Land Use Suitability Analysis for Florence Township, Goodhue County, southeast Minnesota, U.S.A.

Beth J. Knudsen [1,2]
[1]*Department of Resource Analysis, Saint Mary's University of Minnesota, Winona, Minnesota 55987,* [2]*Minnesota Department of Natural Resources, Lake City, MN 55041*

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Abstract

Florence Township is situated 90 miles south of the Minneapolis/St. Paul metropolitan area and is bordered on the east by the Mississippi River. Its steep topography and vegetative cover are typical of the southeast Minnesota bluffland landscape. Its desirable location and scenic appeal have led to increasing rates of housing development, higher traffic levels and changing demographics.

Florence Township developed a comprehensive plan in 2003 using natural resource based planning principals. Using ESRI ArcView and Spatial Analyst, suitability analyses were performed based on the goals of the plan. Locations most suitable for continued agricultural use, natural resource protection and development were determined. Most agricultural lands were found to be well suited to continued production if Best Management Practices are implemented to protect resources. Corridors of sensitive natural resource features were found on and adjacent to the bluff slopes and streams. Areas of less sensitivity were found along the MN Highway 61 and near the existing communities of Lake City and Frontenac.

The development of new land use tools for long term protection of agricultural and natural resource areas will be necessary if Florence Township is to meet its goals. Targeting appropriately designed housing development to less sensitive areas close to existing infrastructure would further enhance the economic, cultural and recreational resources of Florence Township.

Introduction

Florence Township is located in the northeast corner of Goodhue County, Minnesota. It is situated between Red Wing and Lake City and is bordered by Lake Pepin (Figure 1). Its steep topography includes the wooded hillsides, rock outcroppings, surface water and ground water features that are typical of the southeast Minnesota bluffland landscape.

Florence Township lies adjacent to a growth corridor of expanding development that extends from north of St. Cloud to Rochester. This corridor has experienced most of the population growth that has occurred in Minnesota over the past decade. From 1990-2000, Goodhue County experienced a growth rate of 8%. However, the predicted growth rate for Goodhue County for the period of 2000-2030 is 41% (1000 Friends of Minnesota, 2004).

In Florence Township, the growth rate was 21% from 1990-2000. Several other townships within Goodhue County also experienced high rates of

Figure 1. Florence Township is located in Goodhue County, Southeast Minnesota.

growth (Table 1). The townships experiencing the highest growth rates are adjacent to major transportation corridors. In Goodhue County, these are State Hwy 52 and State Hwy 61. State Hwy 52 is currently undergoing a large expansion project to 6 lanes that will potentially impact population distribution and demographics in the region.

A Corridor Management Study examining options for expanding State Hwy 61 was completed by the Minnesota Department of Transportation (MNDOT) in 2003. The findings of the study generated considerable discussion within local communities. Concern about these types of large-scale decisions and the impact they have at the local level lead to increased interest in comprehensive planning by area townships and counties.

During 2003, Florence Township developed a comprehensive plan in

Table 1. US Census data for Goodhue County showing rate of growth by township.

Township	Pop 2000	Pop 1990	Percent change
Belle Creek	437	403	8.40%
Belvidere	458	477	-4.00%
Cannon Falls	1236	1369	-9.70%
Cherry Grove	430	396	8.60%
Featherstone	785	811	-3.20%
Florence	1450	1196	21.20%
Goodhue	530	536	-1.10%
Hay Creek	862	690	24.90%
Holden	457	445	2.70%
Kenyon	437	420	4.00%
Leon	942	916	2.80%
Minneola	657	614	7.00%
Pine Island	628	673	-6.70%
Roscoe	784	662	18.40%
Stanton	1080	838	28.90%
Vasa	872	889	-1.90%
Wacouta	410	398	3.00%
Wanamingo	504	472	6.80%
Warsaw	603	574	5.10%
Welch	697	678	2.80%
Zumbrota	591	609	-3.00%

conjunction with Goodhue County's comprehensive planning process. Throughout the process, Florence Township experienced excellent public participation. They developed a well-supported plan using natural resource based planning principals. Facilitated discussions led to the creation of a vision statement for the community. The vision states that the township will "proactively develop, preserve and maintain a community that sustains its historic integrity, rural character and natural and recreational resources" (Toren and Toren, 2003).

The township formed a Land Use Committee (LUC) to implement the goals of the new comprehensive plan. The committee began meeting monthly in May of 2004. The committee identified protection of the natural resource base, preservation of scenic and cultural resources, and sustainability of the rural agricultural community as important priorities.

To accomplish these objectives, the township wanted to use GIS technology to identify the location of its high quality natural resource features, its important community features, and its agricultural working lands. Identifying locations for additional development would be a secondary outcome.

Before GIS analysis could begin, an understanding of the natural resource based planning principles used to create the Florence Township Comprehensive Plan was necessary. As defined by the Minnesota Department of Natural Resources (2004), natural resource based planning is a process that puts the community's natural resources at the forefront. By identifying natural resources at the beginning of the planning process, the community can determine where development is most appropriate. This way, communities avoid the unintended consequences of the typical planning process where open space becomes the leftover pieces, water resources are degraded, and the character of the community is compromised.

The concept of green infrastructure is central to all natural resource based planning. Green infrastructure was defined by the President's Council on Sustainable Development - Metropolitan and Rural Strategies Task Force, 1999 as "the network of open space, airsheds, watersheds, woodlands, wildlife habitat, parks and other natural areas, which may provide vital services that sustain life and enrich the quality of life".

By emphasizing the importance of green infrastructure during the planning process, the likelihood that these systems will be valued and protected is greatly increased. (Minnesota DNR, 2004). There are also financial incentives for maintaining intact green infrastructure systems. The natural resources themselves are needed for economic development. Also, the free services being provided by functioning natural systems are often not recognized until they are disrupted. At that point, they must be replaced by human built interventions. An example of this would be the natural systems that processes and maintain clean water. If the water supply becomes contaminated, it costs society money to build water treatment plants that replicate the process nature had provided for free.

Florence Township residents have embraced the idea that their long-term quality of life will depend on valuing and protecting natural systems. The concept of protecting green infrastructure is central to their planning efforts.

Methods

The use of GIS to support land use planning is a common application of GIS technology. A map-based product designed to reflect the desires of the community increases the likelihood that suggested zoning changes and land use policies will be adopted. Realizing that citizen acceptance of proposed changes is required for effective implementation, GIS can be used to incorporate citizen input and to prioritize issues. All analysis for Florence Township was a direct result of public input. The LUC was held accountable by the broader community to ensure that the criteria and priorities they developed reflected the goals from the comprehensive planning process.

To facilitate the process of setting criteria and designing new land use policies, a technical assistance grant from the non-profit organization 1000 Friends of Minnesota was obtained. They provided meeting facilitators to help develop protection criteria based on the goals stated in the Comprehensive Plan.

Although several natural resource categories emerged, the LUC chose to combine the criteria into three main areas of concern to be used in the GIS suitability analysis. These areas were:

Agricultural Use Protection
Natural Resource Connectivity
Water Resource Protection

The criteria for the analysis of each area of concern were developed during facilitated small group discussion. These individual groups shared their suggestions with the larger committee and the following criteria were accepted:

Agricultural Use Protection

- Crop Equivalency Ratings (CER) of 60 and above
- Crop Equivalency Ratings (CER) of 80 or above
- Crop Land Units currently being tilled
- Crop Land Units farmed by the owner (not rented)
- Land currently zoned A-1 Ag Protection
- Parcels with registered feedlots
- Parcels with a speciality ag enterprise

Natural Resource Connectivity

- Natural Areas inventoried in Goodhue County ("significant natural areas within the study area" (Bockenstedt, 2001)
- 250 foot buffer of surface water
- 250 foot buffer of steep slopes (30% grade or greater)
- Land in public ownership or permanent conservation easement
- Land identified as having significant biodiversity by the MN DNR County Biological Survey

Water Resource Protection

- St. Lawrence Edge geologic formation
- 200 foot buffer of surface water features
- 500 foot buffer of steep slopes (30% grade or greater)
- 500 foot buffer of karst features such as springs and sinkholes
- 100 and 500 year Floodplain
- Wetlands in the National Wetland Inventory

These criteria are also shown in the Figure 2 flow chart.

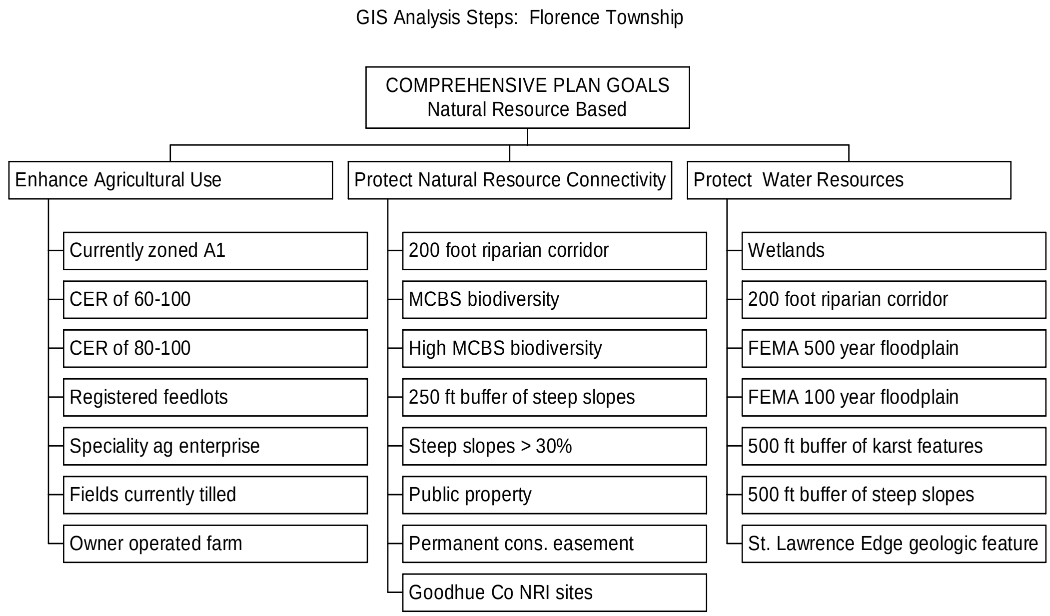

Figure 2. Flow chart of comprehensive plan goals, areas of concern and selected criteria.

Data Selection and Acquisition

Table 2 shows the data necessary for the analysis, the source of the data and a brief description of data processing steps. The data were obtained from four different sources. These were the Minnesota DNR, University of Minnesota, Goodhue County GIS Department and the Goodhue County Conservation Office, which includes the Farm Services Agency (FSA), Soil and Water Conservation District (SWCD) and Natural Resources Conservation Service (NRCS). Data from Goodhue County was re-projected using ArcMap projection tools from the county coordinate system to NAD 83, Zone 15.

Of special interest to this community was information from the Goodhue County Geologic Atlas. This information was presented to the townships in 2003 and had raised the level of awareness and concern regarding their groundwater resource. Of particular concern was the Sensitivity to Groundwater Pollution plate presented in the Geologic Atlas (Figure 3). Florence Township was found to be highly or very highly susceptible to groundwater pollution from contaminants. Infiltration times for surface contaminants to reach the groundwater were estimated as quickly as within hours.

However, sensitivity to groundwater pollution was not selected as a suitability criteria. Because it is a pervasive concern throughout the township, it would simply raise all scores by an equivalent amount rather than helping to differentiate one site from another. Instead, the community decided to make this concern of paramount importance prior to any land use decision. The possibility of groundwater contamination from a land use activity must be addressed prior

Table 2. Data used for suitability analysis relates back to the Comprehensive Plan goals. Each criteria also has a score given by participants.

Comprehensive Plan Goals	Information Need:	Data:	Source:	Data Preparation Steps:	Criteria Score:
Agricultural Preservation:					
Support agriculture as a lifestyle / Develop an agricultural inventory	Location of currently tilled lands	Crop Land Unit (CLU) by farm	FSA[1]	Committee identified each field as tilled or not.	Tilled = 1
	Loaction of parcels with registered feedlots	Parcels data, feedlots inventory	Goodhue Co GIS SWCD	Select parcels with registered feedlots	Feedlot=1
	Location of Ag (A1) Zoning	Zoning Map	Goodhue Co GIS	Selected sections zoned A1.	A1 = 1
	Location of owner operated farms (rather than rented)	CLU data	FSA	Township residents identified each ag field that was owner-operated	Owner Operated = 1
Encourage small scale agri-business	Location of speciality ag enterprises	Parcels data	Goodhue Co GIS	Speciality ag identified, parcels selected	Speciality Ag = 1
Protect highly productive soils	Location of soil type and CER rating	SURSGO soils data CER rating	U of MN SWCD	Edit attributes to add CER according to soil type to SURSGO data	CER 60-80 = 1 CER >80 = 2
Natural Resource Connnectivity:					
Discourage fragmentation of existing natural resource areas	Location of high value natural resource lands	MCBS Biodiversity Ranking	MN DNR	Selected land having biodiversity significance within the township	Biodiv = 1 High biodiv =2
	Location of natural communities on private land	Goodhue Co Nat Resource Inventory	Goodhue Co GIS	Selected private land inventoried for its natural resource value	Inventory lands = 1
	Location of public land and permanent easements	Parcels data	Goodhue Co GIS	Selected parcels owned by public, parcels with conservation easements	Public land = 1 Conservation Easement = 1
Preserve natural drainage systems and landforms (blufftops)	Location of bluffs	Steep Slopes (greater than 30%)	Goodhue Co GIS	County provided shapefile of 30 % slopes derived from 2ft LIDAR data.	Steep Slopes = 1
	Buffer steep slopes	250 foot buffer of steep slopes	Created	Created buffer of 30% slope shapefile (above)	Buffer Steep Slopes = 1
	Location and buffer of streams, lakes and wetlands	200 foot riparian buffer	MN DNR	Added intermittent stream in NE corner of township	Riparian Buf= 1
Water Resource Protection:					
Preserve natural areas, wetland areas and watersheds	Location of protected wetlands	NWI	MN DNR	NWI selected wetland types 2-4 and 6-8.	Wetlands = 1
	Location of surface water features	200 ft riparian buffer	MN DNR	200 foot riparian buffer selected for the township	Riparian buffer = 1
	Location of FEMA floodplain	FEMA Floodplain	MN DNR	Selected 100 and 500 year floodplains	100 yr fp = 2 500 yr fp = 1
Protect quality of surface water and ground water	Location of bluffs	500 Foot buffer of steep slopes	Goodhue Co GIS	Created 500 foot buffer of 30% slope shapefile	Buffer of steep slopes = 1
	Location of karst features	Known springs and sinkholes	MN DNR	Created 500 ft buffer of karst features	Karst = 1
	Location of St Lawrence edge	St. Lawrence Edge geology	MN DNR GW Unit	Selected the occurrences of this geologic feature in Florence Township	St Lawr edge = 1

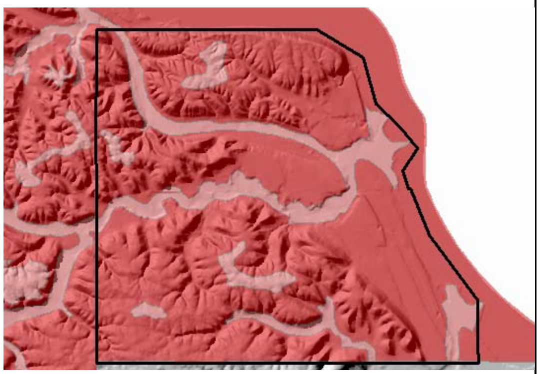

Figure 3. All of Florence township is highly susceptible (light red) or very highly susceptible (dark red) to ground water contamination.

to any consideration for allowing that activity.

Discussions regarding appropriate responses to this high level of susceptibility to pollution are continuing. Goodhue County Public Health, MN Pollution Control Agency and MN Department Natural Resources will provide a framework for deciding on appropriate density and design for septic treatment systems, location of impervious surfaces and stormwater management in response to the sensitivity of the area.

A second emerging issue in groundwater protection is also related to the unique geology in this area. Land use activities near the St. Lawrence-Franconia formation have been identified as a potential concern by Jeff Green, MN DNR Groundwater Hydrologist. Green (2005) stated that the St. Lawrence-Franconia formations are layers of shale, siltstone and limestone that underlie the Prairie du Chien and Jordan formations. The St. Lawrence-Franconia can be found one to twenty feet below the land surface at the base of the wooded hillsides in the Mississippi River valley. Water from aquifers and runoff moves down the hillsides and discharges as springs from the St. Lawrence-Franconia confining layer.

This St. Lawrence Edge is an emerging issue with potential concerns about groundwater recharge, water contamination, bluff stability, and cold water for trout streams. This edge may also serve to remove nitrates as the Decorah Edge formation has been found to do when studied in Olmsted County.

Groundwater recharge can be impacted by surface activities such as heavy equipment use for road construction and housing development. Clearing of the forests can alter the natural hydrology of the hillslope, changing groundwater recharge and discharge patterns. Homes built on top of the shale and siltstone units of the St. Lawrence Edge may experience wet and flooding basements.

Due to these concerns, the location of the St Lawrence-Franconia edge formation was included as a Water Resource Protection criteria. A 500 foot buffer at the top and toe of all bluff slopes greater than 30% was used as an additional criteria to reflect the importance of this area for groundwater recharge.

Data Processing

Much of the data required preprocessing and editing in order to extract the necessary information. The most effort was required to work with Cropping Land Use (CLU) data. This data was obtained from the Goodhue County FSA office and is a digital layer of all registered farm fields in Goodhue County. Each farm consists of several farm fields. An air photo showing the field boundaries was used by members of the LUC to identify ownership, rental agreements, farming practices and

Conservation Reserve Program (CRP) contracts for each field. This information was added to the attribute table to enable the selection of land currently being tilled and land that was farmed by the owner. The creation of this data merged local knowledge with existing information to allow a detailed look at the state of agriculture in Florence Township. In addition to use for this project, the data will be used for tracking changes in agriculture over time.

After the preprocessing for all the layers was complete, the features of interest were extracted from the original data and new shapefiles were created. As an example, the Goodhue County parcels layer was used to find land in public ownership. This is a large data set covering all of Goodhue County. An area of interest (AOI) polygon was created for Florence Township and the adjacent Mississippi River. The parcels that were within Florence Township were selected using the AOI polygon. Geoprocessing tools were used to clip the parcels data to the AOI. The attribute table was used to select parcels

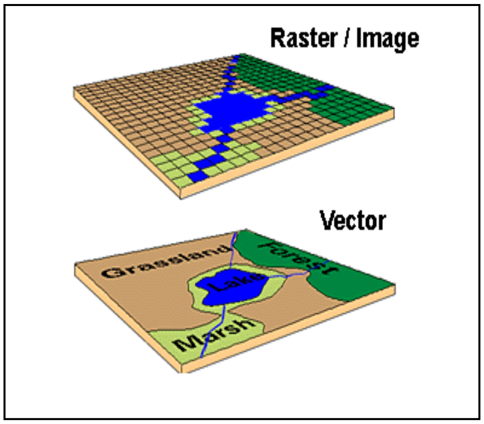

Figure 4. Vector data was converted to 30 meter grid raster data

with a public entity listed as the landowner name. These selected parcels were saved as a new shapefile.

At this point, the vector theme was converted to raster data (Figure 4). All raster data were created using a 30 meter cell size and the Florence Township Area of Interest polygon as an analysis mask. In this case, each cell was given a value of "1" based on the presence of the feature of interest. The no data cells within the AOI were reclassed to a value of "0". The assigned values for all the data can be viewed in table 2.

The next step was to combine all of the criteria grids within each area of concern. It was particularly important that the methods used to create the suitability grids were understandable and transparent to the members of the public and the local township government. They must reflect the local knowledge about the area as well as tie directly back to the goals and objectives expressed in the Florence Township Comprehensive Plan. Additionally, the GIS analysis must incorporate the qualitative input as well as the quantitative.

As described by Mendoza (1998), Analytical Hierarchy Protocol (AHP) is appropriate for this type of analysis. The formula for AHP can be summarized as

$$S = \sum_{j=1}^{n} c_j x_j$$

Each parameter (x_j) is associated with a scale factor (c_j) that represents the relative importance or degree of influence of that parameter to the overall measure of site suitability. For example, when calculating agricultural suitability, the parameter selected to represent highly productive soils was the Crop Equivalency Rating (CER) of each soil type. A CER of 60-80 were given a scale factor of 1. Soils with a rating of 80-100 were given a scale factor of 2. These scale factors were multiplied by the value in each cell. The original values in the cells were either "1" for the presence of valuable soils or "0" if valuable soils were not present. After applying the scale factor, the grid cells held values of 0, 1 and 2.

A summation of the values for every grid cell was then calculated. This produced a grid with values from 0 to 6, from least suitable to most suitable for agricultural protection shown in figure 5. This method was applied to the other

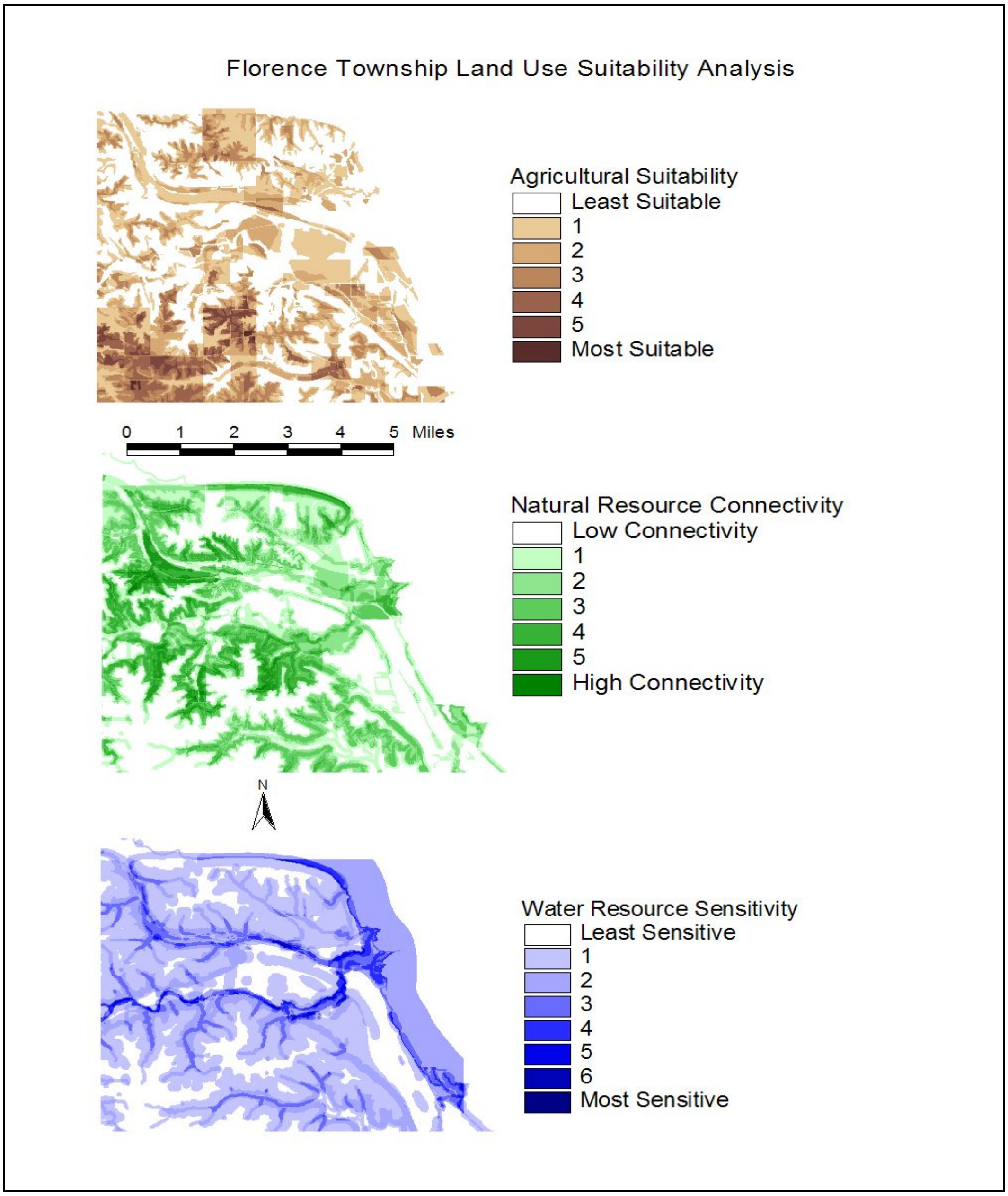

Figure 5. Three suitability grids were developed for Florence Township

remaining data to produce two more suitability grids.

Mendoza (1998) noted that AHP is more transparent and hence more likely to be accepted especially when the suitability analysis will ultimately serve as a basis for land allocation. It allows for the participation of both experts and stakeholders in providing the suitability measure of a site relative to a proposed land use.

AHP was applied to all the criteria compiled in each suitability analysis completed for Florence Township. The relative weights of each factor reflect the input from the CAC and LUC. This relatively simple method will provide the transparency needed for model acceptance by the local community.

Composite Grid

The final land use map for Florence Township incorporated a compilation of the suitability grids. Methods for creating a composite grid from multiple suitability analyses are varied. Roldan (2002) describes a method for developing a cumulative grid without ambiguous values. Rather than generate one accumulated value, an offset is introduced via map algebra prior to combining the grids. This allows the analyst to harvest additional information by creating a scale of cell values that can be added together without generating ambiguous values. In this case, the agricultural suitability values were carried forward without an offset. The Water Resource values were multiplied by a factor of 10 and the Natural Resource values were multiplied by a factor of 100 as shown in Figure 6.

The offset values were created using the following expression in the map calculator:

([AgFinal] + ([Wr_final] * 10) + ([Nr_final]*100))

The resulting weighted composite grid retains the values from all three input suitability analyses (Figure 7).

3	3	3
4	3	3
4	5	5

3	3	3
4	3	3
4	5	5

Agricultural Suitability

\+

3	3	3
5	5	3
5	5	3

x 10

30	30	30
50	50	30
50	50	30

Water Resource Sensitivity

\+

2	2	3
3	3	3
3	5	5

x 100

200	200	300
300	300	300
300	500	500

Natural Resource Connectivity

=

233	233	333
354	353	333
354	555	535

Composite Grid

Figure 6. An offset value was used to generate cell values that reflect all three input grids.

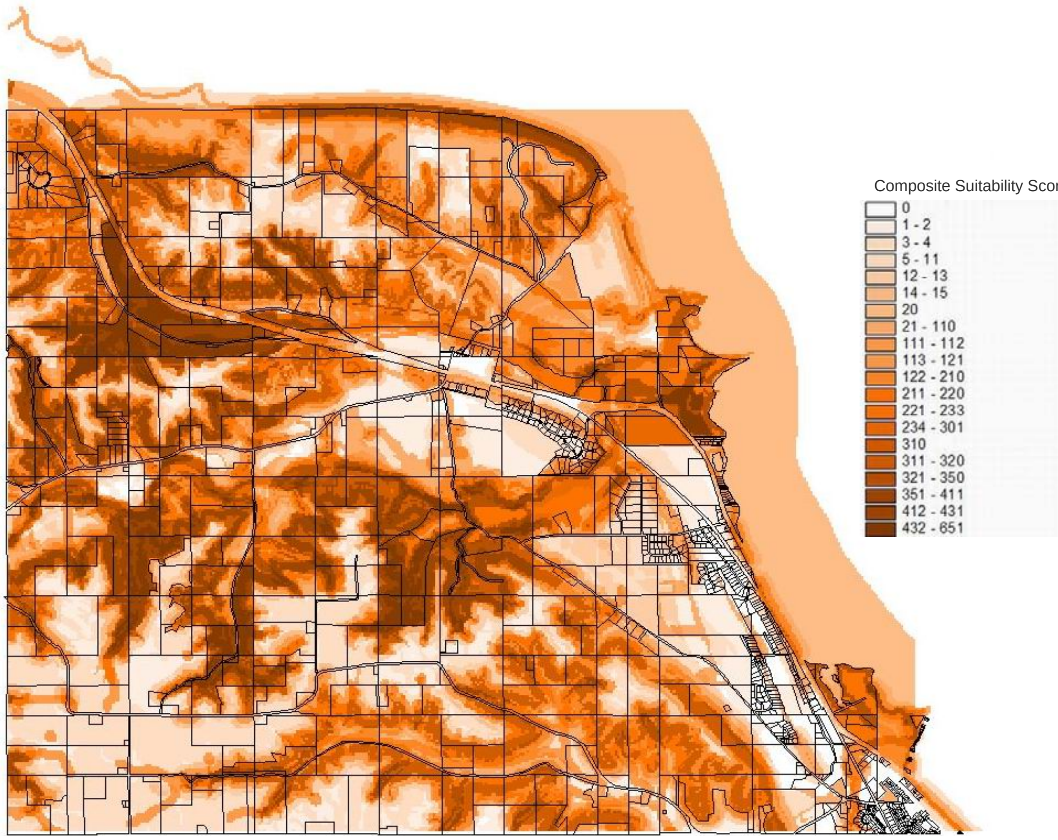

Figure 7. The suitability analyses were combined into a single composite grid.

This composite grid was converted to a shapefile. The DNR Tool Box was used to add area, acres and perimeter to the attribute table. As a final step, the composite shapefile was intersected with the parcels data which added the attributes from the composite grid to the parcels data. However, this resulted in multiple records for each grid value within a parcel (Figure 8). The resulting display is complicated on the township scale, but provides interesting detail on an individual parcel level.

Geoprocessing tools were then used to dissolve the results to the parcel boundary. The average score from each of the three input grids was attached to the parcel. A sum of all the average suitability scores was also generated for each parcel. A legend was created for each of the average value grids and reclassified using a consistent scale. An example of the results showing the sum of the average suitability scores for each parcel is shown in Figure 9.

The township will have the opportunity to use both the averaged values and the composite grid. Both methods give valuable information and the level of detail needed will be determined by the situation.

Results and Discussion

The acreage and percent of the most sensitive lands relative to the entire township are shown Table 3. Those lands in each of the three suitability grids that met four or more of the criteria were selected and quantified. A total of all land that met four or more criteria is shown as well.

Figure 8. The composite shapefile was intersected with the parcels layer resulting in multiple values for each parcel. Detail shows the composite values for one parcel.

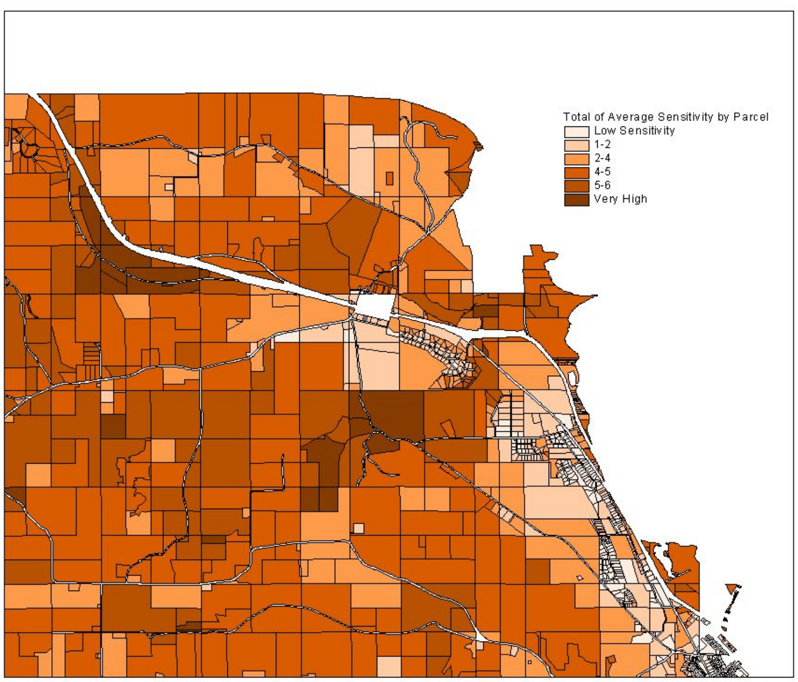

Figure 9. The multiple values shown above were dissolved to the parcel boundary to create an average sensitivity value.

Table 3. Nearly one fourth of the land in the township meets four or more sensitivity criteria

	Natural Resource Connectivity	Water Resource Sensitivity	Agricultural Suitability	Total land meeting 4 or more criteria
Acres	3012	957	1450	5213
Percent of total land base	13%	4%	6%	23%

The location of these lands reveals that the most sensitive lands in the three different grids have very little overlap. In other words, the majority of those lands that are sensitive because of their natural resource connectivity are not the same lands that are found to be most necessary for water resource protection or most suitable for agricultural use.

The few locations where lands were found to be highly sensitive for both water resource protection and natural resource connectivity are shown in red in Figure 10. From a management perspective, it is interesting to note that the majority of this land is already in public ownership. The lands that are not public are found in the riparian area adjacent to Wells Creek. These results suggest that the identified riparian lands could be prioritized for enrollment in a land protection program such as the Conservation Reserve Program (CRP).

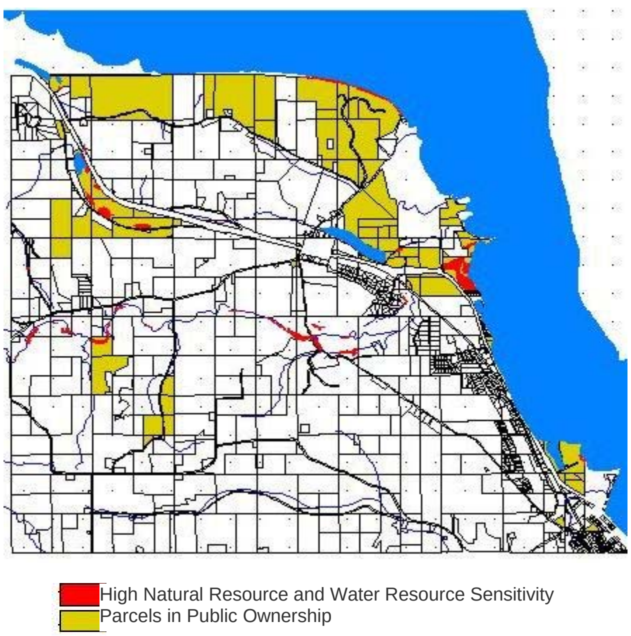

Figure 10. Some of the most sensitive natural resource lands are in public ownership. Much of the privately owned sensitive lands are found in riparian areas.

In addition to quantifying the most sensitive locations, locating areas of less sensitivity was also important. Found primarily along the Hwy 61 corridor, this less sensitive area will continue to receive much of the development pressure for the township. It will be important, however, to apply design standards that reflect the sensitivity of this area to groundwater pollution. This area is a sand terrace that has rapid infiltration rates. Septic system design will continue to drive decisions regarding appropriate densities at this location.

As a final step, Florence Township intends to apply the suitability analyses to new land use decision-making processes. They are developing a checklist of requirements for land use proposals based on whether a project falls within an area identified as sensitive.

Additionally, they are considering developing a Purchase of Development Rights (PDR) or Transfer of Development Rights (TDR) program. This type of program removes the right to develop on lands that would benefit from higher levels of protection and transfers those rights to areas appropriate for development. “TDR can be thought of as a way of encouraging the reduction or elimination of development in areas that a community wants to save and the increase in development in areas that a community wants to grow…. The areas that a community wants to save are designated as ‘sending areas’ and the locations the community wants to grow are designated as ‘receiving areas’” (Preutz, 2003). This analysis of sensitivity can be used as a tool to rank both sending and receiving areas based on the township’s highest priorities for resource protection.

Conclusion

In Florence Township, there are a number of possible outcomes based on this GIS analysis. It may be used to identify sending and receiving areas for a TDR or PDR program. It may also be used to support site-specific development decisions.

Other possible outcomes include a designated urban growth area near existing infrastructure adjacent to Lake City and Highway 61. A conservation overlay district may be considered to provide additional protection for lands meeting multiple sensitivity criteria. Much of this land is currently zoned for agricultural protection as A1 and A2.

Additionally, the township may develop a data sharing and maintenance agreement with Goodhue County GIS department in order to fully utilize the large amount of GIS data they have acquired.

Regardless of the implementation steps that are eventually taken, Florence Township will have access to better information about the landscape features they are charged with protecting. A well-informed governing body can better serve the needs of the community and can lead Florence Township toward the vision expressed in their comprehensive plan.

Additionally, with the high rate of projected growth for Goodhue County and the surrounding area, other communities in this landscape could benefit from similar analysis. Although this particular project relied heavily on the use of advanced GIS technology, there may be other options for visualizing the same data in a less technology dependent method. Static map products showing the location of important community features, existing infrastructure, current growth patterns, existing land use and natural resource features could be easily prepared by most County or State agencies. High quality aerial photography is also becoming easily available and can be used to readily identify features and create new data layers of sufficient quality for planning purposes.

As more communities see implementation of innovative land use protection as necessary to meet their planning goals, the need to carefully document the decision making process may give way to a more streamlined approach. Regional agreement and acceptance of important parameters for natural resource protection could lead to more consistent implementation of land use regulations. While public participation and acceptance is paramount, re-creating the wheel at each new location is not. Particularly within the blufflands landscape with its well-defined topographic features, there is a consistency of similar issues and goals. Addressing these recognized resource issues would lend itself to expansion of this work throughout the region. Perhaps presence or absence of a few key parameters could be built into a region-wide sensitive lands overlay. This would in turn be used to encourage adoption of consistent land use policies for the benefit of communities and their natural resource base. Effective land use management must acknowledge that the natural resources themselves do not end at political boundaries.

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References

Bockenstedt, P. J. Lower Wells Creek Natural Resource Inventory. November, 2001. Retrieved June 2005 fromwww.co.goodhue. mn.us/

Green, J. 2005. Personal Communication. MN DNR Groundwater Hydrologist, Rochester, MN.

Mendoza, G.A. 1998. A GIS-Based Multi-criteria Approaches to Land Use Suitability Assessment and Allocation. Retrieved October 5, 2005 from EBSCOhost database.

Minnesota Department of Natural Resources. 2004. A Quick Guide to Using Natural Resource Information. Retrieved October 2005 from http://files.dnr.state.mn.us/assistance/nrplanning/community/nrig/brochure.pdf.

Pruetz, R. 2003. Beyond Takings and Givings: Saving Natural Areas, Farmland and Historic Landmarks with Transfer of Development Rights and Density Transfer Charges. Arje Press, Marina Del Rey, California.

Roldan, M.K. 2002. Utilizing GIS for Mapping Reforestation of an Agricultural Landscape, 1939-1993, Retrieved October 2005 from http://www.gis.smumn.edu/ pages/Graduate_Projects.html.

Toren, B . A., P.E. Toren, 2003. Comprehensive Plan 2003, Florence Township Goodhue County, Minnesota. Retrieved June 2004 from http://www.goodhue.co.mn.us/Comp/ Florence20Township%20Plan%202003y07.pdf.

1000 Friends of Minnesota. *Managing Growth in Minnesota's Growth Corridor*, *Executive Summary*. May, 2004. Retrieved September 2005 from http://www.1000fom.org/ PDFfiles/ managing_grwth_in grwth_corridor. pdf