Assessing biodiversity concerns of urban sprawl and projecting smart growth in Hays County, Texas

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Abstract

As human population continues to expand into the natural environment, efforts must be made to protect and preserve the biodiversity of plant and animal species. Hays County, located between two major metropolitan areas, San Antonio and Austin, encompasses three distinct ecosystems. Each ecosystem fosters an abundance of native species, some designated by the US Environmental Protection Agency as 'endangered' or 'threatened'.

Our assessment of Hays County's ecological biodiversity identified two 'indicator' avian species for use in a spatial model. Undeveloped areas of Hays County that match the habitat requirements of these species were identified for preservation. Building permits issued over a six-year period from 2000 to 2005 by the county and its municipalities were used to identify development trends and areas of urban sprawl.

Using spatial analyses, including density surfacing, buffering, and raster and vector calculations, biodiversity and sprawl data were modeled. Other environmental components such as soil type, topography, vegetation, and hydrology, were taken into account. Final analyses recommend areas for land development and 'smart growth' – where the expansion of human activities will have the least adverse effect on the habitats of selected 'indicator' species.

This research is set apart from past analyses by the components used in the model and the simple fact that countywide spatial datasets of building permits in Hays County did not exist before this project.

Golden-Cheeked Warbler
photo by Steve Maslowsi, US FWS

Black-Capped Vireo

Methods

To show the development throughout Hays County, T.R.E.E.S. acquired a database showing building permit data from the Capitol Area Metropolitan Planning Organization. These spreadsheets and excel files displayed information about the locations and dates of building permits for Hays County. In order to display this information as a point shapefile through ArcMap, geocoding the building permits was completed. To begin geocoding, a road system for Hays County with detailed street information was necessary to create accurate matches. The Hays County road shapefile we used was acquired from the Capital Area Council of Governments. A standard format was then chosen for the addresses in the excel database to ensure that the address locator, that was later created, would be able to recognize and place the addresses accurately. US Alphanumeric Ranges (Geodatabase) was used because it was most compatible between the street name in the roads shapefile and the address format for the building permit database. Growth was made into a shapefile because it would be easier to visualize after creating a shapefile showing each individual year. The database was then split into five different sections, each having the building permits that were purchased for that year. Once the five database files were changed to a DBF IV (Database Format Four), we were able to import them into the Sprawl Geodatabase as a table. An address locator was created using the same address format, US Alphanumeric Ranges (Geodatabase), to match the addresses of the permits with the road shapefile that we downloaded. ArcCatalog creates a point shapefile of the building permit locations when the address locator matches the permit addresses with the roads shapefile. Once the shapefile has been created (Figure 1), we imported each one into our Permits Feature Dataset as Feature Classes.

IDEAL HABITAT LOCATIONS

Habitat locations were configured using information from literature review. Soils needed were rocky outcrop and loamy clay. Vegetation required was juniper and oak woodlands. Slope required was more than 5 degrees (Figure 5). Additionally, buffers were needed around rivers of 50 meters or 164 feet because the optimal habitat is 50 meters from a river or stream. Buffers were also required around the roads of 50 meters or 164 feet because the birds do not live in disturbed areas and must be a minimum of 50 meters away from roads. These requirements are discussed in more detail in the Literature Review and Background sections of the paper.

HYDROLOGY AND ROADS

In order to find an ideal habitat location for these species we must look at the hydrology and the road system of Hays County. The species of concern must be within fifty meters of a lake or stream, and must be fifty meters away from any type of roads. To find this optimal habitat area we created a buffer for both features. We created a new shapefile from both the hydrology and the roads shapefile with an added fifty-meter buffer. The new hydrology shapefile created was then imported into the Sprawl Geodatabase as a feature class named "good_hydro". This feature shows all of the areas in Hays County that could be good habitats that are within fifty meters of a water source. The new roads shapefile with the fifty-meter buffer was also imported into our Sprawl Geodatabase as a feature class named "bad_roads". This feature shows the area that is an unlikely area for our species to live due to the disturbance from the roads. Next, two new feature classes were used to remove the areas where our unsafe "bad_roads" and our safe "good_hydro" overlap. Subsequently, the Union function was used to find where these two areas overlap and to create a new shapefile in the Hydrology Feature Dataset as "bad_hydro". This new area displayed where the water source was too close to the roads to create an optimal habitat.

VEGETATION AND SOILS

The species of our concern require certain types of vegetation (Figure 2) and soil (Figure 3) to create and maintain a proper nesting site. We used our vegetation shapefile along with our soils shapefile to find areas of overlap that created an optimal area for this species nesting. We created new feature classes in both the Vegetation and the Soil Feature Datasets that then extracted the prime area from each of these two shapefiles. Next, selection by Attribute function was used to find these ideal areas. The new vegetation shapefile that remained was created and only had the vegetation that our species required. Habitat for both the Golden-cheeked Warbler and Black-capped Vireo consisted of Ashe juniper, Live Oak, Texas Oak, Plateau Live Oak, Texas Red Oak and Shin Oak as major vegetation requirements. We also created a new soil shapefile that consisted of the soils that our species required. Soil requirements consisted of rocky outcrops and loamy soils such as: Brackett, Purves, and Real. Once these new shapefile files were created they were imported into our Sprawl Geodatabase as feature classes. Subsequently, areas were found that were our ideal vegetation and soil shapefiles overlap. The union feature was used again to identify the optimal areas where the soils and vegetation meet the habitat requirements and named the shapefile "Good_Earth".

DIGITAL ELEVATION MODEL

We used a digital elevation model to find ideal areas where the slope of the land does exceed five degrees. The Digital Elevation Model (DEM) chosen displays the different elevation through the state of Texas. The extraction feature was used to find the areas of the DEM that are within Hays County. A new raster dataset was created from the extraction of the DEM. The slope function from the Spatial Analyst toolbar created another new raster dataset that displays the slope in Hays County. The new dataset was imported into the Sprawl Geodatabase as a new Raster Catalog using ArcCatalog. Raster Calculator was then used to find the areas with a slope that is greater than five degrees. The DEM (Figure 4) was reclassified into two categories showing the suitable areas with more than five-degree slope, and the unsuitable areas with a slope less than five degrees.

RASTERIZING AND RASTER CALCULATION

The creation of our final analysis required all of our data to be in raster format. The final shapefiles "Good_Earth" and "Bad_hydro" must be put into raster format to make it possible to calculate the final optimal habitat. The Feature to Raster function was used to create the new raster datasets. The new raster datasets are then imported into the Sprawl Geodatabase. Once imported into the database, the raster datasets were reclassified to show optimal areas without reference to slope. The raster calculator was then used to calculate where our optimal slope intersects our "Good_Earth" layer without intersecting our "Bad_Hydro". These areas are not within fifty meters of the road but are within fifty meters of a water source. These areas also meet the vegetation and soil requirements while having a greater slope of five degrees.

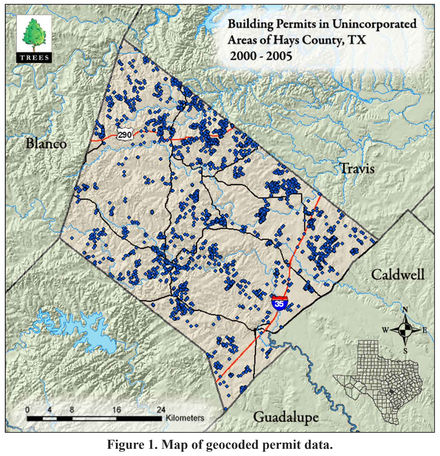

Figure 1. Map of geocoded permit data.

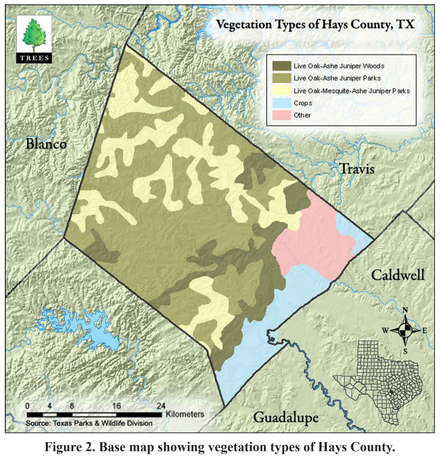

Figure 2. Base map showing vegetation types of Hays County.

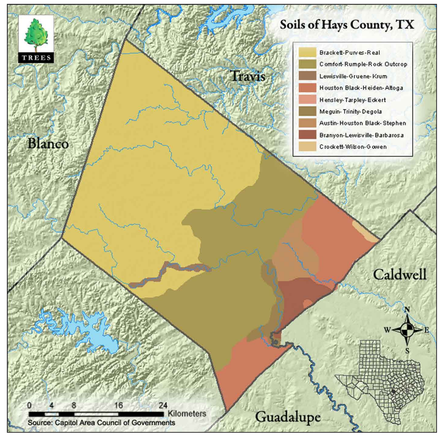

Figure 3. Base map showing soils of Hays County.

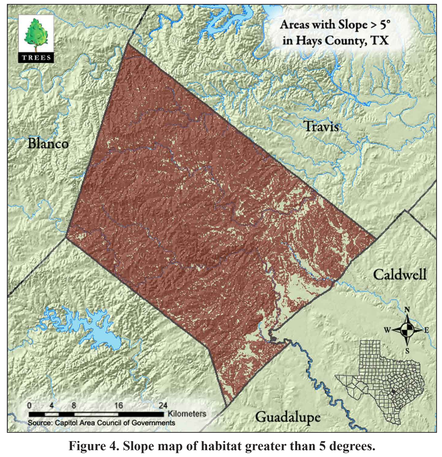

Figure 4. Slope map of habitat greater than 5 degrees.

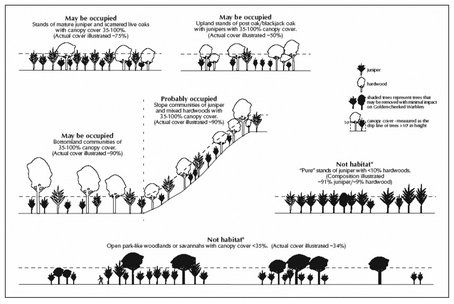

Figure 5. Ideal Habitats for Selected Species

Results

Our first step of the analysis to obtain our results began with creating a 50-meter buffer around the roads. Secondly, a 50-meter buffer was created around the lakes and river systems of Hays County. Suitable vegetation and soils created from analysis are shown in (Figure 6). Habitat analysis created from buffers and vegetation and soils indicating areas that were clipped are shown in (Figure 7). A map was created from density of habitat analysis indicating areas that are of optimal habitat for the concerned species (Figure 8). Our final map shows the smart growth recommendations for Hays County (Figure 9).

Conclusions

Recently, urban sprawl among other environmental issues has become a topic of major concern for communities and local government. Our study was necessary to identify where urban sprawl is currently occurring in Hays County. Secondly, our study identifies the habitat requirements for concerned species in the study area and maps out distribution of suitable habitats. In summary, our project has exhibited an area for smart growth that has the least adverse impact on these habitats. By using our smart growth recommendations, developers can protect endangered species.

Further research should be conducted to further identify areas of concern and additionally ground truthing should be completed in order to verify results from our study.

Additionally, future studies can be conducted on other endangered species in other areas and therefore, our study can be used as a model to identify habitat requirements and sprawl issues.

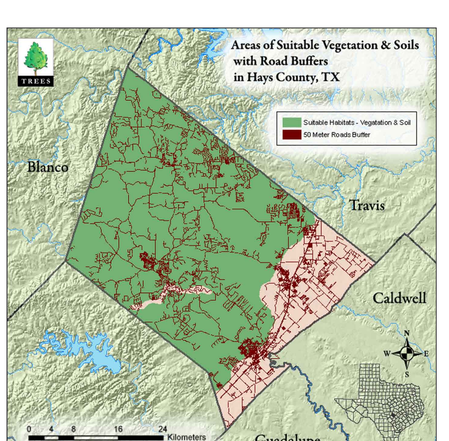

Figure 6. Suitable vegetation and soils map shown with Hays County Roads.

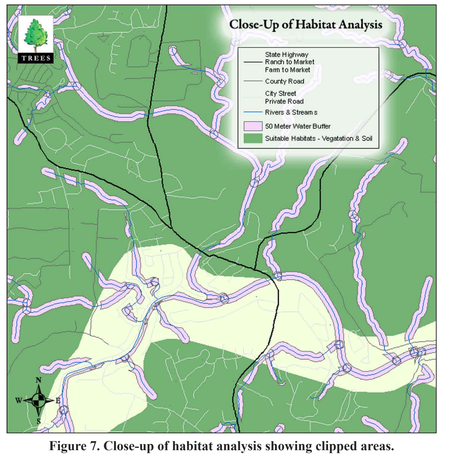

Figure 7. Close-up of habitat analysis showing clipped areas.

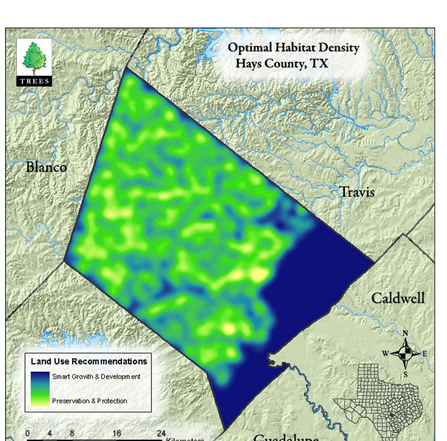

Figure 8. Optimal habitat density Hays County.

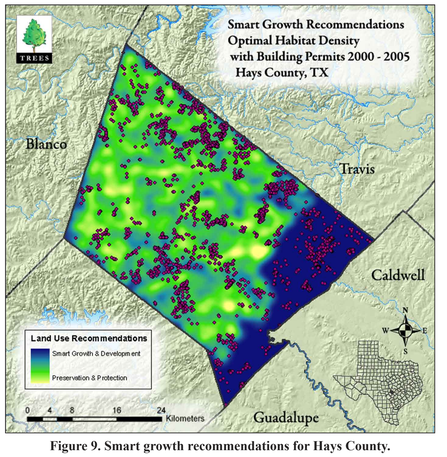

Figure 9. Smart growth recommendations for Hays County.