

Land Use in the Environmental Corridors of the Village of Cross Plains, its
Extraterritorial Boundary, and the Black Earth Creek Watershed

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Abstract: The Village of Cross Plains, located in south central Wisconsin, adopted a Comprehensive Plan in 2008 that, among other things, identified environmental corridors that were to be designated for preservation. The environmental corridors were determined by three criteria relating to land cover, proximity to streams, and the slope of the terrain. These criteria were incorporated into the design process for determining the location of the environmental corridors within the village of Cross Plains extraterritorial boundary using ArcGIS 9.3 software. The project found a substantial portion of the land within the extraterritorial boundary as land designated for preservation, with the majority of these corridors consisting of forest and agricultural land covers.

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The Village of Cross Plains lies in an area of south central Wisconsin that is rich in natural resources. Lying at the entryway of the driftless area, the area offers a scenic landscape of rolling hills untouched by the last Ice Age, with a scattering of forest, prairie, and agricultural land cover. Meandering across this landscape is the Black Earth Creek and its many tributaries. The Black Earth Creek watershed covers 103 square miles in western Dane County and the northeast corner of Iowa County. The watershed contains three lakes and six streams, and its namesake, Black Earth Creek, is a 27-mile tributary to nearby Blue Mounds Creek. While much of the watershed lies in Wisconsin's driftless area, the headwaters of the Black Earth Creek are located within the glacial area, and display morainal features such as depressions and kettles that provide the major spring areas for the creek. The heavily forested slopes provide excellent infiltration of rainwater and groundwater recharge, and contributes the majority of the baseflow for the creek and its tributaries.

Although most of the watershed is rural, the eastern edge is experiencing an increase in residential and commercial development due to its proximity to Madison. The population of Cross Plains is rapidly increasing, with a 23 percent growth rate from 1990 to 2000, a rate roughly five times greater than Madison's during the same period. Dane County in its entirety loses roughly 5,000 acres of farmland each year, thereby making it the third most threatened farm area in the country according to the American Farmland Trust. The greatest portion of land use within the basin is agricultural, mostly in the form of dairying and cash cropping. Other major forms of land cover within the basin include deciduous forest and grassland.

A growing threat to the health of the basin and its water quality is the increasing development in the area. All three municipalities within the watershed direct their stormwater runoff into the Black Earth Creek. This runoff can be harmful to the aquatic ecology of the stream, as it is often warm in temperature and filled with pollutants. New development can also lead to increased sediment runoff during the construction process. In addition to the diminished water quality of the stormwater runoff, the volume of runoff is also exacerbated due to the increased amount of impervious surfaces that exist in developed areas. A heightened volume of runoff can change the hydrology of waterways, increase erosion levels, and increase the likelihood of flood levels and occurrences. In addition to commercial and residential development, land reserved for agriculture can also greatly impact the water quality of a stream. This nonpoint pollution source can contribute to heightened levels of nutrient runoff from manure in addition to chemical runoff from pesticides and herbicides. The existence of urban areas within the vicinity of agricultural land can heighten the runoff of these nutrients and chemicals, due to the increase in impervious surfaces. Overall, it is estimated that 10 percent of a watershed must be impervious in order for water impairment to occur. When impervious surfaces approach 25 to 30 percent of total surface area, the watershed can have severe difficulty in sustaining aquatic life.

Although the amount of impervious surface within the Black Earth watershed is only around one percent of the total land cover, most of the developed land is in close proximity to the streams within the watershed. The rapid rate of development in the area

is thus occurring with the potential to lead to further environmental harm down the road. This is particularly worrisome considering what is at stake: the Black Earth Creek has been historically noted as one of the most productive trout streams in the state, with 6 miles of stream consisting of Class I Trout Water and 6 miles consisting of Class II Trout Water. In addition, substantial portions of the watershed have been designated by the Wisconsin Department of Natural Resources (WDNR) as Outstanding Resource Water (ORW) and Exceptional Resource Water (ERW). Considering the fact that the DNR has designated only 11 percent of Wisconsin's total stream miles as ERW and 7.6 percent as ORW, the classifications suggest the importance of these resources and the need for preservation so that they may remain vital and productive ecologies.

In considering these matters, the Village of Cross Plains prepared a comprehensive plan for their municipality that would, among other things, identify areas suitable for future development and preservation so as to accommodate further growth without handicapping the natural resources of the Village and the greater watershed. The plan was adopted in June of 2008, and encompassed all of the land within the Village of Cross Plains and its 1.5-mile extraterritorial boundary, a jurisdiction permissible by state statutes. One of the main objectives of the plan was in protecting the area's natural resources by adopting compact and environmentally sensitive land use policies. Among other land use regulations, the plan identified specified areas within the Village's jurisdiction as environmentally vital, and proposed various levels of regulation within these environmental corridors based on predetermined levels of importance. These environmental corridors were identified based on the following criteria:

- Water Quality Corridors – Buffer zones in which no development other than parks and Village utility facilities are allowed. The buffer zones are:
 - 300 feet from the centerline of streams that are classified as Outstanding Resource Waters by the DNR, which includes Black Earth Creek east of the Village wastewater treatment plant,
 - 200 feet from the centerline of streams that are classified as Exceptional Resource Waters by the DNR, including Garfoot Creek and Black Earth Creek west of the Village wastewater treatment plant
 - and 150 feet from the centerline of all other streams, including Brewery Creek and the Swanson Swamp drainage.
- Steep Slopes – Land where slopes are greater than 20 percent. Development within areas designated as having steep slopes is prohibited.
- Wetlands – Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface of the land. The preservation of wetlands are to be maintained.

The purpose of this project was in determining the locations of the designated environmental corridors within the Cross Plains extraterritorial boundary, and the land cover types that exist within these corridors (by geographic location and by percentage). This was then compared to the geographic location and percentage of land cover types within the entire extraterritorial boundary of Cross Plains, in addition to the entire Black Earth watershed. In so doing, the project will provide a useful understanding of the various land covers within environmentally sensitive areas relative to their surroundings.

In addition, the project will give a better understanding of how areas designated for conservation can impact the growth of a municipality, as development is often driven by a desire to be in close proximity to nature, even when such development can potentially lead to the degradation of the natural amenity that it seeks. Therefore, this project will highlight the polemical nature of land use, as the ideological differences of developers and conservationists can often manifest in conflicting interpretations of prudent planning.

The project relied on data gathered from a variety of online sources, which was compiled using ArcGIS 9.3 software into a geographical database that provided useful spatial and numerical information. The data sources were as follows:

- Wisconsin DNR - Land Cover Data of Wisconsin
Surface Water (Hydrography) Data
- USGS - Digital Elevation Model (DEM) of south central Wisconsin
- U.S. Census Bureau - Dane County Roads Data
Dane County Places

The data used were a combination of raster and vector files that were projected onto ArcMap using the geographic coordinate system WGS 1984. This was the projection used by the USGS for their DEM files, and became the default projection for the data frame, as the two DEM files were the first ones added to ArcMap. All other files were projected on the fly to WGS 1984. Although the watershed being analyzed for this project was comparatively small, it sat in between two DEM tiles. Thus, both DEM files were needed from the USGS, and the two tiles combined made up a vertical segment stretching from Dane County in southern Wisconsin to Ogle County in northern Illinois. In order to combine the two DEM files into a single layer, both files were used as inputs using the mosaic tool.

With both DEM tiles in one layer, the DEM data became easier to process. The Black Earth Creek watershed was delineated using the point-based method, which derives a watershed based on the selection of a single point. Before this was done however, all of the false sinks in the DEM had to have been filled, so as to avoid distortions in the watershed delineation. Once the DEM was filled, a flow direction raster was made, in order to show the direction that water would flow out of each cell of the elevation raster. This was accomplished using the D8 method, which assigns a cell's flow direction to the one of its eight surrounding cells with the steepest weighted gradient. Once the flow direction raster was made, it was used as the input in forming a flow accumulation raster, which records the number of upstream cells that will contribute drainage to every individual cell within the raster. The flow accumulation raster was used so as to determine the cells that are likely to contain the river lines, by limiting a query in the raster calculator to cells with a flow accumulation greater than 500. With the established river lines, it was thus feasible to determine the mouth of the river where the pour point was to be placed. However, locating the Black Earth Creek amidst a number of other streams became a challenge without proper identification. It was therefore useful to rely on the Wisconsin DNR's hydrography data as a tool in locating the Black Earth Creek by way of its attribute table, as well as a way to determine the level of accuracy in the DEM's river line outcome. With the Black Earth Creek identified, the pour point was placed at the mouth of the stream. In order to ensure accuracy in selecting the cell which

contained the highest flow accumulation value, it was useful to use the SnapPour command, which snapped the pour point directly onto the source. Once the correct pour point was selected, the Black Earth Creek watershed was delineated.

With the Black Earth Creek watershed delineated, the first area of study was established. In order to determine the percentage and geographic locations of land cover types within the watershed, the Wisconsin Land Cover raster had to have been first clipped to the size of the watershed. Because the output extent of a raster clip is limited to that of vector files only, the watershed raster had to be converted to a vector before being used as an input feature. After converting the watershed file, it was then used as an input feature for the clip with the box 'Use Input Feature for Clipping Geometry' checked. Although the clipped output at this stage appeared to be complete, in comparing its attribute table to the attribute table of the (unclipped) Wisconsin Land Cover raster showed that the operation did not automatically update the table data, as both shared the same 'COUNT', a field that pertains to the cell count per land cover type. In order to update the clipped raster, the file had to be exported from an IMG format to a GRID format. With the updated raster, it was useful to gather percentages per land cover type in order to have a clearer picture of the watershed. This was obtained by exporting the table to Microsoft Excel and extrapolating percentages from the 'COUNT' field. With the percentages determined, it is now feasible to create a pie chart of the various land cover types by using 'PERCENT' as the input field.

The next area of study was the Village of Cross Plains extraterritorial boundary. The boundary was established first by adding the TIGER/line file 'Dane County Places' gathered from the U.S. Census Bureau. In the shapefile's attribute table was the Village of Cross Plains. Using this place as the selected input, the buffer tool was used to determine its extraterritorial boundary with a 1.5 mile selected buffer distance. This output could be used as the output extent of a second clip of the Wisconsin Land Cover raster. All the steps after the raster conversion in determining the land cover types within the watershed were repeated in this area of study. The outcome was, like the first, a pie chart with percentages of each land cover type in addition to a land cover map.

The final area of study was the Environmental Corridors determined by the Village of Cross Plains Comprehensive Plan. As was mentioned, the Environmental Corridors were determined as those within proximity to streams, of a high slope, and within wetland areas, all located within the Village's extraterritorial boundary. In mapping the first criterion, those of the Water Quality Corridors, the location of streams within the watershed had to first be established. Because the streams varied in quality based on the Wisconsin DNR's standards, the corridors had to vary in size in relation to the stream quality. As a reference, the Wisconsin DNR's online Surface Water Data Viewer was useful in locating the streams that deserved 300 foot buffers (Outstanding Resource Water), 200 foot buffers (Exceptional Resource Water), and 150 foot buffers (Other). Selected segments of streams were then collected as inputs in the 'Buffer' tool, and were then given buffer distances based on the water quality of the identified stream. In mapping the second criterion, those of steep slopes, required deriving a slope layer. This was accomplished using the DEM as the input raster, with percent rise as the output measurement. Because the output is a continuous raster, the layer had to be reclassified in order to obtain divided slope classes. By placing the number of classes only to 2, it was then possible to distinguish steep slopes based on the Village's definition, by entering 19

and 100 (in percent) as the break values. The reclassified raster thus distinguished areas with a slope below 20 percent to areas with a slope of 20 or higher. Because this project needed the areas with steep slopes alone, it was necessary to convert the data to a shapefile with only the areas with a slope of 20 percent or higher selected. This same step was done to derive the third criterion; with only the two wetland classes selected in the Wisconsin Land Cover raster, it was then possible to export it to a shapefile by using the Raster to Shapefile tool. With all three criteria determined, the layers were then clipped using the extraterritorial boundary as the output extent. In order to determine the land cover within the environmental corridors, the three criteria had to first be joined using the union tool, and then used as the output extent in clipping the Wisconsin Land Cover raster. Like the other areas of study, the remaining steps involved exporting the file into a GRID format, and then using the updated 'COUNT' field in Microsoft Excel to derive 'PERCENT', which was then used as the input field for a pie chart of the land cover types within the environmental corridors.

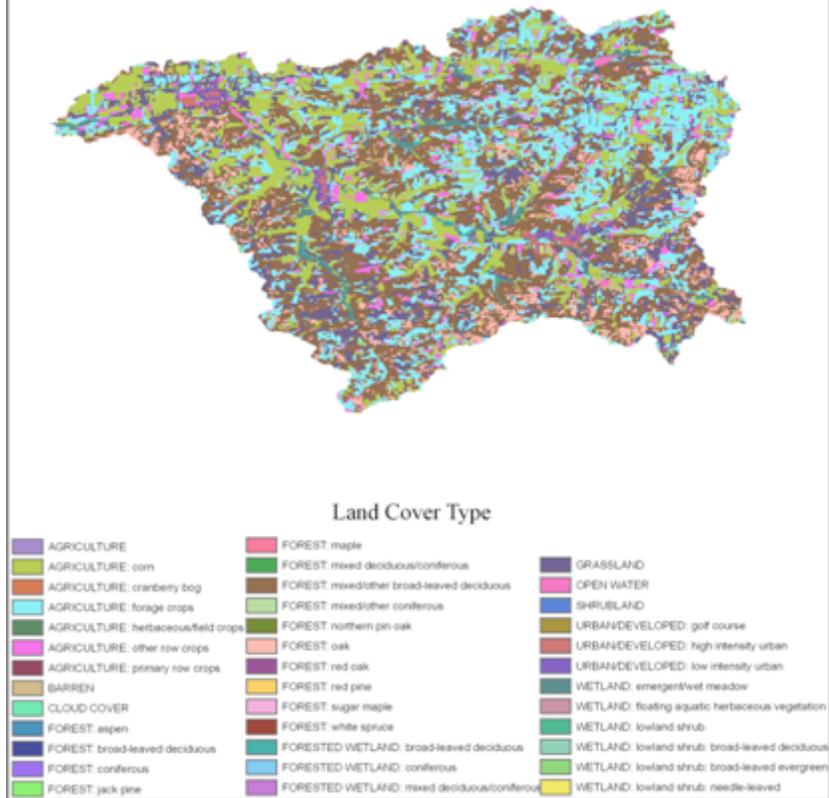
The outcome reveals the areas designated for preservation within the Village of Cross Plains extraterritorial boundary. As is seen in the Appendix, large regions within the boundary are designated preservation areas, thereby making further development restricted to corridors extending north and east of the Village. A mere 2 percent of land cover is classified as urban within these preservation areas, with the majority consisting of forest at 46 percent, agriculture at 28 percent, grassland at 12 percent, and wetland at 10 percent. This is contrasted to the land covers of the entire extraterritorial boundary, which contains roughly the same percentage of urban cover, with the majority consisting of forest at 42 percent, agriculture at 36 percent, and grassland at 14 percent, and contrasted to the entire Black Earth Creek watershed, with roughly half the amount of urban cover of the other two areas of study, and with the majority consisting of agriculture at 44 percent, forest at 38 percent, and grassland at 14 percent. Therefore, it becomes apparent that agricultural land cover does not contribute a large proportion of land within the environmental corridors relative to the other areas of study, while the percentage of forest cover contributes nearly half. The proportion of these two land covers are inversed as the area of study is increased, signaling that the greater proportion of agriculture is outside of the extraterritorial boundary. In considering the 10 percent rule of impervious surface for watershed degradation to occur, the small percentages of urban land cover within all three areas of study signals that the current stage of development is not a hazard to water quality. This of course, is overlooking many other possible measures that could in fact conflict with this conclusion. In summary, the level of urban development is currently small but rapidly growing, and placing development restrictions based on environmental factors is a keen move considering the circumstances. Known for its treasured streams, driftless terrain, and scenic beauty, the Black Earth Creek watershed has attracted a swell of new residents, with the possibility of compromising the natural amenities that have attracted newcomers to the area in the first place. Therefore, it is vital to the region to have a comprehensive plan in place that can accommodate growth without leaving nature behind.

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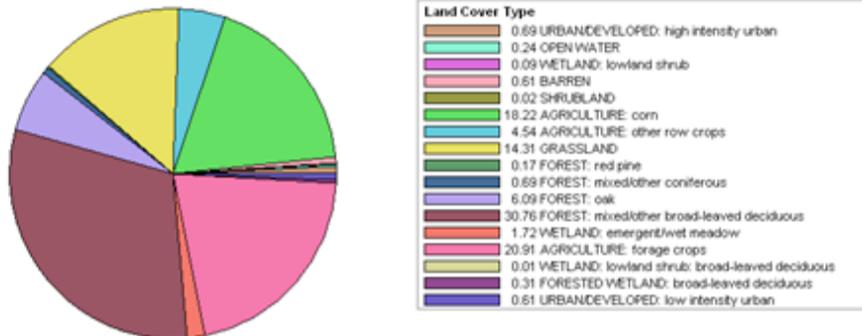
Appendix A

Land Cover within the Black Earth Creek Watershed



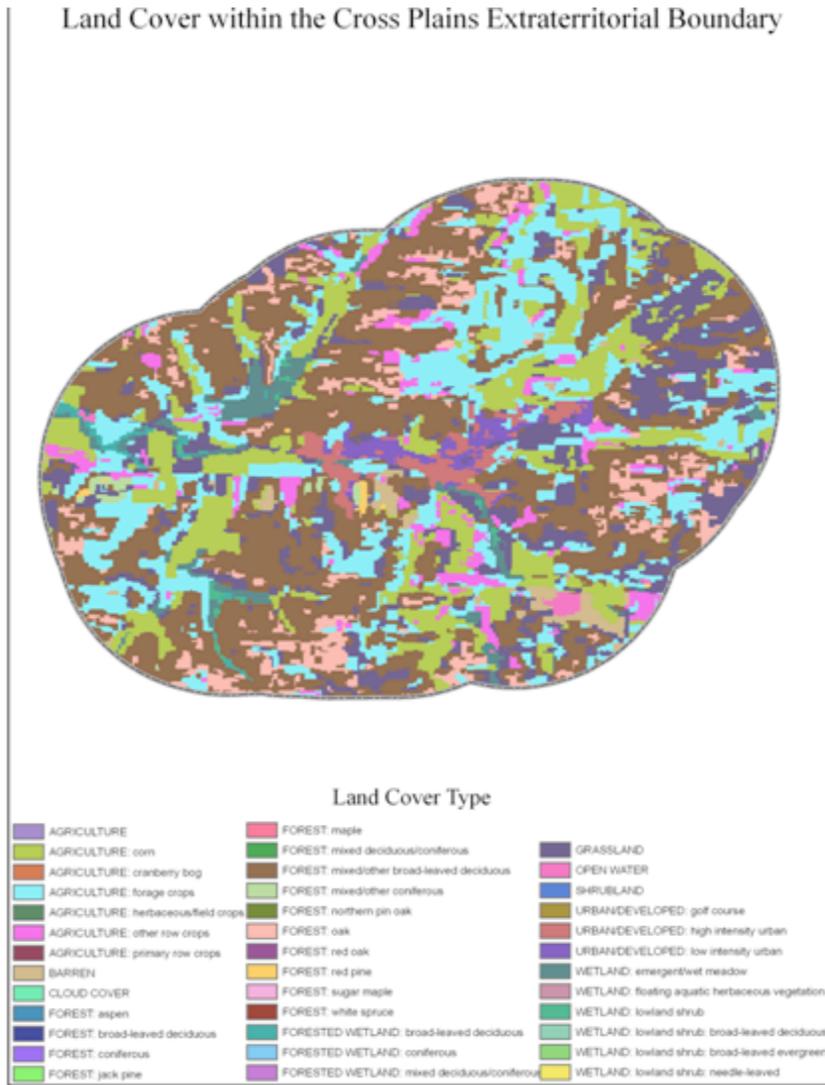
Appendix B

Land Cover within the Black Earth Watershed



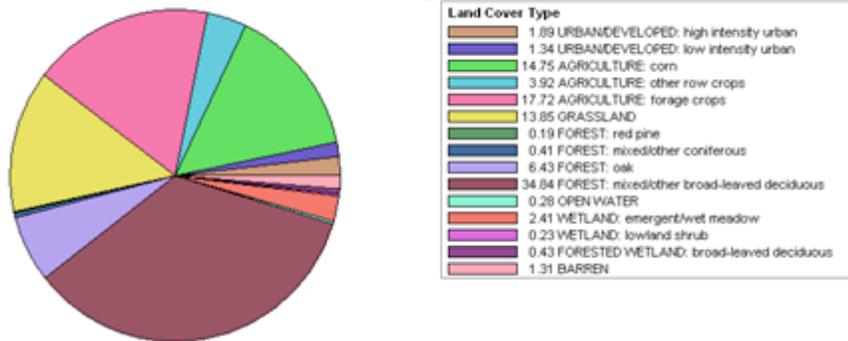
Appendix C

Land Cover within the Cross Plains Extraterritorial Boundary



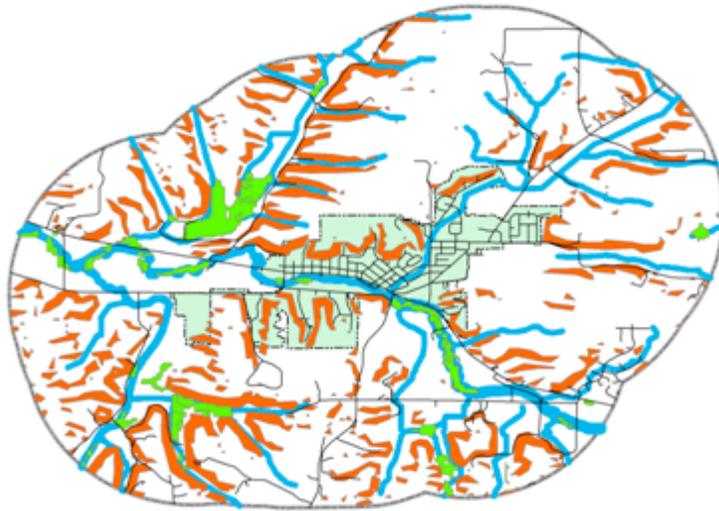
Appendix D

Land Cover within the Cross Plains Extraterritorial Boundary



Appendix E

Designated Environmental Corridors within the Village of Cross Plains Extraterritorial Boundary

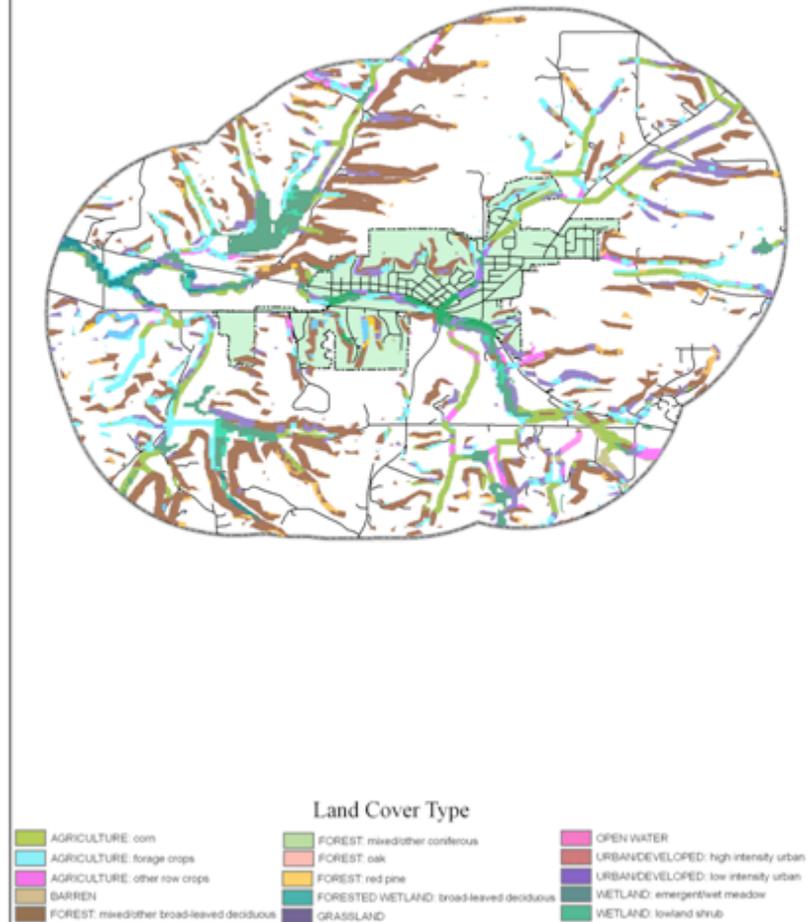


Environmental Corridor Types

- Wetlands
- Steep Slopes
- Water Quality Corridors

Appendix F

Land Covers within the Preservation Areas of the Village of Cross Plains Extraterritorial Boundary



Appendix G

Land Cover within the Preservation Areas

