller & Cypher 2004), recent trends in Illinois, USA, indicate that the population is declining statewide (Bluett 2007). Several factors may be contributing to this decline, including intraguild predation and competition with coyotes and bobcats, and transmission of disease from other wildlife species (Nicholson & Hill 1984, Fedriani et al. 2000, Gosselink et al. 2003, Chamberlain & Leopold 2005). As Illinois’ human population increases (U.S. Census Bureau 2008), land-use changes, such as exurban development (Harden & Woolf 2005, Storm et al. 2007a,b) and forest maturation (Schmidt et al. 2000), may also occur and affect already declining gray fox populations. Therefore, knowledge of habitat factors that can be used to predict the relative abundance of gray foxes in Illinois is important for understanding how landscape changes may affect populations. To address this gap in knowledge, our goal was to conduct an exploratory analysis to assess what landscape patterns influence the relative abundance of gray foxes at the county scale in Illinois, USA.

Material and methods

Study area and general approach
Data regarding gray fox relative abundance was collected throughout the state of Illinois, USA. We evaluated landscape-level habitat characteristics for Illinois at the county scale (N = 102). Habitat throughout Illinois varies from highly cultivated agriculture lands throughout much of central Illinois, to rolling hills and wooded areas in the northern and southern areas of the state, to urbanized areas (e.g. Chicago) in the northeast and other isolated portions of the state. Land cover in Illinois is about 80% cropland pastures, 15% forest and 5% consists of urban lands, wetlands, lakes and rivers (Illinois Natural History Survey 2003). Forest cover at the county level varies from 40-60% in the unglaciated Shawnee Hills region in the southern part of the state to < 5% in east-central Illinois (Illinois Natural History Survey 2003).

Because we did not want to eliminate variables which we assumed were unimportant based on home-range level habitat analyses, we took an inclusive approach in our variable selection process. We used a generalized correlative mapping approach to investigate the relationship of gray fox relative abundance to landscape variables (Saab 1999, Burnham & Anderson 2002, Weyrauch & Grubb 2004, Russell et al. 2007). We used remotely-sensed land-cover information and FRAGSTATS 3.3 (McGarigal et al. 2002) to produce a suite of class and landscape metrics for each Illinois county. After standard variable reduction procedures (see below), we used these metrics to develop and rank *a priori* and *post hoc* models to determine which landscape characteristics may be useful in predicting gray fox relative abundance at the county level. We used SAS Version 8 (SAS Institute, Cary, North Carolina, USA) and STATISTIX (Analytical Software 1996) for all statistical analyses and ARCGIS Version 9.1 (Environmental Systems Research Institute, Inc. 2004) for all GIS analyses.

Relative abundance of gray foxes
The Archery Deer Hunter Survey (ADHS) is conducted annually by the Illinois Department of Natural Resources. Based on the ADHS, sighting indices for Illinois’ major wildlife species are calculated using sightings and effort of deer hunters during the archery deer season (Bluett 2007). With an average of 2,323 survey participants per year, we calculated a gray fox sighting index for each Illinois

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county during 1998-2006, excluding 1999 when data
were unavailable, based on the number of hunter
sightings and number of field hours per hunter (Ver
Steeg & Warner 1997). We classified the index data
into two categories as we were more confident in the
ability of the data to separate gray foxes as high and
low relative abundances rather than as a continuous
index (Seber 1992, Slade & Blair 2000, Joseph et al.
2006). Based on patterns in the data, we considered
relative abundance of gray foxes in a county to be
high at index values $> 0.6$ and low at index values $\leq$
0.6 (Fig. 1). Additionally, this value provided
approximately similar sample sizes for logistic re-
gression analysis.

**Landscape variable selection**

We assessed landscape characteristics at the county
level using remotely-sensed land-cover data with $30 \times$
$30$ m ground spatial resolution from the Illinois
Critical Trends Assessment Project (Illinois Natural
History Survey 2003). Using the program ERDAS
(Leica Geosystems GIS and mapping 2003), we
reclassified the original 29 land-cover types in this
data set into six categories which are the most
representative of Illinois’ landscape: agriculture,
forest, grassland, urban, water and wetland. We
then used FRAGSTATS 3.3 (McGarigal et al. 2002)
to quantify class- and landscape-level metrics for
each county. While class-level metrics were calculat-
ed based on specific cover types, landscape-level
metrics were calculated based on land cover within
each county (McGarigal et al. 2002).

We used standard variable reduction techniques
to reduce the number of variables for further
analysis (Nelson 2001, Rohm et al. 2007, Wilson
& Nielsen 2007) by 1) eliminating variables repre-
sented in $< 40\%$ of the counties, 2) transforming
non-normally distributed variables to improve nor-
mality and removing variables that were unable to
be transformed, 3) removing variables that did not
differ among counties where gray fox relative
abundance was high vs low, 4) grouping all corre-
lated variables in a cluster analysis and 5) assessing
simple pairwise correlations between variables in-
cluded in each model to ensure avoidance of issues
with collinearity.

After eliminating poorly represented variables, we
tested variables for approximation of the normal
distribution and transformed non-normally distrib-
uted variables to improve normality using square
root or log transformations (Shapiro-Wilk $> 0.85$).
Because only numerical variables could be used as
input in our analyses, conversion to multi-level factor
variables was not an option. Therefore, we removed
those variables that deviated too strongly from
normality. Then, we determined if variables differed
($\alpha = 0.05$ throughout) between counties where gray
foxes were present vs absent using ANOVA (PROC
GLM, SAS). Finally, we used cluster analysis
(PROC VARCLUS, SAS; Nelson 2001, Iniguez et
al. 2005, Rohm et al. 2007) with an eigenvalue cut-off
of $0.7$, which creates groups of variables that are as
correlated as possible among themselves and as
uncorrelated as possible with variables in other
clusters (Nelson 2001). We then selected the most
representative variable from each cluster and added
survey effort to account for any effort bias, and used
these 15 remaining variables for further analysis
(Table 1). To further assess potential variable collin-
earity, we assessed simple pairwise correlations
between variables included in each model using the
$r$-correlation coefficient (see below; Table 2). Of all
possible pairwise comparisons, only two were
$>|0.40|$. Hence, variables were generally not corre-
lated for analyses following cluster analysis. While
we admit that the number of variables may be higher
than most studies include, we selected this approach
as an all-inclusive exploration that may provide new
ecological insight at a larger scale.

**Landscape variables affecting relative abundance**

To assess the relationship between 15 landscape
variables and relative abundance of gray foxes at the
county scale, we developed a priori binary logistic
regression models (two response categories, high vs
low relative abundance) based on different levels of
spatial heterogeneity and different categories of
landscape metrics, and then fitted a number of post

![Figure 1. Number of gray fox sightings per field hours for hunters in
each Illinois county was used to categorize the relative abundance of
gray foxes for each county as high ($> 0.6$) or low ($\leq 0.6$) in Illinois,
USA.](https://bioone.org/journals/Wildlife-Biology/18.4/10.1672/14.4.368.F1){:target="_blank"}
Table 1. Description of variables (McGarigal et al. 2002) used for modeling landscape characteristics affecting relative abundance of gray foxes in Illinois, USA, 1998-2006.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
<th>Definition (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AgGyMed</td>
<td>Median radius of gyration of agricultural patches</td>
<td>Median value of patch extent of agricultural patches, accounting for patch size and compaction (m)</td>
</tr>
<tr>
<td>AgParaRange</td>
<td>Range of the perimeter-area ratio of agricultural patches</td>
<td>Range of the lowest and highest perimeter-area ratio of agricultural patches</td>
</tr>
<tr>
<td>AgParaSD</td>
<td>Standard deviation of the perimeter-area ratio of agricultural patches</td>
<td>Variation around the mean of the perimeter-area ratio of agricultural patches</td>
</tr>
<tr>
<td>Effort</td>
<td>N/A</td>
<td>Sum of all hours of all sampling units (hours)</td>
</tr>
<tr>
<td>ForDivis</td>
<td>Landscape division index of forest patches</td>
<td>Probability that two randomly chosen pixels are not situated in the same forest patch (proportion in m²)</td>
</tr>
<tr>
<td>ForEdgeDens</td>
<td>Edge density of forest patches</td>
<td>Density of the edge of forest patches (m/ha)</td>
</tr>
<tr>
<td>FornLSI</td>
<td>Normalized landscape shape index of forest patches</td>
<td>Forest patch aggregation</td>
</tr>
<tr>
<td>ForProxCV</td>
<td>Coefficient of variation for the proximity index of forest patches</td>
<td>Observed interspersion of forest patches over the maximum possible interspersion (%)</td>
</tr>
<tr>
<td>GrassIJI</td>
<td>Interspersion and juxtaposition index of grassland patches</td>
<td>Observed interspersion of grassland patches over the maximum possible interspersion (%)</td>
</tr>
<tr>
<td>GrassnLSI</td>
<td>Normalized landscape shape index of grassland patches</td>
<td>Grassland patch aggregation</td>
</tr>
<tr>
<td>LandRPR</td>
<td>Relative patch richness of the landscape</td>
<td>Percentage of cover types present from the maximum number possible (%)</td>
</tr>
<tr>
<td>LandTA</td>
<td>Total area of landscape</td>
<td>Total landscape area (ha)</td>
</tr>
<tr>
<td>UgyCV</td>
<td>Coefficient of variation for the proximity index of urban patches</td>
<td>Percent based on the standard deviation and mean proximity index, taking into account urban patches &lt; 500 m from the focal urban patch (%)</td>
</tr>
<tr>
<td>WDCAD</td>
<td>Disjunct core area density of wetland patches</td>
<td>Number of disjunct wetland patches (#/100 ha)</td>
</tr>
</tbody>
</table>

Table 2. Model selection based on binary logistic regression used to determine landscape variables affecting relative abundance of gray foxes in Illinois, USA, 1998-2006. Variables are defined in Table 1. K = the number of parameters estimated including intercept. Models were ranked using Akaike’s Information Criterion corrected for small sample sizes (AICc). \( w_i \) = Akaike weights, which can be used to interpret the probability that models would be similarly ranked on repeated sampling of data.

<table>
<thead>
<tr>
<th>Model</th>
<th>K</th>
<th>AICc</th>
<th>ΔAICc</th>
<th>( w_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AgParaSD + GrassIJI + LandRPR</td>
<td>4</td>
<td>108.594</td>
<td>0</td>
<td>0.225</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + GrassIJI + LandRPR</td>
<td>5</td>
<td>108.718</td>
<td>0.124</td>
<td>0.212</td>
</tr>
<tr>
<td>AgParaSD + GrassIJI</td>
<td>3</td>
<td>109.363</td>
<td>0.769</td>
<td>0.153</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + GrassIJI</td>
<td>4</td>
<td>110.208</td>
<td>1.614</td>
<td>0.100</td>
</tr>
<tr>
<td>AgParaSD + Effort + ForProxCV + GrassIJI + LandRPR</td>
<td>6</td>
<td>110.766</td>
<td>2.172</td>
<td>0.0760</td>
</tr>
<tr>
<td>AgParaSD + GrassIJI + UgyCV + WDCAD</td>
<td>5</td>
<td>111.881</td>
<td>3.287</td>
<td>0.0435</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + GrassIJI + GrassnLSI</td>
<td>5</td>
<td>112.240</td>
<td>3.646</td>
<td>0.0364</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + GrassIJI + UgyCV + WDCAD</td>
<td>6</td>
<td>112.309</td>
<td>3.715</td>
<td>0.0351</td>
</tr>
<tr>
<td>AgParaSD + Effort + ForEdgeDens + GrassIJI</td>
<td>5</td>
<td>112.561</td>
<td>3.967</td>
<td>0.0310</td>
</tr>
<tr>
<td>AgParaSD + GrassnLSI + LandRPR</td>
<td>4</td>
<td>112.942</td>
<td>4.348</td>
<td>0.0256</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + GrassnLSI + LandRPR</td>
<td>5</td>
<td>112.989</td>
<td>4.395</td>
<td>0.0250</td>
</tr>
<tr>
<td>AgParaSD + Effort + GrassnLSI + GrassIJI</td>
<td>5</td>
<td>113.625</td>
<td>5.031</td>
<td>0.0182</td>
</tr>
<tr>
<td>AgParaSD + Effort + ForProxCV + GrassIJI + LandTA + UgyCV</td>
<td>7</td>
<td>114.459</td>
<td>5.865</td>
<td>0.0120</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + LandRPR</td>
<td>4</td>
<td>117.164</td>
<td>8.570</td>
<td>0.00310</td>
</tr>
<tr>
<td>AgParaSD + LandRPR + UgyCV + WDCAD</td>
<td>5</td>
<td>117.847</td>
<td>9.253</td>
<td>0.00220</td>
</tr>
<tr>
<td>AgParaSD + ForProxCV + GrassnLSI + UgyCV + WDCAD</td>
<td>6</td>
<td>119.789</td>
<td>11.195</td>
<td>0.000835</td>
</tr>
<tr>
<td>LandRPR + UgyCV + WDCAD</td>
<td>4</td>
<td>121.151</td>
<td>12.557</td>
<td>0.000423</td>
</tr>
<tr>
<td>ForProxCV + GrassIJI + LandRPR</td>
<td>4</td>
<td>124.190</td>
<td>15.596</td>
<td>9.24E-05</td>
</tr>
<tr>
<td>AgParaSD + UgyCV</td>
<td>3</td>
<td>127.961</td>
<td>19.367</td>
<td>1.40E-05</td>
</tr>
</tbody>
</table>

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hoc exploratory models (see Table 2; Li & Reynolds 1994, Burnham & Anderson 2002). We tested each model for lack of fit using the Hosmer-Lemeshow statistic (Hosmer & Lemeshow 1989). We then calculated AICc values and considered those models with ΔAICc < 2 from the top model as competing models.

Habitat model validation procedures often employ using a portion of the data (i.e. 75% of observations) to build the model and a smaller portion (i.e. the remaining 25% of observations) to test the model (Verbyla & Litvaitis 1989, Pereira & Itami 1991). Because of sample size concerns (i.e. only 102 observations), we used data from all counties to build habitat models, leaving none behind for model testing. However, we were able to test the validity of our classification of counties into high vs low relative abundance of gray foxes using an independent data set. Based on a request in the Illinois Digest of Hunting and Trapping Regulations, records of gray fox sightings throughout the state were collected during October 2005 - February 2008. We sent each respondent a map and asked them to pinpoint live and road killed gray fox locations, and mail the maps back to us. With these data, we calculated the ratio of the number of gray fox sightings:number of counties for high abundance and low abundance counties. We reasoned that this ratio should be considerably higher for counties with high relative abundance of gray foxes, and if it was, that our classification of counties was appropriate.

Results

Relative abundance of gray foxes was high in 37 of 102 (36%) Illinois counties (Fig. 2). Counties were generally accurately classified as high vs low abundance of gray foxes. The ratio of gray fox sightings in high-abundance counties was 1.51 (56 sightings:37 counties) and 0.77 (50 sightings:65 counties) for low-abundance counties. No models showed lack-of-fit based on the Hosmer-Lemeshow statistic. Of the 19 candidate models, four were competitive based on ΔAICc scores (see Table 2). Competing models indicated that standard deviation of the perimeter-area ratio of agricultural patches, interspersion and juxtaposition index of grassland patches, coefficient of variation of the proximity index of forest patches and relative patch richness of the landscape affected gray fox relative abundance. Counties with a high relative abundance of gray foxes had higher interspersion and juxtaposition indices of grassland patches and coefficient of variation of the proximity index of forest patches, whereas counties with a low relative abundance of gray foxes had higher standard deviation of the perimeter-area ratio of agricultural patches and relative patch richness of the landscape (Table 3).

Discussion

Our study represents an exploratory analysis that is the first to investigate how large-scale landscape

Table 3. Comparison of variables found in competing models of relative abundance of gray foxes in Illinois, USA, 1998-2006. Variables are defined in Table 1.

<table>
<thead>
<tr>
<th>Variables</th>
<th>High abundance</th>
<th>Low abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>AgParaSD</td>
<td>282.199</td>
<td>296.300</td>
</tr>
<tr>
<td>ForProxCV</td>
<td>381.506</td>
<td>333.444</td>
</tr>
<tr>
<td>GrassIJI</td>
<td>63.583</td>
<td>57.316</td>
</tr>
<tr>
<td>LandRPR</td>
<td>102.252</td>
<td>106.410</td>
</tr>
</tbody>
</table>

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patterns affect relative abundance of gray foxes. In general, the four variables important in competing models had similarities with habitat characteristics preferred by gray foxes at smaller spatial scales (Haroldson & Fritzell 1984, Sawyer & Fendley 1994, Chamberlain & Leopold 2000, Cypher 2003). The variables also provided insight into habitat configurations important to gray fox relative abundance in Illinois.

Standard deviation of the area-perimeter ratio of agricultural patches was higher in counties where the relative abundance of gray foxes was lower, indicating a gray fox preference for habitats with less dispersion of agricultural patch complexity and size (McGarigal et al. 2002). Illinois' agricultural areas are either large and monotypic or complex, fragmenting other habitat types, such as forests and grasslands. Lower abundance of gray foxes in counties with large amounts of these types of agricultural areas is an indication of their avoidance of this habitat configuration as has been similarly indicated by home-range level studies (Haroldson & Fritzell 1984, Sawyer & Fendley 1994, Chamberlain & Leopold 2000, Temple 2007).

The interspersion and juxtaposition index of grassland patches was higher in those counties with high relative abundance of gray foxes. Gray foxes are often described as habitat generalists but with some preference for wooded areas interspersed with grassland and dense understory vegetation (Sawyer & Fendley 1994, Fuller & Cypher 2004). Neale & Sacks (2001) reported a negative association between coyotes and grassland habitat, so the relationship between gray fox abundance and the interspersion and juxtaposition index of grassland patches may also reflect gray foxes' selection of habitats less utilized by coyotes (Crooks & Soule 1999, Fedriani et al. 2000, Chamberlain & Leopold 2005). Therefore, this habitat characteristic is important at both a smaller and larger scale.

Relative patch richness of the landscape is a percentage that takes into account the maximum number of patch types that could be considered in each county, and how many were actually present (McGarigal et al. 2002). Those counties with higher relative patch richness of the landscape had a low relative abundance of gray foxes. Counties with higher relative patch richness may be more fragmented or more likely to contain cover types not as suitable for gray foxes, such as water, urban areas and agriculture. Coyotes and red foxes *Vulpes vulpes* are often located in more agriculturally-dominated and urban landscapes, influencing gray fox avoidance of this cover type (Gosselink et al. 2003).

The coefficient of variation of the proximity index of forest patches was higher where gray fox relative abundance was high. This indicates that more variability of forest patch size and proximity existed in counties with a high relative abundance of gray foxes. This likely reflects that many of Illinois' counties lack forest habitat, but where forest does occur it is still highly fragmented. Smaller-scale studies have indicated a preference for forested habitat by gray foxes (Haroldson & Fritzell 1984, Sawyer & Fendley 1994). While it is clear that gray foxes prefer forest habitat, our results may also indicate a preference for fragmented forest, which could provide more open corridors for travel and foraging.

While we can interpret our findings as reflections of smaller-scale gray fox ecology, larger-scale analyses can provide information to describe patch-corridor matrices not detectable at other scales (McGarigal et al. 2002). The variables occurring in our competing models indicate gray fox relative abundance to be higher in counties containing a high level of fragmentation of preferred habitat types (i.e. forests and grasslands) and lower dispersion of less preferred habitat types (i.e. agriculture). A threshold likely exists for each of these variables beyond which they no longer serve as useful predictors of gray fox occurrence because the habitat has changed to either a more or less preferred state. Although the threshold levels are unknown, they will likely be met with increases or decreases in fragmentation of these habitat types as our results suggest that gray fox abundance is influenced by how cover type patches are configured in the landscape.

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References


Environmental Systems Research Institute 2004: ArcGIS. - Environmental Systems Research Institute, Redlands, California, USA.


McDonald, P.D., Nielsen, C.K., Oyana, T.J. & Sun, W. 2008: Modelling habitat overlap among sympatric meso-


