# METHODOLOGY FOR ASSESSING ENVIRONMENTAL IMPACTS

Prepared by:

Resources Planning Section
Office of Planning and Research
Department of Natural Resources

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For the:

GEORGIA COASTAL ZONE MANAGEMENT PROGRAM

## Coastal Zone Management Technical Committee

Board of Regents of the University System
Brunswick-Glynn County Joint Planning Commission
Chatham County-Savannah Metropolitan Planning Commission
Coastal Area Planning and Development Commission
Georgia Department of Community Development
Georgia Department of Human Resources
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Georgia Forestry Commission
Georgia Ports Authority
Georgia Soil and Water Conservation Committee
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## Credit

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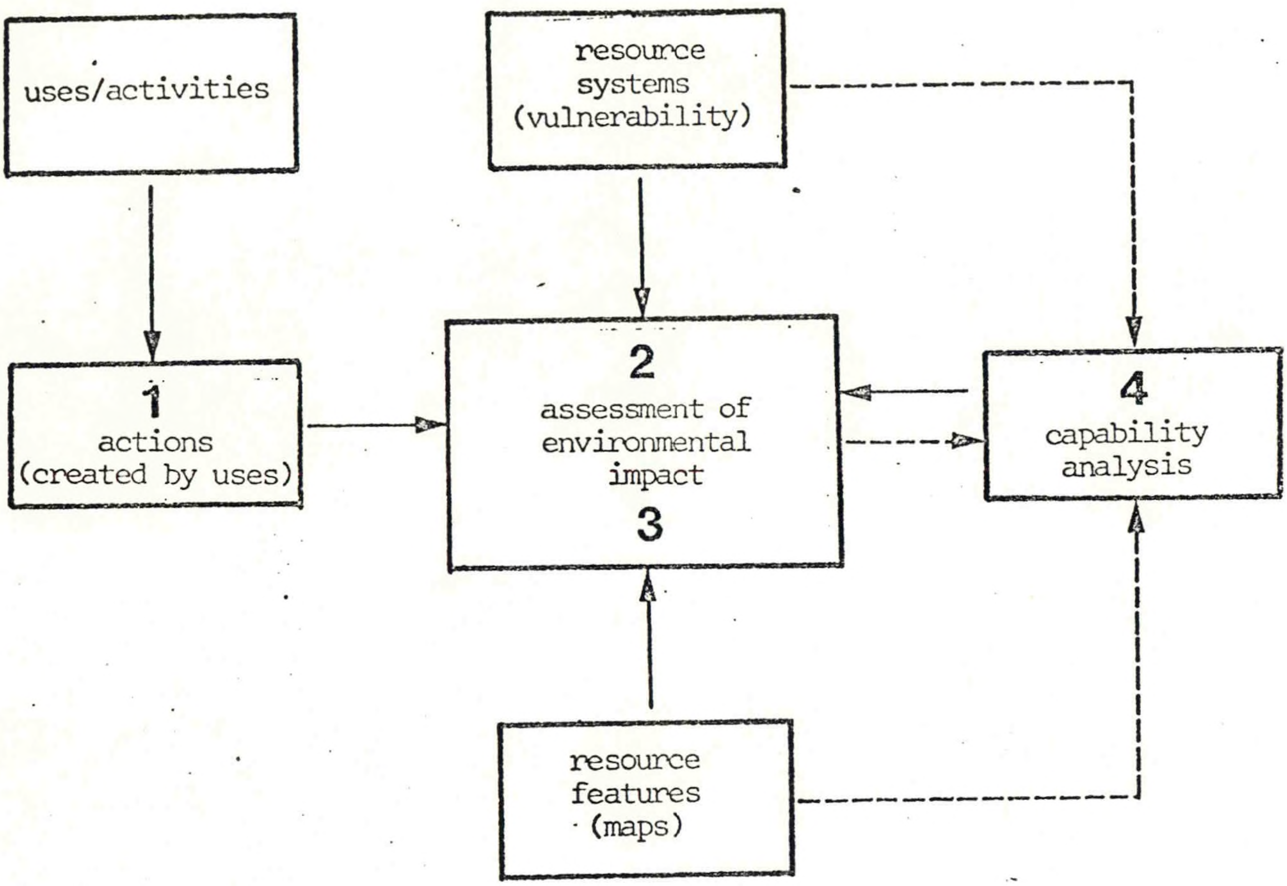
# Environmental Impact Methodology
## Schematic Summary




(1) Identify actions affecting natural conditions which are created by the use or activity. (Matrix #1)

(2) Identify the relationship of actions with resource systems (especially with vulnerabilities). (Matrix #2)

(3) Identify resource maps related to resource vulnerabilities for further definition of environmental impact. (Matrix #3)

(4) Determine the ability of resource features or systems to support certain activities (capability analysis) as further input to the environmental impact assessment.

CONTENTS

ix #1

TIONSHIP BETWEEN
S AND ACTIONS

IONS WHICH AFFECT
URAL CONDITIONS

| USES/ACTIVITIES | PARATION | | | | | | | RUCTURES | | | | | | | | E/ACTIVITY | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clearing | Grading | Excavation | Drilling | Dredging | Filling | Draining | Paving/Roof Areas | Pipelines | Water Storage | Septic Tank/Tile Fields | Solid Waste | Corridors | Barriers | Shoreline Structures | Fertilization/Chemical Control | Aesthetic Conflicts | Noise | Cultivation/Harvesting | Grazing | Water or Air Discharges | Controlled Burning | Pumping of Ground Water |
| **RESIDENTIAL** | | | | | | | | | | | | | | | | | | | | | | | |
| Single Family | ○ | ○ | ○ | | | ○ | ○ | | ○ | | ○ | ○ | | | | | | | | | ○ | | |
| Multi-Family | ○ | ○ | ○ | | | ○ | ○ | | ○ | | | ○ | | | | | | | | | ○ | | |
| **COMMERCIAL/INSTITUTIONAL** | | | | | | | | | | | | | | | | | | | | | | | |
| Office | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | | | ○ | | | | ○ | | | | | ○ | | |
| Retail/Wholesale | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | | | ○ | | | | | | ○ | | | ○ | | |
| Parking Ramps | ○ | ○ | | | | ○ | ○ | ○ | | | | | | | | | ○ | ○ | | | | | |
| **INDUSTRIAL** | | | | | | | | | | | | | | | | | | | | | | | |
| Manufacturing | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | ○ | | ○ | | | | ○ | ○ | ○ | | | ○ | | ○ |
| Warehousing | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | | | ○ | | | | ○ | ○ | ○ | | | ○ | | |
| Extractive (on-shore) | ○ | | ○ | ○ | | | | | | ○ | | | | | | | ○ | ○ | | | ○ | | ○ |
| Extractive (marshlands) | | | ○ | ○ | ○ | | | | ○ | | | ○ | ○ | | ○ | | ○ | ○ | | | ○ | | ○ |
| Extractive (off-shore) | | | | ○ | ○ | | | | ○ | | | ○ | ○ | | ○ | | ○ | | | | ○ | | ○ |
| **TRANSPORTATION/UTILITIES** | | | | | | | | | | | | | | | | | | | | | | | |
| Interstate/other 4 lane roads | ○ | ○ | | | ○ | ○ | ○ | ○ | | | | | ○ | ○ | | ○ | ○ | ○ | | | ○ | | |
| 2-lane roads | ○ | ○ | | | ○ | ○ | ○ | ○ | | | | | ○ | ○ | | ○ | ○ | ○ | | | ○ | | |
| Airports | ○ | ○ | | | | ○ | ○ | ○ | | | | | | ○ | | ○ | ○ | ○ | | | ○ | | |
| Railways | ○ | ○ | | | | ○ | ○ | | | | | | ○ | ○ | | ○ | | | | | ○ | | |
| Ports and Waterborne Commerce | | | | | ○ | ○ | | | | | | | | | ○ | | | | | | ○ | | |
| Overhead Utilities | | | | | | | | | | | | | | ○ | | | ○ | | | | | | |
| Underground Utilities | | | | | | | | | | | | | | | | | ○ | | | | | | |
| Deepwater Ports | | | | | | | | | | | | | | | | | ○ | ○ | | | ○ | | |
| **AGRICULTURE/FISHING/FOREST** | | | | | | | | | | | | | | | | | | | | | | | |
| Cropland | ○ | ○ | | | | | ○ | | | | | | | | | ○ | | | ○ | | | | |
| Pasture | ○ | | | | | | ○ | | | | | | | | | | | | | ○ | | | |
| Game Management | ○ | | | | | | | | | | | ○ | | | | | | | | | | ○ | |
| Feedlot | ○ | | | | | | | | | | | | | | | | ○ | ○ | | | | | |
| Forest Management | ○ | | | | | | ○ | | | | | | | | | ○ | | | | | | ○ | |
| Commercial fish & shell fish fishing | | | | | | | | | | | | | | | ○ | | | | ○ | | ○ | | |
| Oyster harvesting | | | | | | | | | | | | | | | | | | | ○ | | | | |
| **RECREATION** | | | | | | | | | | | | | | | | | | | | | | | |
| Intensive | | | | | | | | | | | | | | | | | | | | | | | |
| golf course | ○ | ○ | | | | | ○ | | | | | | | | | ○ | | | | | ○ | | |
| boat docks | ○ | ○ | | | | ○ | | | | | | | | | ○ | | | | | | ○ | | |
| camping, etc. | ○ | | | | | | | | | | | | | | | | | | | | ○ | | |
| Extensive | | | | | | | | | | | | | | | | | | | | | | | |
| hiking | | | | | | | | | | | | | ○ | | | | | | | | | | |
| boating/canoeing | | | | | | | | | | | | | ○ | | | | | | | | ○ | | |
| hunting | | | | | | | | | | | | | | | | | | | | | | | |

SOURCE: Adapted from "Michigan Natural Environment Survey, prepared for State Planning Division by Johnson, Johnson, & Roy, Inc. 1973, Res[illegible]es [illegible]ning Section, Office of Planning and Research, [illegible] Department of Natural Resources.

trix #2

TENTIAL ENVIRONMENTAL
PACT OF ACTIONS ON
TURAL SYSTEMS

CTIONS WHICH AFFECT NATURAL CONDITIONS

| NATURAL SYSTEM OR FEATURE VULNERABILITY | PREPARATION: Clearing | Grading | Excavation | Drilling | Dredging | Filling | Draining | STRUCTURES: Paving/Roof Areas | Pipelines | Water Storage | Septic Tank/Tile Field | Solid Waste | Corridors | Barriers | Shoreline Structures | USE/ACTIVITY: Fertilization/Chemical Control | Aesthetic Conflicts | Noise | Cultivation/Harvesting | Grazing | Water or Air Discharges | Controlled Burning | Pumping of Ground Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BEACHES, SAND DUNES, OFFSHORE BARS** | | | | | | | | | | | | | | | | | | | | | | | |
| Alteration of sand dune | 4 | 4 | 4 | | | | | 4 | 3 | | 4 | | | 4 | 4 | | | | 4 | 4 | | | |
| Alteration of offshore bars | | | 4 | | 4 | | | | 4 | | | | | | | | | | | | | | |
| Alteration of sand dune vegetatio | 4 | | 4 | | | | | 4 | 3 | | 4 | | | 4 | 4 | | | | | | | | |
| Removal of Sand | | | 4 | | 4 | | | | | | | | | | | | | | | | | | |
| Blockage of sand flow | | | | | | | | | | | | | | 4 | 4 | | | | | | | | |
| **COASTAL BARRIER ISLANDS** | | | | | | | | | | | | | | | | | | | | | | | |
| Removal of soil litter layer | 4 | | 4 | | | | | 4 | | | | | | | | | | | | | | | |
| Contamination of water table | | | | | | | | | * | | * | * | | | | * | | | | | 4 | | |
| Reduction in soil permeability | | | * | * | | 4 | 4 | 4 | | | | | | | | | | | | | | | |
| Reduction in water table depth | | | | | | | 4 | | | | | | | | | | | | | | | | 4 |
| Destruction of salt tolerant vegetation | 4 | 4 | | | 4 | 4 | 4 | | 4 | | | | | | | | | | | 4 | | | |
| Alteration of wildlife habitat | 4 | 4 | 4 | | 4 | 4 | 4 | 4 | * | | * | * | | 4 | | * | | 4 | | | 4 | 1 | |
| Destruction of sloughs. | 4 | | | | 4 | 4 | 4 | 4 | | | | | | | | | | | | | | | |
| **FRESHWATER RIVERS & SWAMPS** | | | | | | | | | | | | | | | | | | | | | | | |
| Blockage of flood waters | | 4 | | | 4 | 4 | 4 | | | | | | | 4 | 4 | | | | | | | | |
| Interruption of wildlife food chain | 4 | | | | 4 | 4 | 4 | | | | | | | 4 | | | | | 4 | | 4 | | |
| Draining of backwater sloughs | | | | | 4 | 4 | 4 | | | | | | | | | | | | | | | | |
| Alteration of rate of water flow | 4 | 4 | | | 4 | 4 | 4 | | | | | | | 4 | 4 | | | | 4 | | 4 | 1 | |
| Destruction of wildlife habitat | 4 | | | | 4 | 4 | 4 | | | | | | | 4 | | | | | 4 | | | | |
| **COASTAL MARSHLANDS** | | | | | | | | | | | | | | | | | | | | | | | |
| Blockage of tidal flow | | | | | | 4 | 4 | | | | | | | 4 | 4 | | | | | | | | |
| Change in salinity | | | | | 4 | 4 | 4 | | | | | | | | | | | | | | | | |
| Destruction of vegetation | | | | | 4 | 4 | 4 | 4 | | | | | | | | | | | | | 4 | | |
| Alteration of wildlife habitat | | | | | | | | | * | | * | * | | | | * | | 4 | | | | 1 | |
| **OPEN MARINE & ESTUARINE WATERS** | | | | | | | | | | | | | | | | | | | | | | | |
| Alteration of currents | | | | | | | | | 3 | | | | | 4 | | | | | | | | | |
| Alteration in nutrient flow | | | | | 4 | 4 | 4 | | | | | | | 4 | | | | | | | | | |
| Pollution of waters | | | | | | | | | * | | * | * | | | | * | | | | | 4 | | |
| Change in salinity | | | | | 4 | 4 | 4 | | | | | | | | | | | | | | | | |
| Alteration of wildlife habitat | | | | | | | | | | | | | | | | | | | | | | | |
| **GROUNDWATER** | | | | | | | | | | | | | | | | | | | | | | | |
| Removal of large quantities of water | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Brackish water encroachment | | | | | | | | | | | | | | | | | | | | | | | 4 |
| **HISTORICAL/ARCHAEOLOGICAL SITES** | | | | | | | | | | | | | | | | | | | | | | | |
| Destruction of site | [illegible] | [illegible] | [illegible] | [illegible] | | | | | | | | | | | | | | | | | | | |

TENTIAL IMPACTS: 1. Beneficial; 2. Benign (favorable); 3. Tolerable; 4. Adverse Blank box: not applicabl

Matrix #3

RESOURCE MAPS*
USEFUL FOR EVALUATING
ENVIRONMENTAL IMPACTS

| RESOURCE VULNERABILITY / MAPS | 1 Soils | 1 Vegetation | 1 Topography | 1 Surface Water | 1 Wetlands | 1 Flood Prone Areas | 1 Geology | 1,2 Minerals | 1 Watersheds | 1 Offshore Sand Bars | 1 Offshore Energy Zones | 1 Historical/Arch. Sites | 1,2 Water Quality Classifications | 1,2 Approved Oyster Growing Areas | 2 Offshore Fishing Reefs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEACHES, SAND DUNES, OFFSHORE BARS | | | | | | | | | | | | | | | |
| Alteration of sand dunes | | | ⊙ | | | | | | | ⊙ | | | | | |
| Alteration of offshore bars | | | | | | | | | | ⊙ | | | | | |
| Alteration of sand dune vegetatic | | ⊙ | | | | | | | | ⊙ | ⊙ | | | | |
| Removal of sand | | | | | | | | | | ⊙ | ⊙ | | | | |
| Blockage of sand flow | | | | | | | | | | | | | | | |
| COASTAL BARRIER ISLANDS | | | | | | | | | | | | | | | |
| Removal of litter layer | ⊙ | | | | | | | | | | | | | | |
| Contamination of water table | | | | | | | | | | | | | | | |
| Reduction in soil permeability | ⊙ | | | | | | | | | | | | | | |
| Reduction in water table depth | | | | | | | | | | | | | | | |
| Destruction of salt tolerant vegetation | | ⊙ | | | | | | | | | | | | | |
| Alteration of wildlife habitat | | ⊙ | | ⊙ | ⊙ | ⊙ | | | | | | | | | |
| Destruction of island sloughs | | | | ⊙ | ⊙ | | | | | | | | | | |
| FRESHWATER RIVERS AND SWAMPS | | | | | | | | | | | | | | | |
| Blockage of flood waters | | ⊙ | ⊙ | ⊙ | | ⊙ | | | ⊙ | | | | | | |
| Interruption of wildlife food chain | | ⊙ | | ⊙ | ⊙ | ⊙ | | | | | | | | | |
| Draining of backwater sloughs | | | | ⊙ | ⊙ | | | | | | | | | | |
| Alteration of rate of water flow | | | ⊙ | ⊙ | ⊙ | | | | ⊙ | | | | | | |
| Destruction of wildlife habitat | | ⊙ | ⊙ | ⊙ | ⊙ | | | | | | | | | | |
| COASTAL MARSHLANDS | | | | | | | | | | | | | | | |
| Blockage of tidal flow | | | | ⊙ | | | | | | | | | | | |
| Change in salinity | | | | ⊙ | ⊙ | | | | | | | | | | |
| Destruction of vegetation | | ⊙ | | | ⊙ | | | | | | | | | | |
| Alteration of wildlife habitat | | ⊙ | ⊙ | ⊙ | ⊙ | | | | | | | | | ⊙ | |
| OPEN MARINE & ESTUARINE WATERS | | | | | | | | | | | | | | | |
| Alteration of currents | | | | | | | | | | | ⊙ | | | | |
| Alteration in nutrient flows | | | ⊙ | ⊙ | ⊙ | | | | | | | | | | |
| Pollution of waters | | | | | | | | | | | | | ⊙ | | |
| Pulse of fresh/salt water flows | | | | ⊙ | | | | | ⊙ | | | | | | |
| Change in salinity | | | | | | | | | | | | | | ⊙ | ⊙ |
| Alteration of wildlife habitat | | | | | | | | | | | | | | ⊙ | ⊙ |
| GROUNDWATER | | | | | | | | | | | | | | | |
| Removal of large quantities of water | | | | | | | | | | | | | | | |
| Brackish water encroachment | | | | | | | | | | | | | | | |
| HISTORICAL/ARCHAEOLOGICAL SITES | | | | | | | | | | | | | | | |
| Destruction of sites | | | | | | | | | | | | ⊙ | | | |

* Maps referenced are available from the Department of Natural Resources. A ⊙ in a box indicates that the scale and detail of data on the map is useful in assessing the effect of proposed actions on resource vulnerabilities. This chart should be used in conjunction with matrices which relate actions to potential impacts on resource vulnerabilities.

**1** - Large-scale map
**2** - Map contained in water activities report

## The Purpose and Scope of Environmental Impact Assessment

On January 1, 1970, the National Environmental Policy Act (Public Law 91-190) became law. Title 1 of the Act declares a National Environmental Policy by stating:

> "The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans." (Sect. 101(b))

The Act includes the provision that a detailed statement of environmental impacts be prepared for federal actions which significantly affect the quality of the human environment. The National Environmental Policy Act of 1969, together with growing support on the part of citizens and officials for conservation of valuable resources, has made "environmental impact assessment" a frequently-heard term.

Actual techniques and methods for completing environmental impact assessments, on the other hand, have received relatively little attention. Commonly, an environmental impact statement will include a detailed inventory of the flora and fauna of the site, a description of the intended action, and a statement that there will be no environmental impacts. In addition, reviewers of environmental impact statements will evaluate the sufficiency of a statement without a rational method or approach to the assessment.

In the broadest sense of the word, an environmental impact assessment is a comprehensive analysis that organizes information so that more informed choices among a range of alternatives can be made. The emphasis of an environmental impact assessment should be placed upon the differences in impacts among alternatives--not a detailed inventory of every conceivable effect of a single proposal.[1] In response to this need, an environmental impact assessment method (or methodology) should focus on organizing information in an understandable fashion so that environmental impacts can be readily identified and the effects of alternative actions compared.

Environmental impact statements are too often developed after the details of a project have been planned. To successfully carry out the intent of the National Environmental Policy Act, environmental impact assessment should be an on-going process. Environmental impacts should be considered at every stage in the planning process; when the project is formulated, when regional location is considered, when site location is considered, and as detailed specifications are developed. At each stage in the planning of the project the assessment of environmental impacts should become more detailed.

## Environmental Impact Assessment and the Coastal Zone Management Act of 1972

The Coastal Zone Management Act of 1972 provides an opportunity for states to assess the problems and potential future of their coastal areas, and provides incentives to develop policies and programs for managing coastal resources. The Act encourages states to consider the full range of existing, proposed or projected future land and water uses of their coastal areas, including the environmental impacts of alternative uses.

One of the specific requirements of the Coastal Zone Management Act

[1] Richard N. Andrews, "A Philosophy of Environmental Impact Assessment," Journal of Soil and Water Conservation, September - October, 1973, pp. 197-204.

(Section 923.12(a)(4) of the Federal Register guidelines for Program Administration Grants) is "an analysis or establishment of a method for analysis of the environmental impact of reasonable resource utilizations." This information is specifically needed to define "permissible land and water uses within the coastal zone which have a direct and significant impact upon the coastal waters."

To be useful for developing a coastal zone management program, an environmental impact methodology should meet the following criteria:

1) Objectivity: The Coastal Zone Management Act envisions a rational, technical planning process that is completed prior to decision-making. An environmental impact methodology should objectively identify environmental impacts; it should not evaluate the relative importance of the impacts or the desireability of one action over another.

2) Open-ended: Scientific information on the functions of coastal ecosystems is rapidly expanding. A methodology should not be limited by available information; instead, it should be flexible and open-ended so that new data can be incorporated as it becomes available.

3) Comprehensive: A methodology must be suitable for identifying the environmental impacts of a wide variety of existing and projected future uses. In addition, it should provide a framework for identifying the full range of environmental impacts.

An environmental impact assessment methodology for use during the development of a coastal zone management program is outlined below.

## Prerequisites for Environmental Impact Assessment

Environmental impact assessment is an important step in a total resource planning process. However, the usefulness and accuracy of the environmental impact assessment can be improved by the completion of special studies, such as a "Vulnerability Assessment" and a "Capability Analysis", before a detailed assessment is undertaken.

Vulnerability Assessment: Vulnerability, by definition, is the natural sensitivity or susceptibility of a resource system or resource feature to change. An assessment of vulnerability identifies the key forces which make the system function. For example, the beach system is "vulnerable" to any action which blocks the flow of sand from offshore sand bars. By identifying vulnerabilities for key coastal systems, a checklist for environmental impact assessment is provided.

Capability Analysis: Capability (carrying capacity) refers to the ability of a natural system or resource feature to support a particular use or activity, based upon the natural characteristics of the resource. Capability analysis begins with the resource and moves toward identifying activities which do not destroy the resource. Environmental impact assessment, on the other hand, begins with the proposed use and identifies the range of changes in the natural environments that are a consequence of the use.

Both of these types of analyses provide very useful background information for environmental impact assessment.

An important prerequisite of environmental impact assessment is the careful definition of uses or activities to be considered. It is well-known that a residential use will have different environmental impacts depending on its specific location, method of construction, type of septic or sewer system, size of house and yard, etc. If general classes of uses are being considered, as opposed to a specific project, assumptions about the nature of the class of uses being considered must be carefully stated.

## A Method for Environmental Impact Assessment

A method for identifying the environmental impact of existing and proposed uses on Georgia's coast is outlined schematically on Figure 1. The methodology links proposed uses with actions which affect natural conditions (step 1). Actions are in turn linked to resource system impacts (step 2) and resource feature impacts (step 3). The impacts of the actions on the resource systems and resource features combined, determine the total environmental impact of the use. As noted previously, the transition from actions to impacts on the environment can be greatly facilitated by advance analysis of resource vulnerabilities and resource capabilities.

This methodology is most accurately applied when a specific project or activity which can be analyzed in detail is proposed. However, to provide a comprehensive overview, major steps in the methodology have been completed for a range of uses and activities. Matrix #1 summarizes the relationship of uses or activities to actions affecting natural conditions (actions are defined on the attached page). Matrix #2 summarizes the impact of the particular action on the resource vulnerability. Finally, Matrix #3 identifies the relationship of various maps of resource features with natural system vulnerabilities. Matrix #3 facilitates the use of resource feature maps in conjunction with scientific information on resource vulnerability.

Capability analysis is in a box with a dotted line on the environmental impact methodology to indicate that it has not been completed during the first year coastal zone management program. The general overview of potential environmental impacts provided by Matrix #2 provides useful information for a capability analysis. The capability analysis, in turn, will provide further information on which environmental impact assessment can be used. The double-direction arrows indicate these inter-relationships.

## Uses of the Environmental Impact Methodology

The environmental impact methodology as described above can be used in several different ways. Most effectively, it can be used as a "checklist" for assessing the impacts of alternative projects for which detailed information is known. In such cases, the matrices should be used without any "answers" filled in. The categories listed on the matrices encourage the analyst to consider the full range of actions that may be linked with a particular activity, as well as the full range of resource vulnerabilities and maps.

The completed matrices are useful for showing the generalized relationships of uses to environmental impacts. Such matrices must be used with caution, however, since certain generalizations and assumptions about the proposed use are made before the matrix is completed. Also, as shown on Matrix #2, the impacts of a particular use and related actions vary with the performance of various systems, structures and activities. When fertilizers are used in proper amounts at the right time of the year, for example, they may have no effect on groundwater systems. On the other hand, if improperly used, the impacts may be significant. Knowledge of the generalized relationships between uses and the natural environment, in turn, may be used to formulate general coastal zone policy and programs.

Finally, the environmental impact methodology is useful as an educational tool. The method poses questions which in turn stimulate consideration of the broad range of potential environmental changes resulting from a project. What is the type of activity being proposed? How will it function after construction? What uses are related to the proposed use? What are the important natural resource aspects that should be considered? The exercise of "running through" the matrix stimulates discussion and understanding of the inter-relationships between uses and natural systems.

The methodology outlined here does not evaluate or compare the various environmental impacts with each other to determine if a use is appropriate for a particular location. In order to complete such an evaluation, information about the contribution of the natural resources and systems to the public health, safety and welfare is needed (resource values). Any evaluation or judgment about the significance of environmental impacts should be made after the contributions and values of the natural systems in their natural state have been identified. In addition, evaluation is generally a process involving the incorporation of the views and personal values of many individuals. It is the responsibility of elected or appointed decision-makers to evaluate environmental impacts, based upon a full array of information, organized in an understandable fashion.

Until this methodology has been actually used for environmental impact assessment, it should be considered a preliminary method. It is expected that the actual application and use of the methodology will result in changes in the matrix categories as well as the relationships identified. In addition, further resource analysis, such as the capability analysis, will improve the accuracy and utility of the methodology.

BIBLIOGRAPHY

ENVIRONMENTAL IMPACT ASSESSMENT

Analyzing the Environmental Impacts of Water Projects, A report submitted to the U. S. Army Engineer Institute for Water Resources, edited by Leonard Ortolano, Stanford University, March, 1973.

Andrews, Richard N. L., "A Philosophy of Environmental Impact Assessment," Journal of Soil and Water Conservation, September-October, 1973, pp. 197-204.

Andrews, Richard N. L., "Approaches to Impact Assessment: Comparison and Critique," paper presented at the Short Courses on Impact Assessment in Water Resources Planning; Amherst, Massachusetts, May 11, 1973.

Andrews, Richard N. L., "Impact Statements and Impact Assessment," Keynote address presented to the Engineering Foundation Conference on "Preparation of Environmental Impact Statements," Henniker, New Hampshire, July 29, 1973.

Andrews, Richard N. L., "Summary: Methodologies and Techniques of Environmental Impact Analysis," The Institute of Man and Science, November 7, 1974.

Dee, Norbert, Janet Baker, Neil Drobny, Ken Duke, Ira Whitman and Dave Fahringer, "An Environmental Evaluation System for Water Resource Planning," Water Resources Research, Vol, 9, No. 3, June, 1973.

Enk, Gordon A., Beyond NEPA, Criteria for Environmental Impact Review, Institute of Man and Science, May, 1973.

Environmental Impact Assessment: Guidelines and Commentary, edited by Thomas G. Dickert, University Extension, University of California, Berkeley, 1974.

Institute of Ecology, University of Georgia, "Optimum Pathway Matrix Analysis Approach to the Environmental Decision-Making Process; Testcase: Relative Impact of Proposed Highway Alternatives," unpublished paper, 1971.

Jordan, James, "A Philosophy of Environmental Impact Assessment: Some Considerations for Implementation," Journal of Soil and Water Conservation, September-October, 1973, pp. 205-207.

Leopold, Luna B., Frank E. Clarke, Bruce B. Hanshaw, and James R. Balsley, "A Procedure for Evaluating Environmental Impact," U. S. Geological Circular 645, 1971 (13), special report.

Lyle, John and Mark von Wodtke, "An Information System for Environmental Planning," American Institute of Planners Journal, November, 1974, pp. 394-413.

Odum, Eugene P., Joseph C. Zieman, Herman H. Shugart, Gene A. Bramlett, Albert Ike, and James Champlin, "Totality Indices for Evaluating Environmental Impact: A Test Case - Relative Impact of Highway Alternates," March, 1973, unpublished paper.

Sorensen, Jens, C., A Framework for Identification and Control of Resource Degradation & Conflict in the Multiple Use of the Coastal Zone, Department of Landscape Architecture, University of California, June, 1971.

Sorensen, Jens, C., "Procedures and Programs to Assist in the Environmental Impact Statement Process," University of California, Berkeley, April, 1973.

Sorensen, Jen C., "Some Procedures and Programs for Environmental Impact Assessment," in Environmental Impact Analysis, Philosophy and Methods, edited by Robert B. Ditton and Thomas L. Goodale, Proceedings of the Conference on Environmental Impact Analysis, Green Bay, Wisconsin, January 4-5, 1972, Sea Grant Publication WIS-SG-72-111.

Vichl, Richard C., Jr., and Kenneth G. M. Mason, Environmental Impact Methodologies, An Annotated Bibliography, Council of Planning Librarians, Exchange Bibliography #691, November, 1974.

Warner, Maurice L., and Preston, Edward H., "A Review of Environmental Impact Methodologies," prepared for U. S. Environmental Protection Agency, April, 1974.

White, Gilbert F., "Environmental Impact Statement," reprint, Association of American Geographers, Annual Meeting, Kansas City, 1972.

Definitions (Cont'd)

STRUCTURES (Cont'd)

| | |
|---|---|
| Water Storage: | surface water impoundments. |
| Septic Tank/Tile Fields: | use of septic tanks for disposal of human wastes, utilizing tile fields in the ground. |
| Solid Waste: | the structure and operation of devices designed to dispose of hard or bulk refuse; i. e. a sanitary land fill operation. |
| Corridors: | construction of a linear communication link; i. e. highway, power line, gas or oil pipelines, etc. |
| Barriers: | an obstruction; i. e. a dam, soils compressed to the point that subsurface water movement is impaired, etc. |
| Shoreline Structures: | a physical component which reaches from the land into or over a water area; i. e. bridge, pier, groin, etc. |

USE/ACTIVITY

| | |
|---|---|
| Fertilization: | the application of chemical or organic nutrients to the soil in order to assure greater plant vigor. |
| Aesthetics: | Visual quality created by a certain use or activity. |
| Noise: | annoying sounds. |
| Cultivation/Harvesting: | to till or loosen the land in order to prepare it for crops. (cultivation) followed by the removal of crops or timber. |
| Grazing: | the feeding of cattle or livestock on a field crop. |
| Water or Air Discharges: | the placement of substances into the air or water as a byproduct of the activity. |

USE/ACTIVITY (Cont'd)

| | |
|---|---|
| Controlled Burning: | the act of burning surface litter in a cool fire for purposes of protection and management. |
| Chemical Control: | the application of chemicals designed to eliminate or control unwanted insects, animals or plants. |

* SOURCE: Many of these definitions are from "Michigan Natural Environment Survey, Survey Summary," prepared for State Planning Division by Johnson, Johnson & Roy, Inc., 1973.

## Appendix B

# COASTAL RESOURCE SYSTEMS

## SUMMARIES OF VALUES AND VULNERABILITIES

Information on the functions and vulnerabilities of coastal natural resources is an important element of the environmental impact methodology, as outlined in this paper. An understanding of coastal resource values and vulnerabilities, in turn, leads to appropriate resource management programs.

Values and vulnerabilities of coastal resources are summarized on the attached pages. These summaries are based upon existing information, especially background papers written by scientists and researchers for the Georgia Coastal Zone Management Program (see The Value and Vulnerability of Coastal Resources: Background Papers for Review and Discussion).

These summaries should be considered a beginning list to which additional scientific information can be added. This list, however, does include the most important values and vulnerabilities. A comprehensive environmental impact assessment can be undertaken, utilizing the vulnerability factors as a check list.

# COASTAL RESOURCE SYSTEMS

## SUMMARY OF VALUES

* The values of coastal resources (in their natural condition) to the public health, safety, and welfare, are the reasons why these natural systems should be conserved and used for activities which do not destroy the natural functioning. Some of the values of individual coastal resources apply to other coastal resources. Other values, especially those related to the unique functioning of a resource system, differ from system to system. These values are summarized below.

### VALUES COMMON TO MOST COASTAL ECOSYSTEMS

Education: Coastal resource systems are natural classrooms for teaching students and adults about the known functions and values of these systems. Many of the dynamic coastal systems can be used to demonstrate basic principles of ecology, including the relationship of man to his environment and the value of fluctuating water levels.

Research: Because of the public values and high productivity of coastal resources, they have been the subject of scientific research. This is especially true of coastal marshlands, where a twenty year data base has been developed. Scientific information on function, value and vulnerability of coastal resources, in turn, contributes to the development of sound resource management programs.

Scenic Beauty: Coastal resources in their natural condition have unique aesthetic and open space values. They provide scenic vistas that are enjoyed by the public in many different ways. People walk the beach, gaze over coastal marshlands and out-to-sea, and are entranced by the dense underbrush of river swamps and coastal islands. The beauty of natural systems in coastal Georgia is beyond description, and has been the subject of numerous national books and articles. The feeling of man and nature together is especially strong on the coastal barrier islands and at the edge of the mainland shore.

Recreation: Most coastal resources have important uses as recreation areas. The type of recreation and the particular demand varies among resource systems.

Wildlife Habitat: Many coastal resource systems are important habitats for fish and wildlife. The wildlife habitat is in turn important for recreation, education, research and aesthetics. The specific type of wildlife varies with different areas. Productivity of fresh water river swamps and coastal marshlands, island sloughs, and other areas, contribute to their value for wildlife, although the prime habitat of the fish and game species might be elsewhere.

Natural Buffer Against Storms and Flooding: Coastal islands, marshlands, river swamps, and beach systems are a natural buffer against storms and flooding. Although these areas have different functions, they often stop the force of ocean storms, and/or absorb excess quantities of water, holding the water until it is needed.

Nutrient Production: Several coastal resource systems produce quantities of nutrients from vegetable matter. This material (called detritus) in turn is important for maintaining fish and wildlife food chains. Coastal marshlands, especially, are known as one of the most productive systems on earth. Fresh water river swamps also produce quantities of nutrients.

# BEACHES, SAND DUNES AND OFFSHORE SAND BARS

## SUMMARY OF VALUES

Natural Buffer: The beach, offshore sand bar and sand dune system protects inland property and lives from storm surges. Areas where sand dunes have been destroyed suffer high damages and sometimes the loss of lives in major storms. The beach and offshore sand bars also buffer inland property and break the force of the waves.

Recreation: The beach, sand dune and offshore sand bar system creates an important recreational resource. Although the dry and nearshore beach is the main area used for sunbathing, swimming, picnicking, walking, etc., the sand dunes and offshore bars provide a natural source of sand for beach maintenance.

Wildlife Habitat: Although beaches, dunes and offshore sand bars are harsh environments for many types of wildlife, different species of plants and animals have learned to survive and use the beach and dune areas as their homes. Beach areas covered with water serve as the habitat for fish and crab which in turn attract plovers, sandpipers, gulls and other shore birds for feeding. Dry beach areas provide nesting areas for the leggerhead turtle, an endangered animal. Two of the six largest loggerhead turtle rookeries of the Atlantic coast are found on Georgia's barrier islands. Moles, marsh rabbits, and other wildlife frequent the upper dune areas.

Nutrient Production: Nutrients washed onto the beach are decomposed by bacteria in the sand and again washed out to sea. In this way they form part of the food chain, supporting ocean fish and shellfish.

# COASTAL BARRIER ISLANDS

## SUMMARY OF VALUES

Uniqueness: Each barrier island of coastal Georgia is a unique natural area, as well as being part of a total system of barrier islands. A number of unique forest associations are found on the islands, such as a large stand of myrtle oak (Cumberland and Little Cumberland Island) and Carolina laurel-cherry (growing on a tiny island in Cumberland salt marsh, the most northerly representative of the species and the only known specimen in the State). Unique wildlife types include the Cumberland Island pocket gopher, the Anastasia Island cotton mouse, the St. Simons Island raccoon and the Blackbeard Island deer. Some of these unique types have developed as a result of the insularity of the island which permits the development of new forms.

The character and use of each coastal island is also unique. This results from variations in size, geology, flora and fauna, and man's use of the islands, both past and present. The islands have been used by prehistoric man, the Guale Indians, Spanish missionaries, and colonial settlers, among others. Many of the islands are owned or controlled by single governmental agencies or individuals, or groups of owners who have agreed on a common purpose.

Wildlife Habitat: Coastal barrier islands which are not connected to the mainland have special value as wildlife habitat because of their insularity. They provide excellent habitat for species that need space to roam, and which need fresh water areas (island sloughs). Island sloughs are especially important for wildlife, since they provide food and water for island animals. In order to protect certain islands for wildlife habitat, national and state wildlife refuges have been established.

Recreation: Because coastal islands are complete ecological units, containing island sloughs, upland forests, sand dunes, beaches, and marshlands, they are especially suited for environmental education and field trips.

Scenic Beauty: A visitor to a barrier island off the Georgia coast must leave behind the "normal" world of cities, cars, and tensions. The uniqueness of the islands, combined with this feeling of separation have very special qualities. This is one important reason for the term "Golden Isles of Georgia." The quiet and beauty of the coastal islands is of special value.

Natural Buffer: Coastal islands are natural buffer between the force of the open ocean and the mainland shore. Together with coastal marshlands, they break the force of waves and protect mainland areas from erosion.

## COASTAL MARSHLANDS

## SUMMARY OF VALUES

<u>Nutrient Production:</u> Georgia's coastal marshlands are an essential life support system for a multi-million dollar seafood industry. In 1973, the dockside value of fish and shellfish landed in Georgia totaled more than 10 million dollars. The Georgia catch in turn contributes to the seafood processin gindustry, which produced 34 million dollars in processed products in 1970.

Coastal marshlands, sounds and the nearshore ocean environment in Georgia produce more food energy than any estuarine zone on the eastern seaboard. They are one of the most naturally fertile landscapes in the world. One acre of tall <u>Spartina alterniflora</u> grass at the streamside produces 17.8 tons annually.

Marshes also export food into deep waters of the ocean to shrimp and other species that spend earlier portions of their life cycle in the marsh. These exported nutrients also support fish and shellfish species that never come into the marsh itself.

<u>Wildlife Habitat:</u> Coastal marshlands serve as a nursery ground for growing juvenile fish and shellfish of sport and commercial value. The marshes also provide important hiding places and shelter for fish. They are a refuge for fur-bearing animals and waterfowl of significant sport and commercial value. Georgia is within the Atlantic Flyway of migratory waterfowl. Marshlands are feeding areas for certain species of these birds; and also contribute to the food chains which support waterfowl in nearby areas. Many species of waterfowl use areas within salt marshes as resting areas.

<u>Nutrient Recycling:</u> Marsh grasses and sediments act as both a sink and a pump, meaning that large amounts of nutrients that come into the estuary from either the sea or land are quickly stored and become available to organisms. Hence the estuarine system is an effective tertiary treatment plant for mineral nutrients from man's systems. When compared with the dollar cost of tertiary treatment plans constructed by man, the dollar value of the salt marsh is $50,000 per acre.

<u>Aquifer Protection:</u> Vital aquifers (water bearing rocks) which provide the primary source of water for coastal industry and residents underlie coastal marshlands. Protection of coastal marshlands in some cases also protects aquifers.

Recreation: Hunters, sport fishermen, boaters, photographers, and others come to Georgia's coast for recreational activities related to the salt marsh.

Research and Education: Because a twenty year data base on the functioning of coastal marshlands has been established, they are of special value for further research and education.

Natural Buffer: Coastal marshlands buffer mainland areas from the force of storm winds and tides by absorbing and hodling waters.

Scenic Beauty: Coastal marshlands are of incomparable scenic beauty. The charm and beauty of the salt marsh is a source of pride for all Georgia.

FRESH WATER RIVERS AND RIVER SWAMPS

SUMMARY OF VALUES

Wildlife Habitat: Coastal fresh water rivers and surrounding river swamps have important value for wildlife habitat. Species such as deer, raccoon, squirrel, bear, aquatic birds and many others frequent the rivers and rivers swamps. Young fish, tadpoles, insects and other organisms that form part of the food chain utilize sloughs and ponds in backwater areas of the river swamp. In effect, these areas function as nursery areas and areas of protection during spawning.

The stream channel itself is a dynamic biological community which supports many species. Bacteria, algae, higher aquatic plants, insects, fresh water snails and mussels all play important roles in the food chain. Snags, composed of dead trees and branches, are especially rich habitat for these invertebrate species. Without these links in the food chain, larger species could not survive.

Nutrient Production: River swamps produce nutrients from decaying leaves and other organic matter which accumulates on the forest floor. During periods of flooding, the nutrients are washed out of the swamp into the river channel where they support a food chain which in turn provides food for a variety of fish and wildlife. The pulsing of the fresh water rivers carries nutrients to the estuary and beyond, to offshore ocean waters.

Recreation: Rivers and river swamps are used for a variety of types of recreation, including hunting, nature study, photography, boating and canoeing. Georgia coastal rivers support many species of sport fish, including fresh water species (pickerel, catfish, sufish, crappie, and large mouth bass) and anadromous species (striped bass and shad). Other salt water species penetrate the river mouths to feed (such as mullet, spot, red drum, flounder, and others.)

Natural Buffer: River swamps provide a natural buffer to upland properties by absorbing the water from flooded streams. Although flooding beyond the boundary of the river swamp may occur during times of heavy rains, without the river swamp, flooding would be even more sever.

Education: Rivers and river swamps are an incomparable educational resource. A few hours spent collecting and studying a living ecosystem of a clear flowing river is an experience a study can remember for the rest of his life.

# OPEN MARINE AND ESTUARINE WATERS

## SUMMARY OF VALUES

Recreation: Open marine and estuarine waters have many recreational values, including boating, fishing and sightseeing. An untapped recreational resource in Georgia is offshore deepsea fishing. Many species of sport fish exist, and sport fishermen are rarely in competition with commercial fishermen.

Navigation and Waterborne Commerce: Open marine and estuarine waters are important natural waterways that support waterborne commerce activities. These navigation routes are also important to recreational boaters.

Wildlife Habitat: Marine and estuarine waters are important habitat for many species of fish and shellfish of commercial and sport value. The fish in turn provide food for feeding birds and larger animals, such as dolphins and whales. The commercial shrimp and crab fishery in Georgia is especially important to the coastal economy. The major fishing grounds are the large sounds and inshore waters.

## GROUND WATER CONDITIONS

### SUMMARY OF VALUES

<u>Source of Fresh Water for Drinking</u>: Ground water (from the principal artesian aquifer) is the major source of drinking water in coastal Georgia. The water is pure enough in its natural condition for use with a minimum of treatment. The only quality restriction is the natural hardness of the water and occasionally a high sulfate content. Municipalities are required to chlorinate the water before distribution, even though the ground water does not naturally contain bacteria.

<u>Source of Fresh Water for Industry</u>: Ground water from the principal artesian aquifer provides an abundant source of water for industrial use. The high quality of the water is especially attractive to industry, since it lowers treatment costs. In addition, large quantities of water can be pumped from a single well. This allows plant location selection on the basis of factors other than proximity to a source of surface water, such as a river.

## BEACHES, SAND DUNES AND OFFSHORE SAND BARS

### SUMMARY OF VULNERABILITIES

(based on background paper by Dr. George F. Oertel, Skidaway Institute of Oceanography)

### BARRIER AGAINST HIGH ENERGY STORM WAVES

Function: Offshore shoals and bars are the initial barrier to high energy storm waves. The second barrier to the high energy storm waves is the beach itself. Finally, during large storm surges, sand dunes often function as the last barrier to the sea. This last barrier also redirects the energy of storm waves in an offshore direction or in an alongshore direction. Together, the system functions to protect property and lives of persons landward of the beach.

Vulnerability: Alteration or destruction of offshore sand bars, the beaches or sand dunes (or alteration of vegetation or straw mounds that encourage dune formation and stability).

Actions which have impact: Leveling and grading of sand dunes; road cuts; removal of sand from beach system; dredging of offshore bars to the extent that the function of the bar is significantly altered; incorrectly designed seawalls or groins.

### ENERGY DISSIPATION

Function: The dunes, beaches and offshore bars dissipate wave energy as waves move landward. The transfer of wave energy from the wave to the bar produces a temporary suspension of sediments and a redistribution of sediment over the surface of the bar. This redistributed sediment in turn is often transported in a landward direction, thus producing a landward displacement of the bar. The dissipation of energy also protects shorelines for erosion during storms. The beach is the second zone of dissipation of wave energy. During very large storms, dunes serve this function as well. The rerouting of water through the intricate maze of foredunes further slows the speed of the water and dissipates the eroding ability of the waves. The energy dissipation function also protects inland areas.

Vulnerability: Alteration or destruction of offshore sand bars, beaches or sand dunes. (Or alteration of vegetation or straw mounds that encourage dune formation and stability).

Actions which have impact: Leveling and grading of sand dunes; road cuts; removal of sand from beach system; dredging of offshore bars to the extent that the function of the bar is significantly altered; incorrectly designed seawalls or groins.

SAND SHARING SYSTEM

Function: The dunes, beaches and offshore shoals and bars together maintain a sediment budget that determines the stability of the shoreline. During low energy conditions, offshore bars migrate landward until they reach the beach or dune areas. During storm conditions, the beach face erodes and a portion of the sediments from beaches and dunes may be transported seaward toward the offshore bars. This redistribution of sediment of "sharing" is necessary to maintain shoreline stability.

Vulnerability: Removal of sand from the sediment budget or blockage of the flow of sand between offshore bars, the beach, or sand dunes.

Actions which have impact: Construction of seawalls, bulkheads or groins in such a manner that the sand sharing system is altered. Leveling of sand dunes, or excessive dredging of sand from offshore bars may also have this impact.

## COASTAL BARRIER ISLANDS

## SUMMARY OF VULNERABILITIES

(based upon background paper by Mr. James R. Richardson and Mrs. Joanne S. Worthington, University of Georgia)

### SOILS - (litter and nutrient cycling)

Function: Soil litter reduces leaching in upper soil layers by dissipating the force of rain. Litter provides most of the nutrient exchange capacity in island soil.

Vulnerability: Destruction or removal of litter layer.

Actions which have impact: Intense fire; grading; destruction of vegetation and/or hydrologic cycle; sewage disposal; agricultural practice; landscaping.

### WATER TABLE

Function: Provides major source of water supporting plants and animals in natural island ecosystem; recharged by rain which enters the ground water; functions as a "fresh water lens", maintaining balance between groundwater and surrounding estuarine waters. Uninterrupted permeability to a depth 40 times its height needed. Prevents salt water intrusion; induces lateral flow of fresh water to ocean.

Vulnerability: Reduction in depth of water table; reduction in soil permeability; contamination.

Actions which have impact: Draining of surface water through channels; ground cover that excludes rain; intense fire which alters permeability of soils; improper septic tanks or sewage disposal systems; excessive use of fertilizers.

### SALT SPRAY

Function: Provides major source of mineral nutrients (in airborne salt) to an area 1,000 meters from the surf line. Creates smooth, dense forest canopy which is shaped like an airfoil, hence protecting other foliage from winds and salt.

Vulnerability: Alteration of salt distribution profile; destruction of salt tolerant vegetation.

Actions which have impact: Construction of barriers to the salt spray; destruction of salt tolerant vegetation, especially forest canopy; alteration of offshore sand bars and shoals which influence wave energy.

UNIQUE PLANTS AND ANIMALS

Function: Due to insularity of islands, unique forms of plants and animals have developed (such as Cumberland Island Pocket Gopher, Anastasia cotton mouse, St. Simons Island raccoon, Blackbeard Island deer; myrtle oak on Cumberland and Little Cumberland Islands, Carolina Laurel on Cumberland Island).

Vulnerability: Intrusion of new species; alteration of coastal island ecosystem which supports wildlife.

Actions which have impact: Construction of bridges to mainland; importation of species; alteration of soils, vegetation, and hydrologic/nutrient cycles of islands. Impact of specific actions varies with the type of wildlife.

ISLAND SLOUGHS

Function: Island ponds and sloughs serve as nutrient traps essential in the food chain; create habitat diversity for wildlife; also resting and feeding areas. The fluctuating water level of the slough stimulates breeding of wildlife and acts as a nutrient pump. Salinity fluxes interrupt the succession of plant life, stimulating nutrient turnover and maintaining open-water systems; salt water flux allows fish to come in.

Vulnerability: Filling or draining of slough; stabilization of water levels or blocking of natural channels.

Actions which have impact: Filling, draining, channelization, blockage of paths between estuary and certain sloughs.

BEACHES AND SAND DUNES (ecological aspects)

Function: Through dynamic sand-sharing system, the beach/sand dune system provides a buffer between inland areas of the island and the sea; provides nesting areas for shore birds and loggerhead turtles; feeding areas for shore birds. Exposed vegetation on sand dune catches sand; roots hold sand in place.

Vulnerability: Destruction of sand dunes and vegetation on sand dunes; interruption of sand sharing system, (both between dune and beach and offshore area).

Actions which have impact: Leveling of dunes; construction of structures blocking movement of sand; trampling, picking or other destruction of sand dune vegetation and roots.

FRESH WATER RIVERS AND RIVER SWAMPS

SUMMARY OF VULNERABILITIES

(based on background paper by Dr. David Gillespie, Georgia Institute of Technology)

## PERIODIC FLOODING

Function: At periodic intervals during the year, fresh water rivers overflow their banks and flood the surrounding river swamp and flood plain. The flood waters pick up organic detritus (dead leaves, bark and other particulate matter lying on the forest floor) and sweep it into the main channel. River swamps are probably the most important single source of energy for the aquatic ecosystem. Detritus is attacked and broken down by aquatic bacteria and fungi, which in turn are consumed by aquatic insects and other invertebrates either on the bottom or after being filtered from the moving water. These invertebrates are then fed upon by larger animals.

Vulnerability: Blockage of natural flooding passageways of the river, the timing of the flooding, or critical links in the food chain.

Actions which have impact: Construction of dams or dikes that block the natural flow of the water; construction of channels that divert the natural flow or alter the periodicity and timing of flood periods.

## SLOUGHS AND RIVER SWAMP LAKES

Function: By trapping water when flooding receeds, river swamp lakes often develop a rich flora and fauna and supply plankton and other organisms to the river during high water. Lakes and sloughs are important as nursery and spawning grounds for many river fishes. Many species of both fish and invertebrates are dependent upon these confined, backwater and swamp environments for habitat and survival.

Vulnerability: Draining of sloughs and backwater lakes, or alteration of flooding patterns that periodically link these isolated areas with the main river channel.

Actions which have impact: Channelization of streams to alter flooding patterns; construction of dams and dikes; filling of river swamp lakes and sloughs.

## COASTAL MARSHLANDS

### SUMMARY OF VULNERABILITIES

(based on Chapter IV, "The Marshes," from An Ecological Survey of the Coastal Region of Georgia, A Report to the National Park Service, by A. S. Johnson, H. O. Hillestad, S. A. Fanning, and G. F. Shanholtzer, August, 1971)

#### TIDAL EBB AND FLOW

Function: The tidal pulse is the basic heartbeat of the marshland system. Twice daily the tide waters carry essential nutrients into the marsh grasses and export detritus and organic matter. By flushing suspended sediments over the marsh grasses, the tide enables the marsh to function as a sediment trap, protecting water quality and protecting upland areas from erosion. Flooding of marshes increases phytoplankton production 4-5 times by exposing more surface area to the light. The tidal ebb and flow is the most important factor influencing the primary productivity of the marshlands.

Vulnerability: Blockage of marshlands from the ebb and flow of the tide.

Actions which have impact: Filling marshlands, construction of dikes, seawalls and other structures.

#### PRODUCTIVE VEGETATION

Function: Marshland vegetation, which in Georgia includes a number of types of Spartina, Juncus, and numerous other salt-tolerant grasses, produces much organic matter and other food energy important in the food chain. Some species of animals graze off the marshland grasses; others (including the majority of fish and shellfish in estuarine waters of Georgia) depend in some way upon the organic matter (detritus) produced by the dead stalks and leaves. The vegetation also serves to slow the force of storm wind and waves, hence protecting upland areas from floods and erosion. Many species of fish and shellfish utilize marshland areas as breeding, nursery grounds, or for protection from predators.

Vulnerability: Marshland vegetation is especially vulnerable to alterations of salinity and alterations of the ebb and flow of the tide.

Actions which have impact: Dredging and filling activities which eliminate areas of vegetation; changes in upland drainage or hydrology patterns which alter the flow of freshwater to the estuarine system; construction of dikes, seawalls, and other structures that block the tides.

FLOW OF FRESH WATER TO ESTUARY

Function: The inflow of fresh water to the estuary affects the estuary by carrying dissolved and particulate matter, and by diluting the saltwater at periodic intervals. This inflow in turn affects the estuarine environment and its value as fish and shellfish feeding, nursery and spawning areas. The estuarine ecosystem depends upon a regular, but periodically varying, supply of fresh water from the coastal rivers.

Vulnerability: Alteration or disruption of the inflow of fresh water to the brackish water estuary.

Actions which have impact: Upstream dikes, dams and channels which alter the natural flooding pulse and flow. Alteràtion of river swamp soils and vegetation which absorb the flood waters.

SUPPORT OF FILTER-FEEDERS

Function: "Filter-feeder" invertebrates are a critical link in the aquatic ecosystem and food chain that help maintain a rich and diverse aquatic community. The tiny filter-feeding insects and crustaceans trap bacteria and detritus carried by the stream (they are often found in thick abundance on river-side snags and branches). These invertebrates are in turn consumed by fish and other species. Some small filter-feeders also purify water that has been polluted.

Vulnerability: Destruction of habitat, especially stream banks and snags; alteration of flooding patterns which provide detritus and organic matter to the river system.

Actions which have impact: Channelization or alteration of stream channel; clearing of dead branches: alteration of river swamp through dredging or filling.

## OPEN MARINE AND ESTUARINE WATERS

### SUMMARY OF VULNERABILITIES

(based on Chapter V, "The Open Marine and Estuarine Waters," from An Ecological Survey of the Coastal Region of Georgia, A Report to the National Park Service, by A. S. Johnson, H. O. Hillestad, S. A. Fanning, and G. F. Shanholtzer, August, 1971)

### WATER CIRCULATION PATTERNS

Function: Interacting forces produce a complicated circulation pattern that determine the distribution of sediments, nutrients, oxygen, temperation, salinity, food, etc. Ocean currents are produced by wind (wind currents), gravity (tidal currents) and differences in the density of the water strata (Gulf Stream).

Vulnerability: Alteration of pattern of currents, especially through blocking of current flows and forces.

Actions which have impact: Construction of stationary structures in offshore waters (such as oil drilling and mining rigs, deepwater ports, etc.); construction of dikes or other structures across tidal creeks.

### FLOW OF NUTRIENTS AND ORGANIC MATTER FROM MARSHLANDS AND RIVERS

Function: The turbidity and productivity of marine and estuarine waters is a result of nutrients flowing from marshlands and rivers. Carbon, nitrogen and phosphorus, for example, are necessary for primary production. Estuarine waters, rich in phosphorus, are flushed into offshore waters where the material serves as a nutrient source for phytoplankton. Vitamin $B_{12}$, for example, is a nutrient essential for the growth of many organisms, such as bacteria, algae, and protozoa. High concentrations of some of these nutrients are found in dark-water rivers, especially at the head of tidal creeks. Organic material that contributes to the turbidity of estuarine and marine waters is exported from marshlands.

Vulnerability: Alteration in the pattern of nutrient flow from marshlands and rivers to marine and estuarine waters.

Actions which have impact: Alteration in marshland and riverswamp productivity (especially in production of organic matter); alteration in water circulation patterns which distribute the organic matter and nutrients (such as dikes, dams and channels); alteration in the volume and time period at which fresh water dilutes salt water.

WATER QUALITY

Function: Maintenance of water quality is important for many coastal activities, such as fishing and recreation, as well as for health and safety reasons. Although marshlands naturally assimilate certain wastes, the quality of the water is directly related to point and non-point sources of pollution.

Vulnerability: Pollution of water quality below health and environmental standards.

Actions which have impact: Non-point source pollution from urban development, agriculture, and wildlife; point source pollution from septic tanks, municipal and industrial outfalls; oil spills and other contamination of the water.

PULSE OF FRESH WATER ON SALT WATER AREAS

Function: Fresh water rivers carry mineral nutrients from inland areas to coastal and near-shore marine ecosystems. Estuaries tend to concentrate these nutrients and organic matter and to export them to waters further offshore. The flushing action of fresh water rivers which flows through the estuaries thus plays an important role in offshore productivity. In addition, the periodic pulse of the fresh water (due to varying discharges during the course of the year) which dilutes the estuarine area in differing degrees is intricately connected with the ecology and wildlife patterns of the area.

Vulnerability: Alteration of pulse of fresh water to salt water areas, such as alteration of quantity or rate of flow.

Actions which have impact: Construction of dams, channels or other structures in fresh water rivers which alter the flow patterns.

GROUND WATER

SUMMARY OF VULNERABILITIES

(based on background paper by Mr. David E. Swanson, Earth and Water Division, Department of Natural Resources)

BRACKISH WATER ENCROACHMENT

Function: The principal artesian aquifer provides the major source of fresh water to residents and industry. However, in the Brunswick area breaches have occurred which allow brackish water from strata below the principal artesian aquifer to move upward and into the fresh water of the aquifer.

Brackish water encroachment is a potential problem in Savannah as well, although for different geologic reasons. Deeper portions of the principal artesian aquifer north and east of Savannah contain water which is brackish.

Both problem areas are affected by the amount, location and rate of pumping of fresh water. Large quantities of pumpage, especially, affect the quality of the principal artesian aquifer.

Vulnerability: The rate, location and volume of pumpage from the principal artesian aquifer in areas of existing or potential brackish water encroachment affects this resource.

Actions which have impact: Industrial or municipal fresh water pumpage in certain places (in large quantity).