Using GIS and Remote Sensing to Identify Critical Habitat for Endangered Species

Introduction

Loss of biodiversity is a crisis currently affecting the entire world, with some studies showing a loss of up to 0.1% (about 10,000) species going extinct every year (World Wildlife Fund). The top causes of species loss are anthropogenic, with habitat loss and fragmentation being the top contributor (Santo et al., 2016). These losses are devastating in a number of ways, but it is important to remember that with such high losses of biodiversity will also come the loss of many ecosystem services humans rely on, which are estimated to be worth over $30 trillion a year. For these reasons it is important to focus on endangered species conservation around the world (World Wildlife Fund).

Habitat conservation should be one of the main focuses when it comes to endangered species conservation. Species often have very specific habitat requirements such as resource availability, total area available, and climate, among many others. In order to ensure conservation efforts are being effectively managed it is important to be able to identify critical habitats that should be prioritized for conservation (Alves et al., 2017). This involves understanding species distribution as well as habitat selection and suitability (Wang et al., 2018). GIS and remote sensing applications can be extremely useful for studying these factors for a variety of different species.

Applications

Mapping habitat and species distribution is one of the first steps in identifying habitat selection requirements for most species (Wang et al. 2018). This can be a resource and time intensive process, but advances in both remote sensing and GIS have made contributed to recently progress in these fields. GIS layers can be used to map and quantify habitat attributes such as land cover, vegetation, soil type, wetlands, habitat linkage, rare species richness, water quality, slope, elevation, distance analysis, etc. This allows scientists to create models to locate and predict suitable habitat, which can then be prioritized in conservation efforts. Identifying species habitat selection is important for applications such as reserve planning, species management, creating habitat suitability indices, and successful reintroduction and translocation planning. It can also help to predict how species distributions will be affected in the face of climate change (Abrha et al., 2018).

Commonly Used GIS and Remote Sensing Tools and Sources

Common GIS datasets used are USGS data such as Digital Elevation Models (DEM), National Wetland Inventory (NWI), land use data, and a variety of locally sourced data (such as RIGIS in Rhode Island). The most common GIS software cited is ArcGIS and ArcMap, with common tools
being digitizing topo maps, quantifying habitat using layers, landscape modeling and analysis, and spatial/distance analysis. The most commonly cited remote sensing tools used are aerial photography and satellite images, however useful remote sensing tools could differ greatly in different types of habitat, such as land vs. marine.

Case Studies

Case Study #1- Snub-nosed golden monkey (*Rhinopithecus roxellana*)

The snub-nosed golden monkey are a species known to actively select their habitat based on very specific habitat requirements. In this study researchers set out to create an index for habitat selection in this species in order to improve reserve planning and management for this species. To do this they first had to identify variables important to this species, which they accomplished using existing GIS and remote sensing data. These data were sourced from Digital Elevation Models (DEM), Shennongjia Nature Reserve Authority, Landsat 8 Remote Sensing Images, National Forest, Resource Database for Forest Management Planning and Design and digitized raster data of Shennongjia Transportation Map. Spatial analysis and Euclidean distance analysis were carried out in ArcMap 10.0 (Wang et al., 2018).

Case Study #2- Mitchell’s Satyr (*Neonympha mitchellii*)

The Mitchell’s satyr is a federally endangered species, and although this study was a relatively long time ago (2002), the methods used are still applicable today. The goal for this study was to identify suitable habitat for the Mitchell’s satyr in order to identify the most promising locations for release to begin efforts to return the butterfly to historic ranges. Layers used included percent natural buffer, wetland size, upland buffer, linkage potential, rare species richness, and overlap with The Nature Conservancy portfolio sites. Data was sourced from Michigan Resource Information System (MIRIS), National Wetland Inventory (NWI), Biological Conservation Database (BCD), and The Nature Conservancy (TNC). A model was created and then used to rank prairie fens in Michigan based on these attributes and higher scoring fens were recommended as release sites of the Mitchell’s satyr (Rabe et al, 2002).

Case Study #3- Red-billed Curassow (*Crax blumenbachii*)

The red-billed curassow is an endangered bird species endemic to lowland Brazilian Atlantic Forest and is an essential seed disperser and predator to the ecosystem there. In this study researchers wanted to better understand habitat selection for this species in order to improve conservation efforts. GIS software was used to map study plots in terms of distance to streams, dirt roads, Mussununga forest, open fields, and forest edge. This would have been much more difficult to manually determine due to the remote location of this species (Alves et al, 2017).
Conclusion

GIS and remote sensing can be applied to a variety of different species and habitat types when it comes to endangered species conservation efforts. Identifying critical habitat is the first step in many different types of studies, and when determining conservation strategies. When identifying habitat attributes these tools can save time and resources, especially where existing GIS datasets are already available for certain areas (Stromberg et al., 2018). In cases where datasets are not available remote sensing tools such as aerial photography and satellite imagery can be used to fill data gaps. This can be especially helpful when studying species with habitats that are difficult to access, such as in remote tropical forests.

References


Annotated Bibliography


This study aimed to predict distribution of the *Juniperus procera* tree in Ethiopia under climate change conditions. Abrha et al. used GIS software to compare species distribution with different environmental layers and then used Maxent to predict future distribution. This paper was an important research tool because it illustrated how GIS can be used to help predict future habitats of species, which is important when analyzing future distributions and population sizes with the changing climate. GIS software used included DivaGIS and ArcGIS.


In this paper Alve et al. study the red-billed curassow an important species endemic to the lowland Brazilian Atlantic Forest. Not much was previously known about habitat selection of this species due to habitat inaccessibility. This study modeled how field data can be collected and then analyzed using GIS. They used GIS software to analyze distance from streams, dirt roads, Mussununga forest, open fields, and forest edge. This study is a good example of how GIS and remote sensing can be useful when habitat selection is currently understudied due to the remote and inaccessible location of the species. This paper did not go over specific GIS software used, which would have been a helpful addition.


In this paper Rabe et al. discuss the Mitchell’s satyr, a federally endangered butterfly, and the possibility of releasing the butterflies into suitable habitat to begin propagation of the butterfly in historic ranges. The study was based almost entirely on using GIS layers to create a model based on important habitat characteristics to identify the most suitable sites to attempt butterfly release. The attributes looked at included percent natural buffer, wetland size, upland buffer, linkage potential, rare species richness, and overlap with The Nature Conservancy portfolio sites. Data was sourced

Santo et al. studied the maned sloth (*Bradypus torquatus*) in Atlantic forests of Brazil. The researchers looked at landscape variables by analyzing land use maps using GIS software. Habitat fragmentation is a huge contributor to species decline, so this paper was helpful in examining how GIS can be used to model the effect this is having on species, and how the quality of habitat is extremely important in these already fragmented landscapes. This paper showed that species with small ranges can be successful in fragmented landscapes as long as key habitat requirements are still met. This is helpful when trying to plan new development and still have land for wildlife set aside, as well as highlighting the importance of keeping land conserved in already fragmented areas. GIS software used included ArcGIS and GRASS GIS.


This paper presents a laboratory exercise for students to learn how to use available publicly available GIS data and GIS software and habitat requirements for an endangered species to in order to identify regions that should be set aside for conservation. This was a very good paper to read to begin learning about using GIS for endangered species habitat identification since it was focused on explaining how to perform this type of analysis to a beginner. The laboratory assignment structure helps the reader understand the step by step process in using GIS to develop a habitat suitability index, starting with identifying key aspects of conservation for their chosen species to proposing specific areas for conservation. The exercise has students use base map with watershed boundaries of the state (from EPA), land cover data, major rivers and lakes (from local Department of Natural Resources, stream flow rates (from USGS), and watershed water quality supplemental maps (from EPA). This gave good examples of where to start when looking for available datasets to carry out species habitat analysis.


In this paper Wang et al. discuss the necessity of understanding habitat selection when considering land for reserve planning and species management and create a habitat selection index for an
endangered monkey, the snub-nosed golden monkey. They do this by analyzing attributes of both habitat and non-habitat of the snub-nosed golden monkey. Data sources include Digital Elevation Models (DEM), Shennongjia Nature Reserve Authority, Landsat 8 Remote Sensing Images, National Forest, Resource Database for Forest Management, and digitized raster graphics of the area. ArcGIS was used to carry out spatial and Euclidean distance analysis. They highlighted how GIS and remote sensing are useful tools when mapping species distribution and quantifying habitat selection by studying specific habitat attributes. The study is a great example of how identifying critical habitat can then be used in conservation efforts.