Using Geographic Information Systems for the Natural Resource Assessment and Planning of a Proposed County Park in Olmsted County

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Abstract

As cities continue to grow, in both population and area, so does the increased use of our natural resources and open spaces. Olmsted County is aware of this issue and concerned with development encroachment, exploitation of rare species and overuse of natural areas. To address these issues, Olmsted County Park staff has proposed to establish another county park in its system. Geographic Information Systems (GIS) was used to determine site suitability for the proposed location as well as to demonstrate GIS benefits for managing parkland.

Introduction

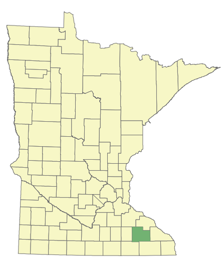

Figure 1. Olmsted County is located in SE Minnesota.

Olmsted County, located in southeastern Minnesota, experienced a significant growth in population between 1990 and 2003 (Figure 1 and Table 1). Current population figures suggest the population of Olmsted County is 132,013; this includes the 93,037 who live in the city of Rochester (State of Minnesota, Department of Administration-State Demographic Center, 2003). Overall, these figures represent a 19% growth to Olmsted County since 1990.

As the population in Olmsted County grows, projected to reach 170,530 by 2030, so will the use of its parks. This is significant because a large percentage of projected growth is within the city of Rochester.

As population increases, so does the potential for negative impacts on Olmsted County's open spaces. Human encroachment on these areas can affect natural communities and resources. Open space reduction brought about by development and overuse of our natural areas includes negative impacts on watershed quality and on endangered and/or sensitive flora and fauna (Ryan, 2004).

Many communities are experiencing similar population growth and are aware of the needs and benefits of setting aside open spaces devoted to recreational use for visual beauty and natural resource protection. Dakota County is among the list of Minnesota counties experiencing this growth,

Table 1. Table shows past, current, and projected population of Olmsted County, Minnesota.

	1990	2000	2001	2002	2003		2010	2020	2030
Total	106,470	124,277	127,123	129,804	132,013		140,510	156,290	170,530
City	70,745	85,806	89,325	91,264	93,037		99,600	113,000	125,100
County	35,725	38,471	37,789	38,540	38,976		40,910	43,290	45,430

adding approximately 8,000 new residents each year (Dakota County, 2004). In 2002, Dakota County residents and government leaders recognized this growth and responded by passing a $20 million referendum for open space preservation.

Currently, Olmsted County boasts two regional parks in the county park system that serve as open space areas. These parks, Oxbow Park/Zollman Zoo and Chester Woods, are classified as “regional” because of their large size and the number of communities they serve (Ryan, 2004 and Drescher and Franco-Willis, 1997). According to the Olmsted County Public Works Department, Oxbow Park hosted 40,000-50,000 visits and Chester Woods hosted 80,000 visits in 2003. Based on 2000 Census Block Data, there were 82,753 residents within a 10-mile radius of Chester Woods. Likewise, there were 69,926 residents within a 10-mile radius of Oxbow Park/Zollman Zoo (Table 2). Visitors used the parks for hiking, fishing, picnicking, swimming, canoeing, horseback riding, cross country skiing, snowshoeing, and camping. These uses are in addition to Olmsted County’s interest in prairie restoration, environmental education, tree nurseries, and providing habitat for native flora and fauna.

Table 2. Number of Olmsted County residents within 5-mile and 10-mile radius to present and proposed parks.

Radius (mi)	Oxbow Park/Zollman Zoo	Chester Woods	Fugle’s Mill (proposed park)
5	**5,306**	**7,608**	**6,764**
10	**69,926**	**82,753**	**64,325**

Each of these parks truly has unique landscapes and features. Oxbow Park/Zollman Zoo gets it name from the river bends called “oxbows” that meander through the wooded hillsides (Olmsted County Public Works Department, 2004). Chester Woods Park is home to several remnant communities of native prairie plants. Also, each park offers different amenities for recreational uses. Chester Woods has a swimming beach, trails for horseback riding, and established prairies. Oxbow Park/Zollman Zoo features a nature center and a zoo that is home to some of Minnesota’s native “critters” that provide urban residents opportunity to observe what may live in their backyards.

In 1995, Olmsted County adopted a General Land Use Plan, which addressed protecting natural and sensitive environments (Rochester-Olmsted Planning Department, 1995). According to the Olmsted County 2000 Land Cover, 11.5% of Olmsted County's total land area is urban (Table 3 and Appendix 1). Minnesota Department of Natural Resources Natural Heritage Database indicates that there are approximately 9,000 acres of remaining natural communities in Olmsted County.

Table 3. Olmsted County land cover classified at Level 1.

Land Cover	*Acres*
URBAN	48,229.52
CULTIVATED VEGETATION	24,0463.87
FOREST	54,529.28
WOODLAND	2,213.31
SHRUB	2,213.39
GRASSLAND	68,526.71
CLIFF	57.72
OPEN WATER	2,848.35

Olmsted County's land use evaluation system model (CLUES) that helps decision makers determine and guide growth to the most suitable areas does not include Olmsted County Biological Survey data and locations and surroundings of the County's two parks. According to the Rochester-Olmsted Planning Director, the plan may have had an adverse effect on the preservation of natural communities (Wheeler, 2004). The plan protects areas used for agriculture but accommodates development in natural resource areas such as woodlands, steep slopes, and natural communities. Currently, the Rochester-Olmsted Planning Department is reviewing this model to include biological survey information and county park location.

Recent reports have indicated that there is a link between public lands such as county parks and the well-being of the communities that provide access to them (Kiernan, 2003). Olmsted County Public Works-Parks Division is concerned with future population growth and is aware of the importance of open space to residents, the community, and the environment. Open space enhances residents' quality of life by giving them an opportunity for active and passive recreation that reduces stress and builds self-esteem (City of Eugene Oregon, 2004). Open space gives communities a sense of pride in its beauty and opportunities to be involved in protecting biological diversity, enhancing water quality, and protecting the natural landscape of Olmsted County.

Olmsted County first became interested in a site near Fugle's Mill and the need to protect it because it was included in a suburban development proposal (Figure 2).

Figure 2. Historic Fugle's Mill is located near the proposed park site.

This site was also chosen because it is accessible with controlled access, it is home to several rare/endangered and threatened flora and fauna, and it is in close proximity to Olmsted County's population (Table 2).

Site Description

The site shown in Figure 3 is located in Richard J. Dorer State Forest, a wide-ranging woodland that stretches across seven southeastern Minnesota counties. The proposed site is comprised of approximately 667 acres along the Root River- North Branch (Figure 3). Made up of state and privately owned land, the area remains mostly undeveloped. Though the park is still a proposal and a name has not been selected, for the purpose of this project, the area will be known as Fugle's Mill, from the historic site located south of the park boundary. The proposed site would be a beneficial resource to the public because of its biodiversity, scenic values, and varied ecological conditions (Figure 4). The area is home to some of Minnesota's native plant communities including Floodplain Forest, Lowland Forest, Dry and Mesic Oak Forests, and White-Pine Forest, as shown in Figure 5.

Figure 3. The North Branch of the Root River meanders through the proposed park boundary.

Descriptions of these communities and locations, based on Minnesota's Native Vegetation manual, can be found in Table 4 (State of Minnesota, 1993).

Also located in this area are several endangered, threatened, and special concern plant species. The most threatened species is Leedy's roseroot (*Sedum integrifollium* ssp. *leedyi*)

Table 4. Description of natural forest communities found in the boundary of the proposed county park.

Natural Community	Soil Type	Location	Representative Tree Species
Maple-Basswood	mesic to wet	steep north to east facing slopes	sugar maple, basswood, and red oak
Lowland Hardwood	mesic to wet	areas above flood levels	sugar maple
Oak – Mesic Subtype	mesic to dry	west and east (gradual) facing slopes and broad ridge crests	red oak and white oak
Oak – Dry Subtype	dry	south to west facing slopes	pin oak and bur oaks
White Pine	dry to mesic	cliffs and bedrock	white pines
Floodplain	wet	along rivers and river bottoms	silver maple

Figure 4. Scenic overlook of proposed park site.

Figure 5. View of the white-pines growing on a cliff in the proposed site.

(State of Minnesota, 1993). Minnesota is one of two states in which populations of this species can be found. These populations are located on moist to wet moderate cliff communities. These cliffs stay cool from the presence of cracks in rocks which extend from the cliff face to cold underground caves. These cliffs also provide habitat for several other rare species, including whitlow-grass (*Draba arabisans*), which is present within the site's boundaries.

Controlling access is important in park management. Topography in this area allows for limited vehicle access. Currently, there is only one drivable roadway into the proposed site that would allow public access. The other roadway is located on the east boundary and, according to the Olmsted County surveyor, this roadway has deep ruts from low maintenance and is only accessible with a 4X4 vehicle (Kuisle, 2003).

Another objective of this project was to give Olmsted County Park managers and staff assistance on how GIS can be beneficial in current and future management decisions.

The use of Geographic Information Systems (GIS) has become a critical tool in the way government agencies manage the environment. It allows planners to use spatial data to make better management decisions. GIS can play an integral role in management decisions in areas of habitat protection and restoration, in addition to locating trails, campsites and picnicking areas. Concerns county park managers have are the lack of access to geographic data and biological information (Ryan, 2004). As land managers, they have the knowledge of issues and how to manage problems, but they lack the ability to obtain and map the information.

Trail routes are important features for recreational use in parks because they are the main source for travel. Not only are trails used for hiking and cross-country skiing, but also for environmental education to inform the public on the park's ecosystems. Overall, parks depend on a well-established trail system.

High trail use is the reason planning routes are important factors in management plans and infrastructure of a park (Drescher and Franco-Willis 1997). The best way to avoid problems, like drainage and erosion, is to determine trail routes in the planning stage of a park.

Planning for any trail route requires careful evaluation of its use, as well as the types of people who will use the trails and the anticipated activities that will likely define the trail (Long and Todd-Bockarie, 1994). Typically, trail routes are created either by following contours on a USGS elevation quad or using trails that were already established such as logging roads.

Computer-generated trails are a new technique (Ferguson, 1998). In this model, the trail generated is an example of how park managers might want to address any trail limitation.

Methods

Data for this project were obtained from the Rochester-Olmsted Planning Department. Data used were projected in NAD83 Lambert Olmsted County Coordinate System. Overlay analysis and suitability modeling were performed using Environmental Systems Research Institute, Inc (ESRI) ArcGIS 9.0 and Spatial Analyst. Data were clipped based on the park boundary, which allowed for efficient analysis.

For modeling, each dataset was converted from vector to raster with a 98.46-foot cell size that was determined based on the default of a converted 30-meter USGS digital elevation model (DEM) into Olmsted County projection's unit of feet.

Location Analysis

To determine if the proposed location was suitable for a park, a cost weight/suitability analysis was performed on population, location of natural communities, and the existing park location. Natural communities located near higher population blocks, but away from current parks, were determined to be more suitable. The Fugle's Mill site generally meets these criteria.

Trail Suitability Model

A trail suitability model was created to determine a suitable or "best" location for a hiking trail in the proposed park boundary. The process began by establishing a ranking scale for each dataset attribute. Higher values were assigned to those attributes that were more suitable for a hiking trail route.

Data Attributes

Data attributes were used to determine which dataset would be included in the model.

Areas of Special Concerns

Areas that provide habitat to endangered or threatened plants and/or animals were ranked based on county park manager concerns (Ryan, 2004). Though these areas are often an interest to the public, park managers do not want these areas harvested for personal profit or degraded from human impact.

Slope

One physical factor related to trail degradation is slope. Slope information was derived from the converted elevation dataset, DEM, and used to identify steep slopes in the proposed park boundary. These areas, primarily slopes over 18 percent, should be avoided because soil erosion potential increases (Ferguson, 1998 and Rochester-Olmsted Planning Department, 1995).

Soils

Soils data contained the most important attribute for the model. Soil classes, as shown in Table 5, were ranked 1 to 5, with 1 having the most limitations (Table 5). Limitations for trail routes are expressed as slight, moderate, and severe (USDA, 1980). Slight means that the soil is favorable for trails and that any limitations can be overcome. A moderate ranking indicates soil limitations such as slope or wetness; those limitations can be overcome or aided by other methods such as trenching. Severe refers to soils unfavorable for trails. Areas with rocks or steep slopes would be difficult to build and maintain due to cost and erosion.

Table 5. The degree of soil limitation for trail use.

Limitations	Ranking
Slight	5
Moderate (Slope)	4
Moderate (Wet)	3
Moderate (Flood)	2
Severe	1

Land Cover

The land cover database used had been classified to either Level 3, Level 4, or Level 5. This classification is based on the Minnesota Land Cover Classification System. This database Level 1 classification was used to reclassify the land cover types in Olmsted County to eight general classes and then they were ranked according to suitability (Table 6). Rankings of 1 to 6 were determined by the effect of human impact on vegetation types. A ranking of 1 indicates that there would be no impact on vegetation.

Proposed Trail Route

Once data attribute suitability was ranked, datasets were reclassified with new values based on a common scale of 1-10. Higher values were given to dataset attributes that were less suitable for a trail route.

Table 6. Ranking of land cover attributed at Level 1 for trail suitability.

Description	Classification	Ranking
Urban	10000	3
Cultivate	20000	5
Vegetation		
Forests	30000	4
Grassland	60000	6
Cliff	70000	2
Open Water	90000	1

Proposed Trail Route

Once data attribute suitability was ranked, datasets were reclassified with new values based on a common scale of 1-10. Higher values were given to dataset attributes that were less suitable for a trail route.

Table 7. Ranking of data used for trail suitability.

Attributes	Attribute Suitability Rank	Percentage Weight (%)
Soils	3	**50%**
Slope	4	**25%**
Land Cover	2	**12.5%**
Areas of Special Concerns	1	**12.5%**

The next step before creating a suitability model was to reclassify each dataset. Since all datasets were not equally important, hiking trail routes are not preferred to go through steep slopes or wet soils, weight percentages were placed on reclassified datasets (add to 100%) (Table7 and Figure 6). The higher the percentage, the more influence the dataset will have on the suitability model (McCoy and Johnston, 2001). Datasets were combined using Spatial Analyst's raster calculator, which calculates the sum for each cell. The outcome is a new data layer indicating suitable locations, a suitability model, for proposed hiking trail routes.

[Reclassified Land Cover] * .125 + [Reclassified Slope] * .5 + [Soil Reclassify]*.25 + [Species Distance]*.125 = Trail Suitability Model

Figure 6. Combined percentage weighed datasets equation.

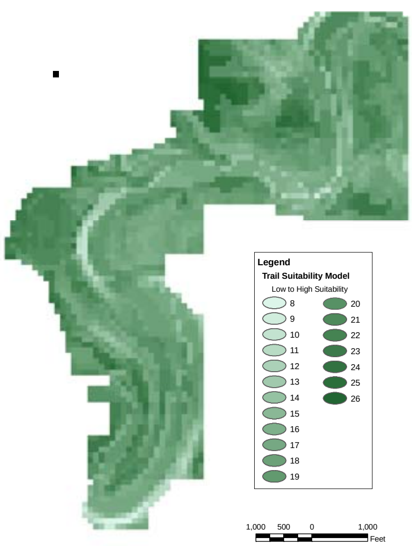

Figure 7. Trail suitability model from reclassified and combined datasets.

Once datasets were combined to create a suitability model, a shortest path or a least-cost path scenario was used to test the validity of the model. This scenario is a function in Spatial Analyst that involves calculating a least-cost path from a destination point to the cheapest source using cost weighted function.

Before this function could be performed, the suitability model was reclassified, since more suitable cells had higher values.

After the suitability model was reclassified, it was used to create cost-weighted direction and distance layers. The cost-weighted direction identifies a route to take from any cell, along the least-cost path, back to the nearest source (Figure 8). Cost-weighted distance assigns a value for the least accumulative cost between two points to get back to the source (Figure 9). Finally, surface analyses from these layers were input into the least-cost path/shortest path function for five selected point locations to create a path/trail (Figure 10).

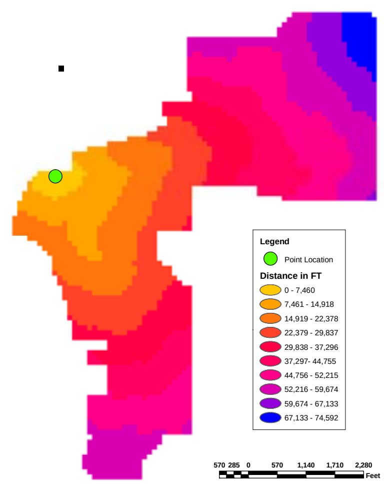

Figure 8. Cost weighted distance grid from the trail suitability model.

Results/Discussion

This paper was a preliminary analysis for a proposed county park in Olmsted County, Minnesota. Its purpose was to use GIS to determine if the proposed site was suitable as well as to identify suitable areas for potential hiking trail.

The proposed site location in terms of suitability ranked low (Appendix 1). There are other natural communities in Olmsted County that would serve as a possible third park; however, areas that scored higher have already been developed. An identical natural community that had a similar

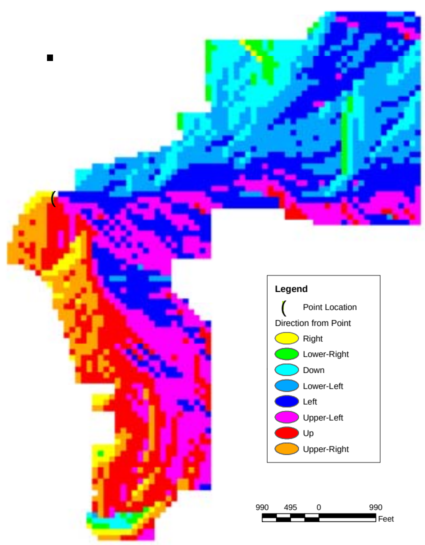

Figure 9. Cost weighted direction grid from the trail suitability model.

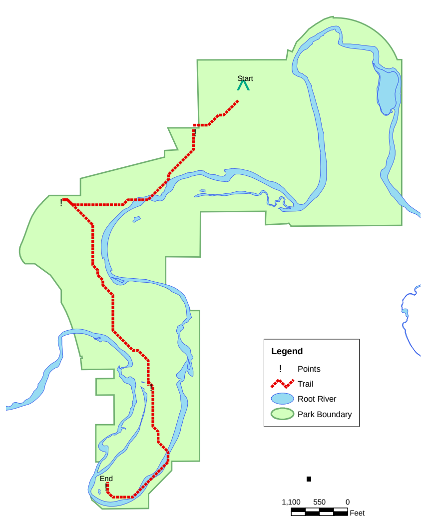

Figure 10. Path of least resistance for five points located within the proposed park boundary.

score to the project area is located in the NE corner, but it is in close proximity to Carley and Whitewater State Parks. The suitability score for the proposed site would have been higher if park location data had included parks outside of Olmsted County.

Planning for any trail routerequires careful evaluation of the purpose of use, as well as the types of people using them and the activities conducted on them. This suitability model focused on hiking and not horse, biking, or ATVs use. This method would be valuable at the other Olmsted County parks to determine any future trail routes because the parks have more features like existing trails, historic attributes, and established prairies, to be used in the model. The entire trail suitability model allows for modifications based on specific project needs of a target area.

Data Improvements and Limitations

Improvements of this trail suitability model could be made by including factors such as water bodies, rivers, and additional resource information like sinkholes as well as data revisions.

Raster Cell-Size

The cell sized used was large compared to other county-wide models, such as the CLUES model which uses 66-foot cell size. This could be a limitation in the model because of the small proposed park area. The cell size used would not completely convert the linear rivers feature into raster. It was because of this limitation that rivers were not included in the model.

Slope

Since the completion of the suitability model, new elevation data had been created by Rochester-Olmsted Planning Department. Any future trail suitability model revision could use these 10-foot contour data to re-identify steep sloped areas. Also, this data could be used in establishing smaller cell-size by creating a new DEM.

Soils

Soils data were derived from the original vector soils files created by Minnesota Land Management Information Center (LMIC) and edge-matched into a county-wide coverage (Rand, 2004). There were some concerns within this data that had the possibility of adding inaccuracies to the suitability model. These concerns include 1) several polygons with no-data that was assigned data by using the Soil Survey of Olmsted County manual, and 2) "heads-up" redrafting were performed in areas missing polygons. However, the proposed park area was not a noted area of high concern. Also, it is known that the Natural Resources Conservation Service (NRCS) is in the process of releasing a revision of this data.

Another update to the model, using updated soils, could incorporate original/historic vegetation data. Also, this data could be used to further assist Olmsted County Park staff in any future restoration/rehabilitation projects.

Other

Sinkholes could have been added to the model because the geology of the area is made up of limestone, dolomite, shale, and sandstone, known as karst, where sinkholes are a common feature. Sinkholes can be an important attribute for trail routes, either because the change in vegetation makes an interesting landscape or they represent safety hazards if unmarked.

Trails

Trails for the model were created by randomly selecting points within the proposed park area. Hillshades need to be created for further use to determine the scenic importance of an area. This was a virtual trail, and any future computer-generated trails should be ground verified to determine any obstacles, such as man-made structures, not captured in the model.

Conclusion

Olmsted County officials recognize that natural resources have value and benefits for their residents.

GIS Benefits

This paper gives current park managers and staff an idea on how GIS could be used to make more informed management decisions. Data would provide them with information to see if an area has been disturbed and enable them to develop an effective mitigation plan. As shown in this paper, GIS can assist them to create a suitability model for new trails. Also, suitability models could be used for other park uses including, but not limited to, possible trail extensions and/or connections to current trail locations and areas for future park expansions and facilities. GIS will help park managers and staff to plan, design, and implement natural resource management more efficiently.

Future

To implement growth, a community must decide where land should be protected for recreation, community character, the conservation of natural resources, and open space. Though Olmsted County has a land use plan, it needs a strategic approach to land conservation. This approach should provide guidelines for growth and development while preserving areas of natural resources, native species, and agriculture. It should focus on ecologically important resource areas like woodlands, high quality wildlife habitat, and other critical areas. It should not only focus on protecting large areas, but also establishing connectivity and ecological corridors between areas.

Overall, establishment of another county park in Olmsted County would preserve natural communities found in this area and increase open space.

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