

Developing a Baseline GIS for Riparian Wetland Restoration, Big Bend National Park, Texas

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INTRODUCTION

In the Chihuahuan desert of the Big Bend region of Texas and Mexico, wetlands are a rare and important ecosystem. In the vicinity of Rio Grande Village in Big Bend National Park (Fig. 1), the Boquillas Hot Spring system is developed along a set of faults. These springs give rise to wetlands. In the early 1900's much of these wetlands were cleared and drained for agricultural purposes. With the development of the park in the 1950's, paved roads, campsites and powerlines invaded the remaining wetland area. Today, less than 6 acres of this wetland remain. Fault controlled springs still feed the area's standing body of water, a small artificial lake, exclusive habitat of the Big Bend Mosquitofish, *Gambusia gaigei*.

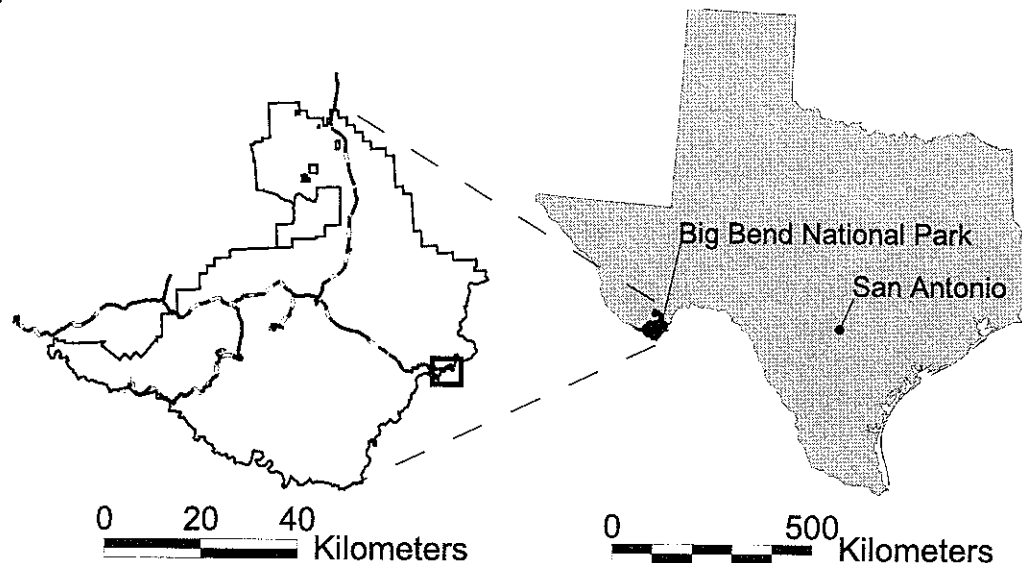


Figure 1. Index map showing Big Bend National Park in Texas. Left map shows the park boundaries with major roads. The rectangle indicates the area near Rio Grande Village that includes the wetland and springs.

Riparian zones are plant communities adjacent to and directly influenced by the hydrologic features of intermittent lotic and lentic water bodies. Riparian areas are often transition zones between wetland and upland areas, and the riparian zone at Rio Grande Village illustrates a distinct transition between wetland and upland vegetation. The riparian zone, as it is encountered today, has a moderate/low level of ground water and low topography. Thus, while the area does

border the Rio Grande River and has a spring-fed water body, it is not a true wetland, as the water table is not constantly at the surface.

The National Park Service is beginning the process of restoring this wetland to its historic size, approximately twice its current area. This project developed a baseline GIS to be used in the evaluation and planning of that restoration project. The Global Positioning System (GPS) was used to map the major features of the Big Bend riparian zone. These data were then incorporated, along with NDVI from Landsat TM satellite imagery, USGS digital elevation models, and existing geologic map data, into a GIS. This GIS clearly shows the extent and geologic controls on the Big Bend riparian zone, and will be vital in the implementation of a proposed hydrogeomorphic (HGM) remediation plan for the area. Three thermal springs along the Rio Grande, upstream of Rio Grande Village, were also mapped for the purpose of pinpointing these small eco-niches within the park.

FIELD METHODS

Because both the wetland and upland areas of the riparian zone are vegetated, wetland mapping cannot be accomplished with visible or multispectral imagery. Thus, mapping of this area was done on the ground using the wetland-upland vegetation transition. The dominant wetland vegetation in the area is willow grass; the emergent species of the upland area is mesquite. The topography of the upland area was hilly and sustained little vegetation (save for the boundary area) in comparison with the wetlands, which provided a useful visual distinction between the areas and from which rough maps of the transitions were constructed.

The area was mapped using differential GPS (DGPS) techniques. DGPS involved setting up a base station (we used a Trimble Pro-XRS) which gathered real-time, code and carrier phase signals from available satellites. The data it gathered were then used to correct positions collected with code phase, hand-held, Trimble GeoExplorer II GPS units. The base station position was determined to submeter accuracy using OmniSTAR satellite relayed, real-time DGPS correction data.

It was not possible to walk the boundary of the wetland in a continuous path to create a closed polygonal feature. The procedure was to wade through the dense (thorny!) mesquite toward the wetland until willow grass was encountered. The GPS was then used to gather a series of fixes which were averaged to reduce positional error. The GPS unit was then "paused" while a careful retreat was made, followed by another foray into the mesquite. By using the pause capability of the GeoExplorer II, the boundary data could be gathered as closed polygonal features.

The hand-held units were also walked around every accessible area of the wetlands, including the lake, the spring and the building that encloses the spring, creating GIS polygonal features. The complete road system through the wetlands and the adjacent campgrounds was mapped with code phase GPS, and a USGS benchmark was mapped with carrier phase GPS. After the base station was shut down, the Pro-XRS was used to map existing and planned utility pole locations with real-time DGPS.

The three thermal springs that were mapped using GPS in Big Bend were located on or near the Rio Grande River upstream of Rio Grande Village. This mapping was conducted with the assistance (and canoe) of Raymond Skiles, a biologist from the NPS. The first spring was located in the Rio Grande River itself. The area had a 250 foot perimeter, and had several species of grasses thriving in its expanse. The area was accessed by canoe, and a data-point polygon was created by walking the code phase GPS unit around the area. The second spring was housed by a man-made cove at the edge of the Rio Grande. A true thermal spring, water temperature here reached 104 degrees Fahrenheit. In order to map this spring, the code phase unit was brought to the edge of the protective cove and held over the spring itself, collecting a data point location. A polygon perimeter location could not be collected due to high river levels that were flooding the cove. The third spring was totally enclosed from the trails of the park, masked by thick reed growths that reached close to ten feet in height. The spring itself was a clear pool, about ten feet in length and five feet in width, with reeds covering the banks. These reeds made obtaining a satellite position nearly impossible, as their cover blocked most of the Pathfinder's signals. By beating down some of this growth cover and elevating the unit as high as possible (around nine feet), satellite contact was achieved and a point location was taken. Photographs were taken of each spring to add as an attribute in the GIS data-base.

PROCESSING

Differential corrections to the GPS data were performed using Trimble's Pathfinder Office software. The wetlands area was corrected using our Pro-XRS base station data as its reference. The GPS positions of the springs were corrected using data from Texas Department of Transportation base station in Midland, Texas. All GPS data were converted from Geographic Lat/Lon coordinates with WGS84 datum to UTM Zone 13 coordinates with NAD 27 datum, to match

existing NPS GIS layers. Polygon and line features were then exported to ArcView (Fig. 2) and attribute tables constructed.

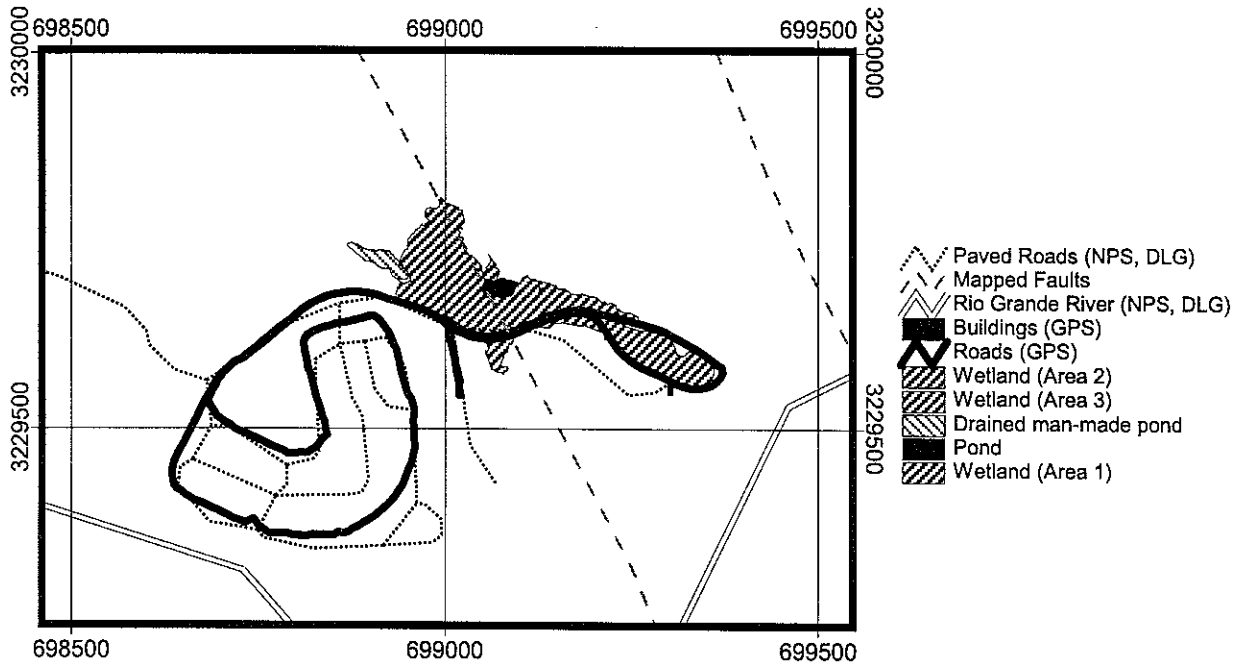


Figure 2. GPS surveyed wetland map at Rio Grande Village. NPS road layer based on DLG data is shown compared to our GPS surveyed roads. Map is UTM Zone 13 projection based on NAD27 datum. Coordinate grid shows UTM northings and eastings in meters.

The correctly referenced, GPS gathered data became the primary layers of our GIS. In order to place the wetlands, springs and attributes in their topographic context, the Rio Grande Village 7.5 minute Digital Elevation Model (DEM) was imported as a raster layer into the GIS. A surface-shaded layer, derived from the DEM, visually depicts the relief of the area where the wetlands and springs are located. Using ArcView's calculation abilities, slope and aspect layers of the area were calculated from the DEM layer. This information is most valuable for those referencing this GIS during the riparian zone remediation project, where weathering, flow and transport issues will need to be considered. The correlation of the wetlands with the DEM also illustrates that the wetlands are in an area of low topography (Fig. 3).

Remotely sensed imagery was the next component added to the GIS. ER-Mapper software was used to locate the riparian area on a Landsat TM satellite image of Big Bend National Park. This was accomplished by comparing the Landsat false-color images with the Rio Grande Village topographic sheet. Having isolated the precise area of the field study, the areas of dominant growth were delineated by creating a Normalized Differential Vegetation Index (NDVI) image. A color lookup table was selected to highlight the Rio Grande River in black, the wetlands areas in red, and the uplands in blue and white. In order to incorporate this satellite image into the GIS, it was geographically referenced using ground control points chosen at road junctions and stream intersections clearly identifiable both on maps and on the satellite image. Then using Geographic Transformer software, the image was "warped" into the correct datum (NAD 27) and projection (UTM, Zone 13) with a second-order polynomial transformation.

The geology of the study area was incorporated into the GIS using ArcView's digitizing capabilities. Geology was digitized from the Geologic Map of Big Bend National Park, Brewster County, Texas (Maxwell, 1968). The map used a Lambert Conformal Conic projection and NAD27 datum, so digitized features were converted to UTM Zone 13 projection. Initially, the hard copy map was registered using latitude/longitude registration marks printed on the map. This procedure repeatedly failed to produce digitized features that aligned with equivalent features in existing GIS layers. We surmised that the registration marks were misprinted on the map. When we registered the map using a set of major road intersections, the alignment was excellent, confirming our suspicions.

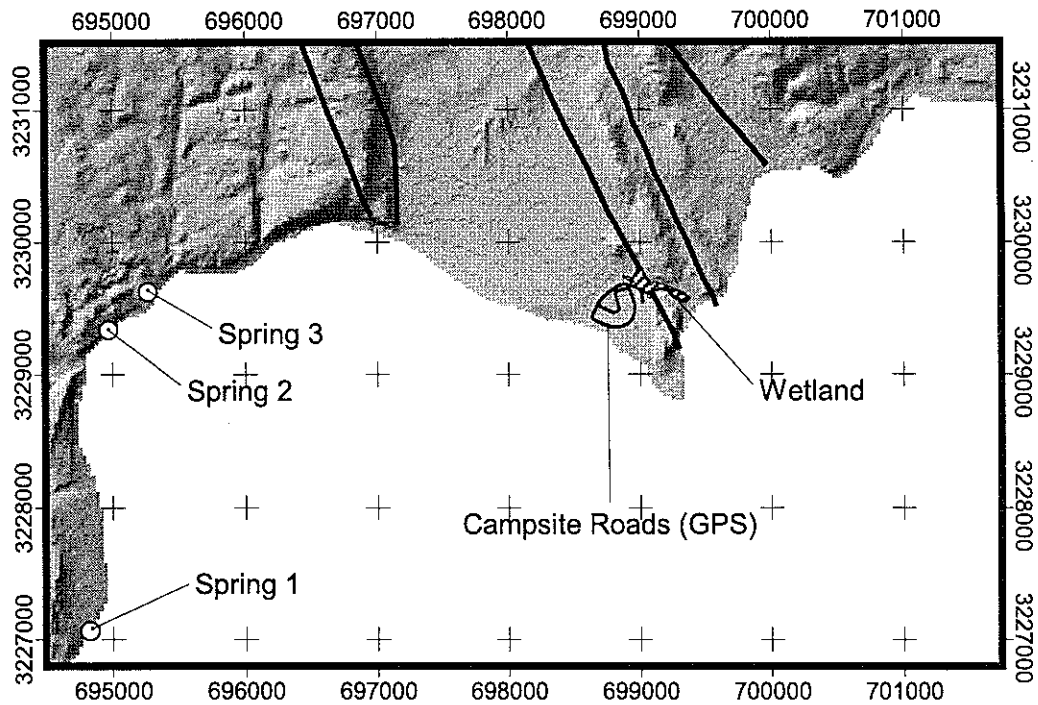


Figure 3. Wetlands and springs mapped on a hillshaded DEM. Mapped faults from Maxwell (1968) are shown. Map is UTM Zone 13 projection based on NAD27 datum. Coordinate grid shows UTM northings and eastings in meters.

Each geologic unit in the area was digitized as a closed polygon. Mapped faults in the region were digitized as a polylines and imported into ArcView as a separate layer. ArcView's attachments referenced this information into the correct geographic locale, allowing it to be overlain by the wetlands, springs and attributes previously described.

A Digital Line Graph (DLG) layer of the Rio Grande River and tributaries, provided by the NPS, was imported as a layer into the GIS. Layers for dirt and paved roads in Big Bend National Park were also provided by the NPS. These road and stream layers were very coarse due to their origin as DLG data. The roads in the Rio Grande Village campsite, and those skirting the riparian region were much more accurately represented by our own GPS road layers.

To complement the data in the GIS, photos of each thermal spring were imported into the ArcView as TIFF files (by means of conversion from JPEG to Tiff using Adobe Photoshop software) to add a visual aspect to these geographic data points. Further, the expanse of the Big Bend National Park wetlands is shown by a digital orthophoto quad (an aerial photograph) provided by Microsoft's Terra server.

CONCLUSIONS

The ultimate success of this project will be the use of this GIS in the implementation and monitoring of the remediation of this wetland. As a result of this GIS development effort, it is clear that the existing geologic map is incorrectly registered. Comparing the mapped faults with the DEM and wetland features, it is clear that the topography and spring locations are fault controlled. The Landsat image suggests that these faults bend as they approach the Rio Grande, however, the existing geologic map does not behavior of the faults. This suggests that a complete understanding of the relations between the springs, wetland and faults requires more careful mapping of the faults in the area immediately around the wetland.

REFERENCES CITED

Maxwell, Ross A., 1968, Guidebook 7: The Big Bend of the Rio Grande: Austin, Bureau of Economic Geology, University of Texas, 138 p.