Coastal Mississippi Land Development Suitability Model

Kevin L. Schultz and J. Grant Larsen, Mississippi Department of Marine Resources (MS DMR), Lori B. Cunningham and Mark A. Forsyth, Jr., Coastal Environments Inc. (CEI), and Tiffany A. Toft, Planning Systems Inc. (PSI)

Abstract

The Mississippi Department of Marine Resources' (MS DMR) Comprehensive Resource Management Plan (CRMP) developed a non-regulatory regional planning tool, called the Coastal Mississippi Land Development Suitability Model, for guiding coastal development and environmental change. The model used ArcView and Spatial Analyst Model Builder to identify areas more suitable for development and, conversely, areas more suitable for preservation according to mutually agreeable criteria. The tool is used by local jurisdictions to assess environmental conditions, address growth management issues, accommodate sustainable development, and reduce pressure on coastal wetlands and marine resources. The paper will present the model inputs, results, and examples of its use.

Overview

The Comprehensive Resource Management Plan (CRMP) is a special management program of MS DMR focused on developing a comprehensive strategy to balance coastal resource protection with economic development for promoting smart growth and smart economic development in Coastal Mississippi. In 1997, MS DMR initiated the CRMP planning effort in response to increased demands on natural resources resulting from a new and booming casino industry. Through CRMP meetings and workshops, stakeholders identified cumulative and secondary impacts as the most critical issue facing Coastal Mississippi. The mission of CRMP is "to develop a plan to sustain Mississippi's coastal resources and to provide for a healthy economy in the coastal area." The overall goal is to enhance the capacity of local jurisdictions to manage and protect coastal wetlands and marine resources in Mississippi by coordinating agency efforts, developing the necessary partnerships among public and private entities, and integrating wetland and water quality protection and management into the lifestyle of the coastal community. CRMP strives to be a leader in sustainable development and in providing geospatial information technology tools to local jurisdictions.

CRMP typifies partnerships, collaboration, and consensus-based decision-making via involvement by the public and private entities at stakeholder meetings, conferences, and workshops. CRMP designated twelve coastal cities and the six coastal watershed counties of George, Hancock, Harrison, Jackson, Pearl River, and Stone as stakeholder sites. CRMP equipped these 18 local government entities with a computer, ArcView GIS software, GIS data layers, and the Land Development Suitability Model. More than 350 members representing 72 groups comprise the CRMP stakeholder membership. These members include political and business leaders; city, county regional, state, and federal government professionals; planners; engineers; scientists; environmentalists;

conservationists; realtors; concerned citizens; non-profit organizations; and economic development groups.

Through its annual Coastal Development Strategies Conference and its bi-monthly stakeholder meetings, CRMP serves the public by fostering collaboration and promoting economic and environmental education, communication, and networking among coastal entities. The conferences present innovative ideas in land use planning and design, revitalization and restoration, economic development, smart growth, and storm water management. For example, the 2004 Conference was held at Casino Magic in Bay St. Louis, Hancock County, MS, and promoted the theme "Protecting the Environment – Encouraging Economic Development".

APPROACH

In November 2001, CRMP released the Land Development Suitability Model. The model is a non-regulatory regional planning tool used by CRMP participants to assess environmental conditions, address growth management issues, accommodate sustainable development, and reduce pressure on coastal wetlands and marine resources. GIS basemap data layers and digital imagery form the basis of the model. The data layers and model are available on CD-ROM and on the CRMP ArcIMS website. This provides local government agencies, planners, engineers, developers, realtors, and others with data layers highlighting political boundaries, land use/land cover, soil types, flood zones, hydrologic areas, wetlands, watersheds, coastal preserves, wildlife management areas, Gap Analysis Program (GAP), evacuation zones and routes, utility districts, transportation corridors, and other important information.

The model uses geospatial information technology tools to identify areas more suitable for development and, conversely, areas more suitable for preservation according to mutually agreeable criteria established by the CRMP stakeholders. Critical data layers were assigned a relative numerical value based on the inherent characteristics of each data layer and geographically analyzed using a weighted overlay method, thereby creating the spatial suitability index model. This approach fostered the development of a strategic plan for balancing coastal resource protection with a healthy economy for promoting smart growth and achieving sustainable development.

METHODS

The weighted overlay technique applied a common scale of values to diverse data for performing an integrated analysis. This technique reclassified data layer input values according to a spatial suitability index to determine land most suitable for development and land most suitable for preservation within the Mississippi coastal counties. The input values were weighted by their relative importance and summed to produce an output value.

For weighted overlay modeling purposes, the variables were grouped into four themes, or areas of influence. Although ESRI's ArcView Spatial Analyst Model Builder allows

numerous themes to be included in the analysis, the sum of each theme's relative influence on the model cannot exceed 100%. Four themes comprise the CRMP Land Development Suitability Model: (1) Government Owned Land/Restricted Development Areas), (2) Land Use/Land Cover, (3) Hydric Soils, and (4) FEMA Flood Zones. Because each theme was assigned a 25% Influence on the model, each theme has an equal weighting or relative influence on the outcome. Table 1 lists the Definitely Not Developable categories.

Table 1. Government Owned Land/Restricted Development Areas = Definitely Not Developable

➢ National Forests	➢ *Coastal Preserves*	➢ NASA Stennis Space Center Buffer Zone
➢ State/Natl. Parks	➢ *Mitigation Areas/Banks*	➢ *Conservation Easements/Trust Lands*
➢ Indian Lands	➢ Wildlife Refuges	➢ Wildlife Management Areas

The CRMP Technical Committee established conservative relative input values for the initial model, and these values were adjusted during CRMP stakeholder meetings. Table 2 lists the Input Values, % Influence (Weighting), Scale Values, and Output Values for the original 2001 model and the revised 2002 model.

The first step in creating the CRMP Coastal Mississippi Land Development Suitability Model was to identify all areas, sites, and land features usually considered unavailable or inappropriate for development. The unavailable for development land use/land cover classifications were assigned an absolute value of "Restricted" in the model scoring system. Land areas designated as "Restricted" were not considered in subsequent model calculations.

Land considered potentially available for development (i.e., all land areas not classified as "Restricted") was assigned a relative value based on the inherent characteristics of its classification. The relative value assigned to a particular classification was chosen through an interactive group review process of the CRMP stakeholders.

For land areas considered potentially available for development (i.e., not "Restricted"), relative values were assigned on a scale of 1 to 9, with a value of 1 representing the lowest level of suitability for development and a value of 9 representing the highest level of suitability for development. "Restricted" classifications were assigned a value of 0 and were precluded from scoring points above 0, thereby functioning as an on-off switch. The assignment of relative values based on inherent characteristics of each classification constituted a determination of relative suitability for development.

According to national trends, private forestlands have a relatively high potential for development. Forestland sales increase when development pressure increases and returns from forestland sales are greater than those from continued timber production. Also, Cropland/Pasture/Grassland may have a higher potential for development than Forestlands, particularly if they have been fallow.

Each theme consists of a corresponding and spatially comparable 30 meter square grid of cells encompassing the six coastal counties. Each cell in the grid was assigned a classification representing its identifying characteristic in that theme. In the "Restricted Development Areas" theme, for example, each cell in the grid was classified as either "Government Owned Land" (Definitely Not Developable) or "Potentially Developable". If a particular cell was located in an area Restricted from the model (i.e., National Forest, National/State Park, Proposed Preserve, Mitigation Area/Bank, etc.), the cell was classified as Definitely Not Developable. Otherwise, it was classified as Potentially Developable. The Land Use/Land Cover theme classified each cell by its land use/land cover designation. The Hydric Soils theme classified each cell essentially as either hydric or non-hydric. The FEMA Flood Zones theme classified each cell according to FEMA's scheme of differentiating flood zone characteristics.

In operation, the model examines grid cells in each theme and calculates an outcome score (Output Value) for each theme's grid cell based on the theme's relative influence (% Influence) and the theme's relative Input Value (Scale Value). The formula follows:

% Influence x Scale Value = Output Value.

A cell's Total score represents the sum of its Output Value scores in each theme. To better understand how the model operates, two examples are provided below using the input values shown in Table 2. Model results are essentially a map showing each cell's total score in the study area (Figures 1 - 2). Cells representing Restricted classifications (Output Value = 0) are not illustrated on the map/model. Cells exhibiting a total score of 1 to 9 are color coded on a gradient according to its total score.

Example #1: A parcel is:

- Located in a Developable area 2.25
- Classified as Tidal Marsh, 0.25
- A Hydric Soil Type, and 0.25
- Located within FEMA Flood Zone AE, 0.25
  - ∅ **Then**, the summed **Output Value is:3.00**. Given these factors, this parcel is more suitable for preservation based on the relative spatial suitability index.

Example #2: A parcel is:

- Located in a Developable area 2.25
- Classified as Upland Sand Barren, 2.25
- A Non-Hydric Soil Type, and 2.25
- Located within FEMA Flood Zone A, 0.75
  - ∅ **Then**, the summed **Output Value is:7.50**, or a value of 8 when rounding up. Given these factors, this parcel is highly suitable for development based on the relative spatial suitability index.

As the Output Value increases from 2 toward 8, the potential for development increases based on decreasing input factor constraints.

RESULTS

Table 3 provides the model results and acreage figures for each suitability index value by county and year. Overall for the 6 county area, there was a decrease in acreage for Suitability Index values “7”, “5”, “4”, “3”, and Restricted from 2001 to 2002. There was an increase in acreage for Suitability Index values “8”, “6”, and “2”. The increase in a Total acreage of 116 resulted from the different spatial resolutions of the soils data layer and the addition of the FEMA Flood Zones data layer in the 2002 model results. The Mitigation Areas/Banks caused an increase in the Restricted acreage, whereas, the Private Forest In-Holdings caused a decrease in the Restricted acreage. The Hydric Inclusions in the soils data layer skewed the results.

There are a number of differences between the two model result years. The 2002 Model incorporated Mitigation Areas/Banks and Private Forest In-Holdings in the Government Owned Lands/Restricted Development Areas. The FEMA Flood Zones were added to the 2002 model for the northern counties (Pearl River, Stone, and George). The Flood Zone maps for the northern counties were outdated and were less detailed than the southern counties (Hancock, Harrison, and Jackson). These maps contained fewer yet more vague categories. For two of the northern counties (Pearl River and Stone), both Models contained an inclusion category for the SSURGO Hydric Soils data layer. Because the SSURGO soils data layer was unavailable for George, the less detailed STATSGO data layer was used.

Although Figures 1 - 3 show static snapshots in time, the CRMP Suitability Model was not designed to be static. The model was designed to be dynamic and evolve over time as new data layers are integrated, existing data layers are refined, and input values are tweaked. Figure 1 depicts the results for 2001, whereas, Figure 2 shows the results for 2002. Figure 3 provides a good illustration of the weighted overlay process for a specific area of interest.

SUMMARY

Most of the “Highest Suitability for Development” areas occur in the currently urban areas, higher elevation areas, non-floodprone areas, and forestlands outside national forestlands. Most of the “Highest Suitability for Preservation” areas occur along hydrologic features and areas containing both hydric soils and hydrophytic vegetation (high potential wetlands).

MS DMR is encouraging the coastal cities and counties to adopt and incorporate the CRMP Land Development Suitability Model as part of their comprehensive plans and local ordinances. One way to accomplish this is to add the CRMP Suitability Model as an amendment to these plans and ordinances. MS DMR is currently working to improve the CRMP Suitability Model by incorporating local government GIS datasets and by creating new GIS datasets. MS DMR furnished the CRMP Suitability Model GIS data layer and many other GIS data layers to all coastal cities and counties, and they are available on the CRMP ArcIMS website. The City of Gulfport is taking the lead in

Coastal Mississippi in creating and using GIS datasets in their comprehensive planning efforts. Because the CRMP Suitability Model is designed to evolve and adapt to environmental changes and development activities to sustain a healthy economy, MS DMR also envisions the coastal cities and counties incorporating these revisions as they are generated.

The coastal cities and counties are enabled to add their own or other local government GIS datasets, such as zoning, land use, and water and sewer infrastructure availability, on top of the CRMP GIS datasets and the Suitability Model to help guide development in Coastal Mississippi. This is important because the coastal area has a relatively large amount of wetlands, meaning a wetland jurisdiction will probably be necessary in most areas, especially in the southern counties.

POTENTIAL MODEL IMPROVEMENTS

CRMP envisions improving the Land Development Suitability Model through the addition of one or more of the following potential enhancements.

1. The soil inclusions for the northern counties will be excluded from the next model run. Soils will be analyzed regarding their septic tank suitability and incorporated with actual septic tank locations.
2. Wetland permit locations by type could be integrated to assist in determining cumulative and secondary impacts.
3. National Wetland Inventory (NWI) maps could be incorporated to refine the wetlands land use/land cover data.
4. Additional digital imagery will be incorporated for creating, updating, or analyzing various GIS datasets, such as impervious surfaces, land use/land cover classifications, change detection, and vegetation classifications and assessments.
5. Buffered locations of threatened/endangered species by type and age/year of sighting will be incorporated.
6. Larger blocks/tracts of undeveloped land will be assigned a higher wildlife habitat value.
7. Local government parcels, land use, zoning, address, and building permit datasets will be incorporated.
8. Local government roads and streets will be buffered to create transportation corridors and incorporated into the model.
9. The 2000 Census blocks and associated data will be incorporated to project demographic future trends and compare with 1990 Census data and projections.
10. Other potential model improvements include fine-tuning the % Influence/Weighting of each theme and the FEMA Flood Zone Scale Values.

About MS DMR:

The Mississippi Department of Marine Resources (MS DMR) is dedicated to enhancing, protecting, and conserving marine interests of the State of Mississippi by managing all marine life, public trust wetlands, adjacent uplands, and waterfront areas to provide for the optimal commercial, recreational, educational, and economic uses of these coastal resources consistent with environmental and social concerns and changes.

Author Information:

Kevin L. Schultz, *Information Technology Planner (GIS Manager)*, Mississippi Department of Marine Resources (MS DMR), Comprehensive Resource Management Plan (CRMP), 1141 Bayview Avenue, Suite 101, Biloxi, MS 39530, Tel 228.374.5000, ext. 5053, Fax 228.374.5008, Kevin.Schultz@dmr.state.ms.us

J. Grant Larsen, *Community Planner V (GIS Specialist)*, Mississippi Department of Marine Resources (MS DMR), Comprehensive Resource Management Plan (CRMP), 1141 Bayview Avenue, Suite 101, Biloxi, MS 39530, Tel 228.374.5000, ext. 5374, Fax 228.374.5008, Grant.Larsen@dmr.state.ms.us

Lori B. Cunningham, *GIS Division Manager* and *Senior GIS Specialist*, Coastal Environments, Inc. (CEI), 1260 Main St., Baton Rouge, LA 70802, Tel 225.383.7455, Fax 225.383.7925, lcunningham@coastalenv.com.

Mark A. Forsyth, Jr., *GIS Specialist*, Coastal Environments, Inc. (CEI), 1260 Main St., Baton Rouge, LA 70802, Tel 225.383.7455, Fax 225.383.7925, mforsyth@coastalenv.com.

Tiffany A. Toft, *GIS Specialist*, MSAAP Building 9121, NASA John C. Stennis Space Center, Bay St. Louis, MS 39529, Tel 228.688.4371, Fax 228.688.4853, toft@nrlssc.navy.mil

Table 2. Land Development Suitability Model Input Values by Year: 2001 vs. 2002.

Theme & Input Value	% Influence	Scale Value 2001	Scale Value 2002	Output Value 2001	Output Value 2002
Government Owned Land/Restricted Development Areas	25%				
➢ 0 (Potentially Developable)		9	9	2.25	2.25
➢ 1 (Definitely Not Developable)		Restricted	Restricted	None	None
➢ No Data		5	5	1.25	1.25
Land Use/Land Cover	25%				
➢ Bottomland Hardwood Forest		2	2	0.50	0.50
➢ Burned Area		5	5	1.25	1.25
➢ Cropland/Pasture/Grassland		9	9	2.25	2.25
➢ High Density Urban		9	9	2.25	2.25
➢ Marsh (Non-Tidal Hydric Soil)		2	2	0.50	0.50
➢ Medium Density Urban		9	9	2.25	2.25
➢ Outside		Restricted	Restricted	None	None
➢ Surface Water		Restricted	Restricted	None	None
➢ Swamp		2	2	0.50	0.50
➢ Tidal Marsh (Tidal Hydric Soil)		1	1	0.25	0.25
➢ Upland Cutover Land		7	7	1.75	1.75
➢ Upland Deciduous Forest		7	7	1.75	1.75
➢ Upland Mixed Forest		7	7	1.75	1.75
➢ Upland Pine Forest		8	8	2.00	2.00
➢ Upland Sand/Barren		9	9	2.25	2.25
➢ Upland Scrub/Shrub		8	8	2.00	2.00
➢ Wet Cutover Land		4	4	1.00	1.00
➢ Wet Pine Forest/Savannah		3	3	0.75	0.75
➢ Wet Sand/Barren		4	4	1.00	1.00
➢ Wet Scrub/Shrub		3	3	0.75	0.75
➢ No Data		Restricted	Restricted	None	None
Hydric Soils	25%				
➢ Y = Yes = Hydric		1	1	0.25	0.25
➢ N = No = Non-Hydric		9	9	2.25	2.25
➢ U = Unranked		5	None	1.25	None
➢ N/A = Not Available		5	5	1.25	1.25
➢ Inclusion		None	3	None	0.75
➢ Water		None	Restricted	None	None
➢ No Data		Restricted	Restricted	None	None
FEMA Flood Zones	25%				
➢ A = 1% Annual Flooding Potential, No BFEs		3	3	0.75	0.75
➢ AE = 1% Annual Flooding Potential, BFEs Determined		1	1	0.25	0.25
➢ AH = 1% Annual Flooding Potential, BFEs, 1-3 Feet		2	2	0.50	0.50
➢ Undesignated		1	1	0.25	0.25
➢ VE = 1% Annual Flooding Potential ,Velocity Hazard		1	1	0.25	0.25
➢ X = Outside 1% and 0.2% Annual Flooding Potential		9	9	2.25	2.25
➢ X500 = 0.2% Annual Flooding Potential		3	3	0.75	0.75
➢ Inside City Boundaries		None	5	None	1.25
➢ Outside City Boundaries		None	9	None	2.25
➢ No Data		Restricted	Restricted	None	None
Mitigation Areas/Banks	*Merged*				
➢ Areas	*with*	None	1	None	0.25
➢ Banks/Bio-Reserves	*Govt.*	None	1	None	0.25
➢ No Data	*Land*	None	5	None	1.25
Forestland Ownership	*Merged*				
➢ Forest Service/Public Domain	*with*	None	1	None	0.25
➢ Private In-holdings	*Govt.*	None	9	None	2.25
➢ No Data	*Land*	None	5	None	1.25

NOTE: BFEs = Base Flood Elevations