Using GIS to Determine Critical Forest Areas for Protection Based on Desired Community Benefits

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ABSTRACT

An interactive, GIS-based tool that identifies and indexes forest areas based on "urban" benefits and allows users to weight benefits and identify for protection, forest areas of local importance.

Tree canopy has been demonstrated to provide a range of benefits to communities that include air and water quality, energy conservation, and carbon sequestration. The study of forest and tree canopy has implications for development of county and regional comprehensive planning and long-term strategies for carbon sequestration, greenspace planning, watershed assessment, and identification of critical areas based on local priorities. To protect forest resources that best mitigate the impact of human activity, local government needs a tool to identify and prioritize forest areas of local importance.

This project: identifies and measures canopy change from 1985-1999; determines the rate of change in forest and tree canopy; 1985-1992 and 1992-1999; identifies and prioritizes remaining critical forest area based on an index of urban/suburban benefits; identifies and quantifies gains and losses in tree canopy based on critical forest area criteria; projects expected losses of critical forest area based on each county's future land use; and, provides this information in an interactive format that is county specific and useable at the planning and ordinance development and enforcement level.

Data acquisition required for this project include Landsat 5/7 TM imagery because of the characteristics of the imagery, the price, the required classification scheme, and the imagery's dynamic spectral range which is well suited for identifying subtle changes in vegetation reflectance

The vegetation classification and canopy change analysis was accomplished by conducting an automated classification followed by the use of ancillary data from outside sources and information from the field training sites to calibrate the computer to properly recognize cover types outlined in the following vegetation classification scheme:

- Hardwood (>70% deciduous)
- Pine (>70% evergreen)
- Pine/Hardwood (30/70% Mix)
- Hardwood/Pine (30/70% Mix)
- Pasture/Grass
- Water
- Urban

Canopy density is generally used as a relative measure of stocking of an area. The denser the forest canopy, the higher the basal area and the more environmental benefits the site can provide. Canopy closure was classified as:

- 25 % canopy closure;
- 25 – 40% canopy closure;
- 41 – 80% canopy closure;
- 81 – 100% canopy closure.

This initial set of data, vegetation class and canopy closure, was combined with available GIS data. These layers included: digital elevation map (for slope and aspect), state soils map, and hydrology. Remaining attributes needed to make the environmental ranking work with the methodology were created and are outlined as follows:

1. Create a unique identifier for each forest polygon;
2. Reclassify slope and aspect to meet study criteria;
3. Merge slope and aspect with vegetation (slope, energy budget);
4. Determine watershed characteristics for each forest polygon;
5. Merge stream order to vegetation (watershed position);

6. Create stream buffer;
7. Merge buffer width with vegetation (riparian buffer);
8. Merge soils layer with vegetation (capability);
9. Create remaining attributes (forest type, canopy class, acreage class);
10. Create the environmental rank attribute and set to zero (0).

The valuation methodology developed indexes forest area based on the resource's "urban" benefits. Benefits are improved air quality, enhanced water quality, reduced stormwater handling costs, continued supply of forest products, wildlife habitat and migration corridors, aesthetic health and psychological benefits, recreational opportunities, increased property values, wetland buffering, protection of riparian zones, temperature amelioration, and regional climate modification, and carbon sequestration. A relative index is assigned for each of the benefits based on forest type (e.g. pine, hardwood), canopy closure, and spatial arrangement relative to potential centers of pollutants. The methodology can be transferred throughout the state and other geographic regions.

The software that calculates the environmental rank for each forest polygon was developed in Visual Foxpro® and converted to Visual Basic®. This program uses the forest polygon attribute data and the end-user's weighting factors for local desired benefits to calculate environmental rank. Critical Forest Land (CFL) calculations are based on the assignment of "value" for benefits that forest land can provide in developed or developing counties/cities. The urban forest benefits include: stormwater, air pollution, carbon sequestration, urban heat island, and non-game wildlife/recreation. The features of urban forests that are associated with those benefits include: forest type, riparian characteristics, slope, site productivity, size of tract, energy available for growth (aspect), and position within the watershed. The program algorithm uses the end-user desired weighting, those factors associated with each, and canopy closure to develop the environmental ranking.

The effective weighting of the forest benefits as they might apply to your community hinges upon the users knowledge of the environmental pressures being brought upon the community from local and regional sources. The following "Benefit Matrix" points to the relationships between the "Forest Features" and the identified benefits they provide. This matrix will help you understand the impact the forest associated physiological features of your community have upon environmental concerns.

Forest Features/Benefit Matrix:									
Enter Environmental Weights in orange cells for benefit factors.		Forest Type	Riparian Buffer	Slope Class	Soil Capability	Acreage Class	Energy Budget	Watershed Position	Forest Features
	Water Quantity	✓	✓	✓	✓	✓	✓	✓	
	Water Quality	✓	✓	✓	✓	✓	✓	✓	
	Air Quality Non-Particulate	✓	NA	NA	✓	NA	✓	✓	
	Air Quality Particulate	✓	NA	NA	✓	✓	NA	NA	
	Carbon Sequestration	✓	NA	NA	✓	NA	✓	NA	
	Urban Heat Island	✓	NA	NA	NA	NA	✓	NA	
	Wildlife, Non-Game, & Recreation	✓	✓	NA	NA	✓	NA	NA	
= 100%	Benefit Factors								

Forest features are associated with each benefit based on current research available related to urban forest benefits.

The environmental ranking program develops important thematic data sets that meet critical local needs related to quality of life issues. The image classification, and data processing capabilities represent important steps provide to local users that makes the technology available.

Because the final data product is an ArcView® shapefile, delivery and use by end-users can take several forms. The use of ArcExplorer® is a cost-effective application (ESRI freeware). It also provides additional GIS database querying capabilities and enhanced mapping. It is the simplest form and allows end-user to display forest areas under various environmental ranking scenarios. Forest polygons can be located relative to the other local GIS layers bundled with the application (e.g. highways, utilities, public property). For more sophisticated local governments, ArcView® will provide complete spatial analysis capabilities for studies of environmental benefits of forest areas.

The environmental ranking program is compatible with any of these end-user applications. The Arc-Explorer and ArcView options for end-users provide an incentive for partnerships to develop with local governments to generate additional geospatial data for their area of interest.

This study is unique in approach because it:

- creates a logical and understandable link between urban and rural areas of the study area; this
- "link" will demonstrate the important environmental relationships that exist between developed and rural areas;
- develops a valuation methodology that indexes forest area based on the resources "urban" benefits; and, this methodology is based on current research and easily measurable parameters;
- assesses the forest area resource for a regional perspective, but supports site level, local and regional evaluations from different perspectives;
- identifies the specific critical forest area gains and losses that occurred during the period;
- quantifies the current state of the resource (1999), but places this in the context of total change and rate of change during the 14-year period; and,
- analyzes expected gains and losses based on future land use as identified in comprehensive plans.

CONCLUSION

This project provides communities with a needed decision-making tool that allows them to better manage critical forest areas and development. Communities can weigh the urban/rural benefits indices based on desired local benefit and determine the tracks of critical forest areas to protect based on that track's associated value. This project also enhances a community's critical-thinking and decision-making skills for comprehensive planning and land development.

While this project provides communities with a needed decision-making tool to identify critical areas for protection, long-term, the ultimate success of this project is represented in the long-term protection of identified areas. Short-term, project data will be used by this office and the local governments for comprehensive planning to determine local needs and priorities and then to apply the indices to determine tracts that provide identified benefits. This information will play a part in determining a jurisdiction's future land use patterns. Additionally, protection priorities will be incorporated into the Comprehensive Plan's Work Program and will not only identify which properties are identified for protection but will

identify how they will be protected. This will assist the local government in identifying funding priorities, regulatory initiatives, or coordination efforts with other organizations (i.e., land trusts) and landowners in achieving desired protection. Protection will be accomplished through easements, fee-simple acquisition, management strategies, and local regulation. It will be up to the local government, working in conjunction with the regional planning agency, land trusts, state agencies, and other interested parties, to determine the best method to protect identified areas.