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IDENTIFICATION AND EVALUATION OF COASTAL RESOURCE PATTERNS IN FLORIDA

Florida Coastal Coordinating Council

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Pilot study in the coastal zone of
Lee, DeSoto, and Charlotte Counties

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I. ABSTRACT

The following is a report describing a method of procedural steps and examples for classification of coastal areas for purposes of regional land/water use evaluation, planning and management, with a demonstration of its application in the coastal areas of Charlotte, Desoto, and Lee Counties. The report includes a summary of our concepts and criteria and a statement of procedures for making a map of resource subsystems, for preparing maps analyzing the hydrological system and subsystems, for identifying important factors and interactions within and between subsystems, and for locating sensitivities in order to guide planning, protective actions, and other measures for maximizing values. Our classifications include: subsystems of the natural environments on land, subsystems of the natural environments in the bordering seas, subsystems of the urban areas, subsystems of the agricultural areas, and the network of water flows that is common and critical to all the other systems. In our description of the procedure that one uses to make interpretations and evaluations, we include examples of regional maps with a mosaic of subsystems, examples of energy network diagrams for the subsystems matrices of man-system impact interactions that follows from the network diagrams, and examples of the kind of observations which may be made about a resource system which has thus been characterized. Our hydrological study includes consideration of slope, surface permeability, surface runoff, potentiometric head, and storm tides, on a regional scale. Finally, we indicate by what criteria the various subsystems may be evaluated for planning purposes and make tentative gross term suggestions in respect to planning and control measures in the coastal zone.

II. INTRODUCTION

This study deals with a problem well known to many: Florida's coastal zone is subject to rapid exploitation in a manner often disrespectful of certain societal interests, such as the needs for long range stability and survival. Many known that waters are being polluted, water resources are being depleted, wildlife is diminishing, and that certain landscapes are disappearing. But few understand the structure and magnitude of these problems; our economy, welfare, and survival are at stake. This study illuminates certain potential values, interactions and sensitivities of the existing coastal resources, in order that their true significance to society can be understood and duly considered.

The ultimate purpose of this research project is to help render practically useful knowledge for wise societal planning and decision making, particularly in respect to the state's natural resources in the coastal zone. Such decisions need to be based on comprehensive and specific understanding of the problems and their potential solutions: In addition to measures of the values of existing resources, to which knowledge this project contributes, knowledge is also required in respect to the future values of such resources, plus knowledge of the values of the combined natural and man-made systems that would result from an analysis of a representative sample of the full spectrum of possible alternative use patterns projected into the future. Subsequent research projects may provide this additional knowledge.

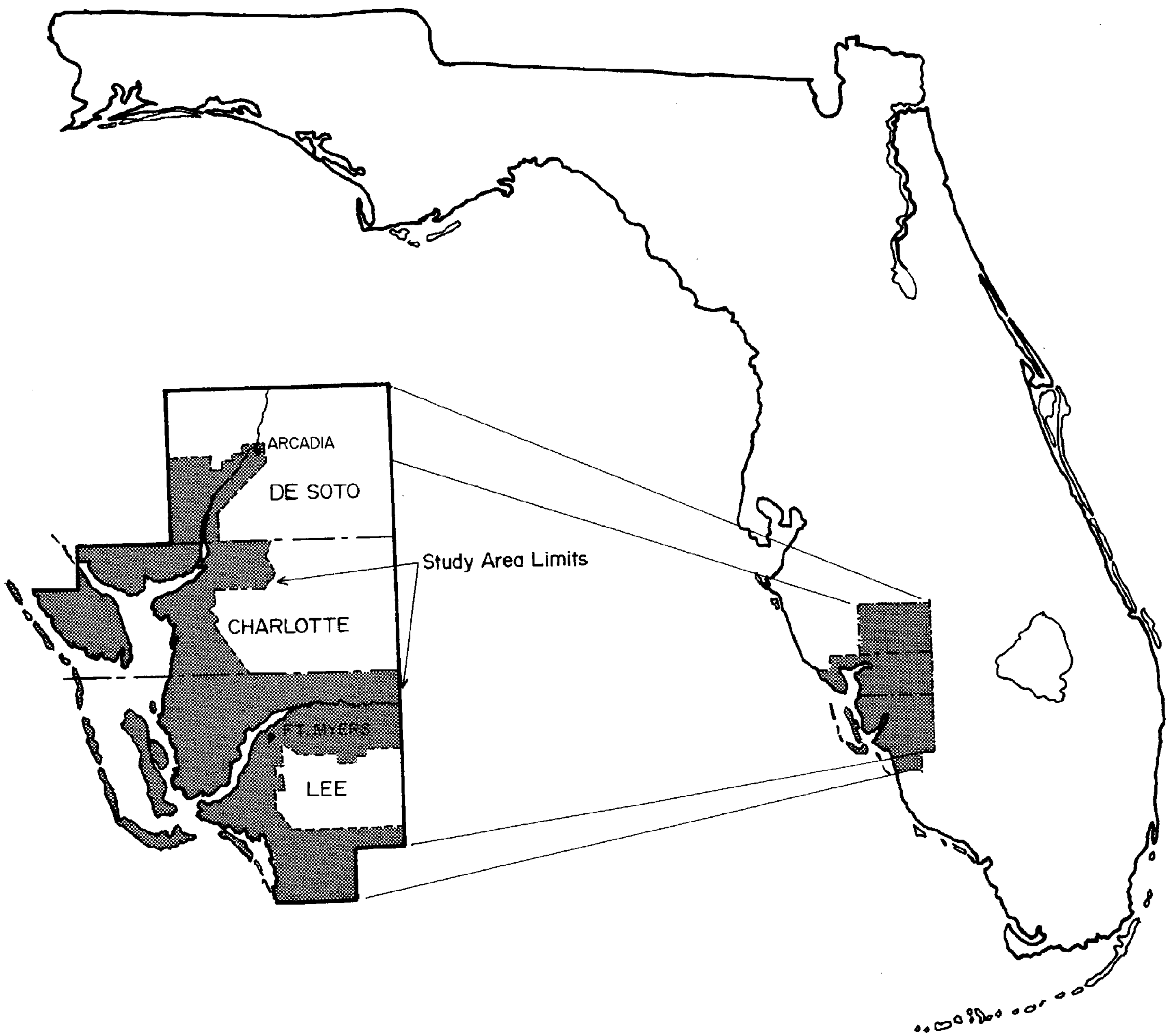
This study has developed a procedure for land/water resource classification and evaluation for planning purposes. This procedure is divided into three stages:

1. Collection of area maps and aerial photographs, identification of subsystem types, and preparation of maps delineating these subsystems; this stage may be accomplished by para-professional personnel.
2. Preparation of energy network diagrams and matrix diagrams of the subsystems and the regional system, and evaluation of these diagrams to determine the values and sensitivities of the systems; this stage must be executed by a specialist in this technique.
3. Identification of areas requiring various protection measures; this stage requires professional knowledge in environmental design.

In order that district planning offices may consider this method in relation to their own region and initiate the required work, this study contains instructions to complete the first stage, examples of the diagrams and evaluations that are to be completed in the second stage, and suggestions as to how the evaluations may be used to guide decision making in the third stage.

Our method is illustrated through application to the coastal zone of Lee, Charlotte and DeSoto Counties. This study area is shown in Figure 1.

Figure 1: Study Area Map



III. GENERAL CONCEPTS AND CRITERIA FOR EVALUATION OF COASTAL RESOURCES

A. CONCEPTUAL APPROACH

In order to make knowledgeable decisions regarding the future use of a region, one needs to have articulate measures of the societal values of a representative sample of the full spectrum of potential use patterns. Near one end of this use spectrum is "non-development"; near the other is "intensive development". The societal value is a highly complex composite of the interests of all affected people, which includes living and future generations, the local landowners, the developers, the local residents, the state, the country, and the world. This value includes both direct effects on man and his economy and indirect effects via the various parts of the world's life support system. A decision to restrain development enterprise through protective measures would issue from knowledge that such enterprise would result in a use pattern consisting of a combination of natural and man-made systems having a lower net societal value than other potential patterns (including non-development dominated patterns). The highest societal value should be the ultimate criterion for determining what protection measures are needed.

It follows that, the more valuable an existing pattern is, the more likely it is to merit protection. It also follows that, the more sensitive to disturbance from development intrusions an existing system is, or the rarer a system is, the more likely it is to merit protection. And it follows that, due to the intricate and essential interdependence between the various subsystems, and desired protection effort must have sufficient breadth to have the intended effect. These observations constitute the bases for our most important protection criteria recommendations.

However, it also follows that these observations are not conclusive. Even existing resource patterns of relatively low value or low sensitivity may warrant protection from relatively lower value developments. By the same measure, a new pattern of relatively high value development may merit displacement of a relatively high value existing resource pattern.

Obtaining the knowledge of sufficient breadth and depth to make knowledgeable environmental planning decisions requires extensive analysis of the values of all possible use patterns. Such thorough investigation is not possible currently but clearly warranted when major environmental decisions are to be made, and through appropriate research, methods may be developed, increasing the efficiency and warrant of such investigations. Short of this, we can use models that organize our available knowledge and our uncertainties.

This project contributes to the understanding of the values, sensitivities and interdependence of the coastal resource systems which knowledge can be used both to complete the understanding and methods ultimately required for truly knowledgeable decisions, and to provide a preliminary basis for certain urgently needed governmental (state) protection measures.

In order to assess the values, sensitivities and interdependence of the systems of the coastal resources, we first define, identify, and map the various natural ecological, hydrological and man-made systems. The natural and man-made systems are delimited on the basis of their visual legibility on aerial photographs and in the field, and/or their functional homogeneity and distinction from adjacent areas. Hydrologically, the study area is treated as one system.

The systems distinguished in this study are referred to either as resource systems or subsystems, depending on the context. The subsystems are systems in themselves, which indeed contain other subsystems, which are systems, etc. Analogously, the overall regional resource system, the coastal zone of DeSoto, Lee, and Charlotte counties, is also a subsystem of larger systems.

We then describe the processes of each subsystem by means of maps, energy diagrams and matrices. Our study incorporates energy diagrams for three subsystems: one marine, one natural terrestrial, and one man-made urban; and one matrice for the marine subsystem. Reference is made to other publications containing such information in respect to several other subsystems of the study area. (See Section IV.A.3, Diagramming Interactions)

With topologically and quantitatively complete energy network diagrams, showing both the pathways and amounts of energy flow, we can quantify system values, sensitivities and interdependences. With energy diagrams lacking quantitative energy flow data, we can demonstrate the principles of interdependence, and sometimes estimate values and sensitivities. The scope of this study permits inclusion of this step only in the form of estimates. On the basis of which by means of the general criteria described in the following section, we can gauge tentatively the need and warrant for protective measures.

B. GENERAL CRITERIA FOR DETERMINATION OF AREAS REQUIRING PROTECTION

The following general criteria are recommended for evaluation of resource systems for purposes of identification of those areas requiring protection from development. They are the criteria used in our evaluation of the subsystems defined in this study.

1. High Value in Existing State

Both natural ecosystems, and man-modified or man-made systems (eg. areas in natural state, farms or cities) may be evaluated in terms of annual work and as estimable replacement costs, the latter as the product of annual energies and replacement time. It may be helpful to consider this value as a composite of two types of values:

a: Values of indirect utility to man: This refers to work flows by natural systems on their own soils, vegetation and micro-climate, based on their contribution to productivity of biomatter as a common denominator. These work flows and storage values are measured in energy units.

b. Values of direct utility to man and paid for by money payments: This applies to man-made and aspects of man-modified systems, and, for areas in natural states, would apply to uses such as recreational, aesthetic, buffers, filters, aquifer recharge areas, etc. These can be measured in energy or money units.

These values are affected by the scarcity or abundance of the system being evaluated, not only within the study area: certain system classifications may, for example, be abundant in local context, but scarce in national or global context.

2. High Sensitivity to Intrusions

A system's sensitivity to intrusions may be evaluated in two respects:

a. Component sensitivity: This means that certain components of a system may be highly sensitive and quickly destroyed by certain intrusions while the system continues to function. These sensitivities are represented on energy network diagrams (Figures 8, 9a, 10) by the pathways, and in matrix diagrams (Figure 9b) by the intersections of system properties with development actions.

b. Overall system sensitivity: This refers to the ability of the system as a whole to endure stress from intrusions, and to function despite the possible loss of some components. The overall system's values are sensitive to interference or loss of energy pathways of interaction in which each type of subsystem serves the whole as a component. Our overall regional energy network model (Figure 16) shows what we know about this

3. High Value in Interdependence of the Systems

Although clearly distinguishable, none of the systems are independent. They are, in fact, often highly dependent upon each other, which means that protection of one system classification may require protection of one or many related system classifications. In the case of coastal resource planning, protective measures may need to extend inland far beyond the boundaries of the coastal zone.

With an overall energy model for the town or region that shows pathways of interaction among the resource subsystems, (Figure 16), the properties of interdependence can be objectively established, and each subsystem can be evaluated in gross terms for its effect on the regional system as a whole.

4. High Cost of Development and Maintenance

The ability (or inability) of an area to accommodate developments is a criterion which may warrant mention here. It is separate from the question of displaced natural values. Included here would be measures of the bearing capacity of the soil, susceptibility to flooding, etc. which contribute to high cost and/or maintenance of developments. Dependable measures for such characteristics can be objectively established.

Resource evaluations based on these criteria, may not by themselves lead to logical conclusions in repect to state resource protections. It would be necessary to develop and simulate models of potential developments, and compare the values of the new developments, (combined natural and man-made systems), with the values of the resource system prior to development; if a net loss would result, a development should be restrained through appropriate governmental (state) protections. The value of the combined system of the natural and man-made systems should be maximized.

It is possible, however, by means of the above recommended criteria, to discern certain tentative conclusions from evaluations of the existing resource patterns. The high value and high sensitivity ends of the value and sensitivity spectra tend to require strenuous governmental (state) protection, while the low value and low sensitivity ends of the spectra require less protection. Yet, due to the high degree of interdependence that exists in all areas of the state, both inside and outside the coastal zone, all areas are in need of governmental (state) protections to some degree. Our suggestions for protective measures are offered in the latter sections IV, C3 and 4 of this study.

IV. PROCEDURE FOR CLASSIFYING AND EVALUATING COASTAL RESOURCES FOR PLANNING

The procedure for the classification and evaluation of coastal resources occurs in three stages:

1. Information accumulation, subsystem identification, and mapping: Topological and navigational maps, and aerial photographs of the study area are acquired; hydrological data are collected; resource subsystems (natural man-modified, and urban) are defined, located geographically, and mapped; hydrological data are mapped. This stage can be performed by non-specialist personnel.

2. Diagramming and evaluation: Energy network diagrams and matrices are produced for the resource subsystems and the overall regional system, illustrating the interrelationships of system components and the impact of development intrusions; numerical values are determined for the energy flows; the diagrams are evaluated to determine the dollar values, sensitivities and interdependences of the systems; value spectra and sensitivity spectra are then produced from this information. This stage of diagramming and evaluation can only be accomplished by a specialist in this technique.

3. Employing evaluations in planning: The hydrological maps are colored (with a tone of gray for example) to illustrate those areas most likely to experience harm from developments; the evaluations of the resource subsystems (values, sensitivities, interdependence) can be used as guidelines to help determine which subsystems are most in need of protection from development, the degrees of need of protection can then be illustrated by tones of gray – the darkest gray indicating the greatest need or protection; an overlay of these two toned maps gives a regional composite, illustrating those areas which are in greatest need of protection, which will be darker. This stage requires professional knowledge in environmental design.

In order to aid those who want to apply this procedure to their regions, we illustrate the technique in our study area of Lee, Charlotte and DeSoto Counties.

A. COASTAL RESOURCE SUBSYSTEMS

The coastal resource subsystems, as defined in this study, are those natural and man-made elements of the land and water surface which are systems in themselves, have geographic limits, and can generally be identified by ground and aerial observation. Although they are functionally interdependent, they do not physically overlap.

The procedure for developing criteria for evaluating the land/water subsystems includes definition and identification, locations of the subsystems on maps, preparation of energy network and matrix diagrams, evaluation of the diagrams to determine sensitivities and values, and translation of this information into a form useful as a planning tool.

1. Definition and Identification of Subsystems

The subsystems of the land and water surface consist of the natural terrestrial systems the agricultural (or man-modified terrestrial) systems, the marine systems, and the urban (or man-made) systems.

This section contains descriptions of those subsystems found in the coastal zone of Lee, DeSoto, and Charlotte Counties. Sources of information for identifying other subsystems in the coastal zones of Florida can be found in the STEP-BY-STEP PROCEDURE, Section IV,D.

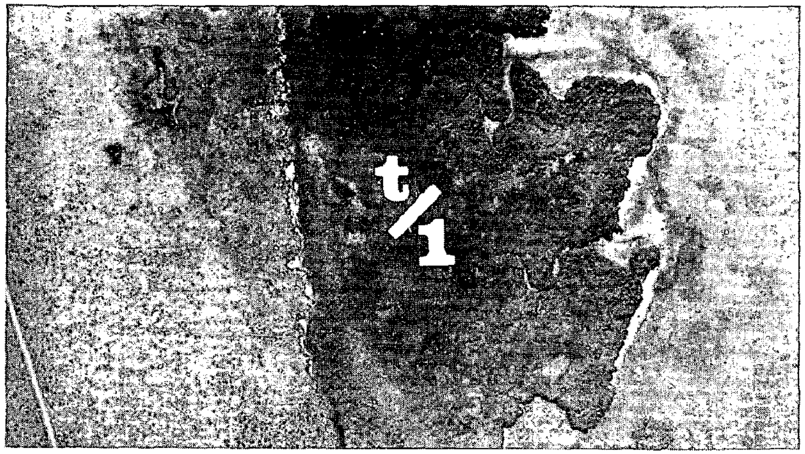
NATURAL TERRESTRIAL SUBSYSTEMS*

Our region of interest is composed of several distinct ecosystem types which are coupled together by the flows of energy and materials. The biotic components of these ecosystems reflect very closely the physical characteristics of the Florida landmass, which is generally extremely permeable and of low natural fertility. The biological effects of these two factors may be considered as environmental stresses, to which the biological assemblages of species, and the species themselves, are adapted. Stresses of this type are, in effect, limiting factors (e.g. water, nutrients, etc.), of which the year-round availability of water may be the most important on a regional basis. Thus, the ecosystems common to the study area may be described in terms of the availability of fresh water. This includes both the local water budgets and the overall heat balance as it relates to the evapotranspiration of water.

Following are descriptions of the natural terrestrial subsystems found in the Lee, Charlotte, DeSoto coastal zone.

*The following descriptions are based on information found in *Models for Planning and Research for the South Florida Environmental Study*, A. E. Lugo, S. C. Snedaker, S. Bayley, H. T. Odum, August 1971.

Figure 2a. MANGROVE



MANGROVES T/1

Mangrove ecosystems are found bordering much of the coastline around south Florida. These systems are marine-based forests which have special adaptations for roots growing in salt water and in anaerobic muds. Some species cleanly separate freshwater from salt, after which the fresh water is transpired through their leaves as part of the drive for the system. Their complex branching roots support a great diversity of marine animals and their crowns carry many terrestrial animals.

The apparent zonation of the mangrove species is related to the salinity of the water, tidal fluctuations, and contiguity to the upland areas. The red mangrove is found in the more uniformly saline waters, and the black mangroves in areas subjected to more extremes of low and high salinity, black mangroves may be observed further upstream in rivers than the red mangrove because of the lower salinity of the water.

Mangroves are very productive systems, but, the assimilated energy is not completely used with the mangrove systems themselves. The system returns to the water organic nutrients of certain types, producing specialized plankton, including those that cause luminescent and brown waters. Nutrients are then carried, in the form of detritus, in to the contiguous estuary, where they form a portion of the detrital foodweb supporting the estuarine fisheries.

Mangrove forests are used for forestry purposes, but may have higher value in sedimentation control, coastal hurricane protection, panorama, and as buffers.

The mangrove systems appear to be dependent upon freshwater inputs from the landmass, and a source of nutrients brought in by surface runoff, tides and currents. They are sensitive to alteration in current patterns which change the salinities of associated waters. Of particular concern is the effect of parallel drainage canals which preclude runoff of freshwater and nutrients from entering the landward edge of the system. Also, mangroves are sensitive to water borne pollutants and wastes which enter the system from the seaward side. Conversion of mangrove ecosystem sites to other uses not only destroys the integrity of the system, but also effects the fisheries which mangroves help to support.

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  9  500      Map appendix: p. [iii]-xl]. %
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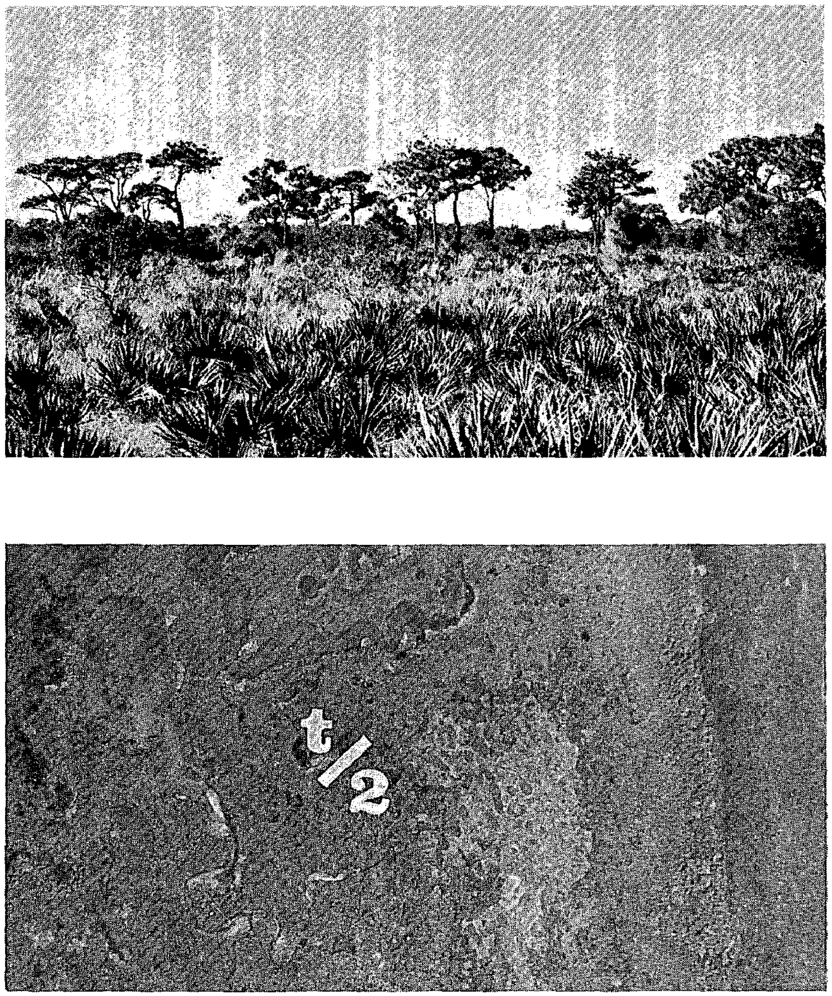
Figure 2b. SCRUB



SCRUB T/2

On the more elevated areas or in areas of deep, well-drained sands, one may find several distinct ecosystem types. One of the most unique is the *scrub*, named for its dry scrubby appearance. The dominant scrub species are adapted to prolonged periods of water stress and occasional fire. Althouth these areas receive as much rainfall as contiguous ecosystems, the permeable sands preclude significant water storage. The minimal amount of water, which is not immediately drained away after a rain, is eventually lost through evapotranspiration. Because fire and limited supplies of water and nutrients are so important to the maintenance of the unusual ecosystem type, the system is particularly sensitive to alterations in the intensity and/or frequency of fire and the availabilities of water and nutrients. Fire prevention, for instance, permits the buildup of organic fuels which increases the likelihood of a hot, devastating fire. The system is also adapted in various ways to maintain its nutrient storage by tight internal cycling, particularly in the decomposition of litter and the re-uptake of nutrients by roots. Thus, disturbance of the soil interferes with this process and ultimately may alter the composition and morphology of the systems.

Figure 2c. DUNE TRANSITION

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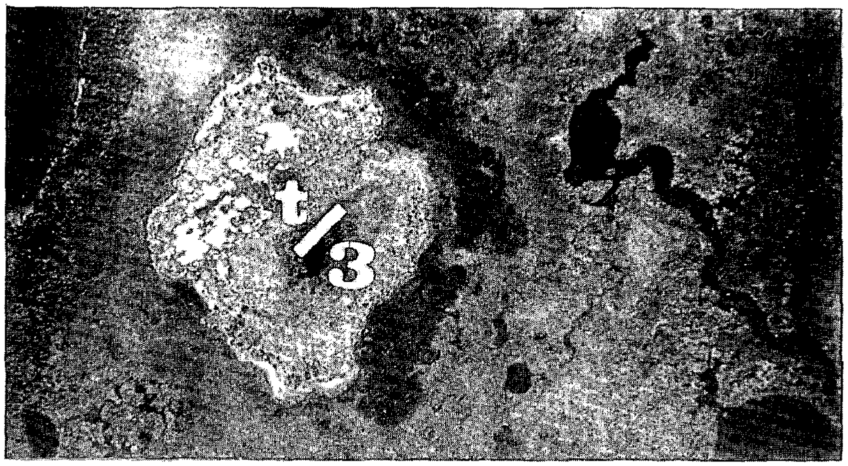
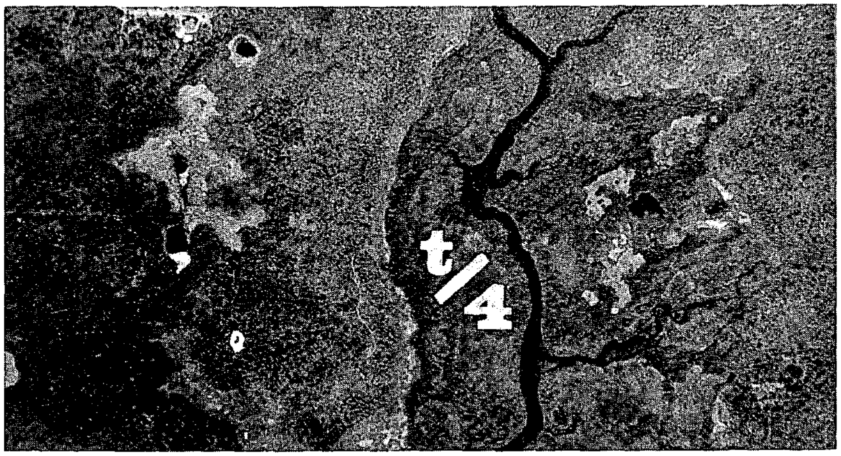


DUNE TRANSITION T/3

Ecosystems similar to scrub, because of the deep sand and poor water holding ability, are the transitional areas located between ecosystems adapted to haline conditions and those adapted to more upland conditions. These are areas easily recognized on aerial photos. The *dune transition ecosystems* exist in an environment which is subject to periodic inputs of sea salt. As such, they are not wholly adapted to estuarine conditions, as are mangroves and salt marshes in the traditional sense, or wholly adapted to a supply of only freshwater. The randomness of periodic salt stress produces an assemblage of species which can tolerate these unusual conditions. As a result, the systems are particularly sensitive to alterations in the periods of exposure to saline versus fresh water. The classical mounded dunes are also extremely sensitive to any physical disturbance which might cause wind or water erosion of the sand mound. Dune transitions, usually found between mangrove and upland systems, are sensitive to upland drainage, removal of the mangrove buffering effects and domestic and industrial waste products.

Figure 2d. HYDRIC HARDWOOD AND HAMMOCK



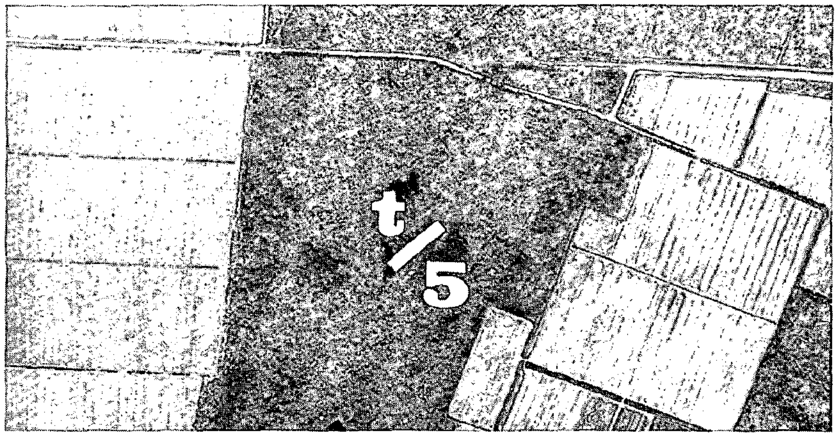
HYDRIC HARDWOOD AND HYDRIC HAMMOCK T/4

Not all of the regional landscape is subjected to stress due to water deficits, i.e., lack of freshwater. On the contrary, some areas are perpetually or frequently inundated by freshwater. Likewise the biological components of the ecosystems are adapted to wet conditions. Two of these subsystems in study area are hydric hardwood and hammock, and cypress domes and strands.

Hydric hardwood and hammock ecosystems are the most diverse of the terrestrial ecosystems, in both temperate and tropical species. As a system, these hammocks add to the overall diversity and stability of the regional ecosystem and are particularly attractive to man.

The hammock ecosystem represents a climax community maintained by the power sources: solar energy, rain, frost and coastal influences, such as salt spray during hurricanes. As long as the system's moisture level remains high, it is unaffected by fire. Frost and salt spray control the diversity of species indicated as populations of deciduous (temperate) and evergreen (tropical) species including the lianas and epiphytes. Adequate moisture, seed dispersal and germination, and the closed mineral cycles all serve to maintain the diversity and stability of the system.

Figure 2e. CYPRESS DOMES AND STRANDS



CYPRESS DOMES AND STRANDS T/5

Cypress ecosystems occur in those areas subjected either to flowing water or stillwaters, such as may be found in areas of perched water tables. Cypress ecosystems are distinct from *hydric* hardwood ecosystems that have other dominant species though in many areas they may be found integrating into one another. These "wet" ecosystems exhibit a greater organic production because, in addition to abundant water, they also receive nutrients in the runoff from other, more elevated systems. In a sense then, the limiting factors of water and nutrients are overridden.

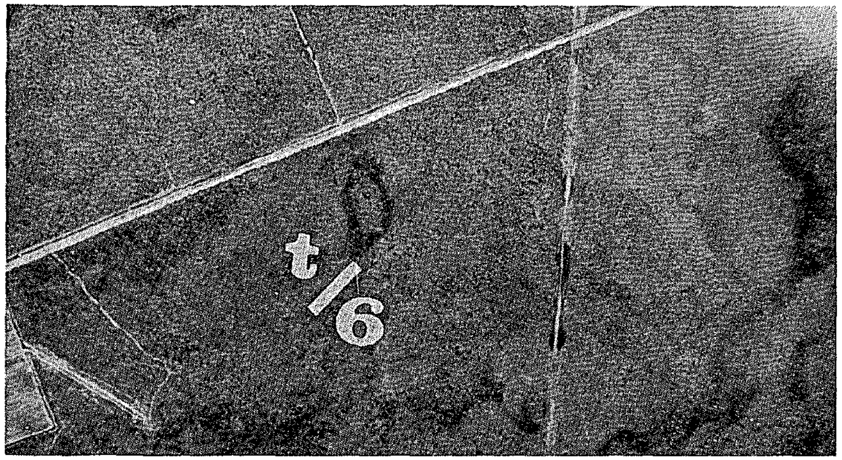
The main producers in this subsystem are cypress trees, aquatic plants, other component tree species, and many epiphytes and herbs. These producers provide both local and migratory wildlife with an abundant diversity of foods. These wildlife species are then shown to have specialized roles in the mineral cycles of the system. Also contributing to the nutrient pool are the decomposers which do work on the pool of dead organic matter and peat. The cypress trees are the dominant species and have interesting adaptations and interactions with the other components of the system. The cypress knees, for example, are presumed to contribute to high productivity by pumping oxygen into the roots (growing in anaerobic conditions) and therefore stimulate mineral and water movement through the trees. In addition, cypress trees are known to produce hydrocarbons and dissolved organic matter (such as tannic acid) which might be important to the system's energy economy.

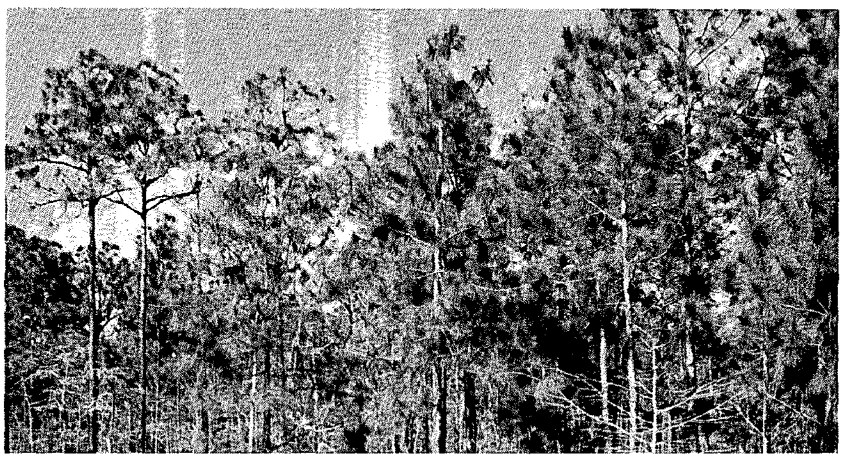
Peat, wildlife components, and the hydrocarbon-dust films are the export pathways to other systems. This emphasizes the coupling of the cypress swamps with surrounding ecosystems.

The rather salubrious environmental conditions and the high productivity of cypress and hydric hardwood systems are characteristics particularly attractive to man. As a result, these areas are particularly susceptible to developments of various types. These systems serve as natural filters of surface water and their removal reduces the regional system's capacity to process and purify surface waters.

Both hydric hammocks and cypress domes are sensitive to alterations of the hydroperiod which may occur through increasing the period of inundation or the height of the water level during inundation. These conditions frequently occur when the water storage capacity of the upper watershed is reduced and runoff is increased. The hydroperiod is also affected by drainage or otherwise lowering the local water table. Because these systems are exposed at one time or another to the majority of the region's surface water, water quality is important in their maintenance. Toxic or biologically dangerous materials may be sequestered and accumulate in the wetlands with essentially unknown consequences for man.

Figure 2f. PINELANDS





PINE LANDS [1] T/6

The dominant components of the vegetation of this subsystem are pines (canopy) a diverse understory of palms and hardwood, and a herbaceous layer composed of seedlings and repair (or successional) species. The important environmental stresses are soil moisture, available nutrients, fire, and the shallow substrate. Because of the relatively high frequency of fire, the litter storage is kept low even though it is continually being replenished by programmed leaf fall.

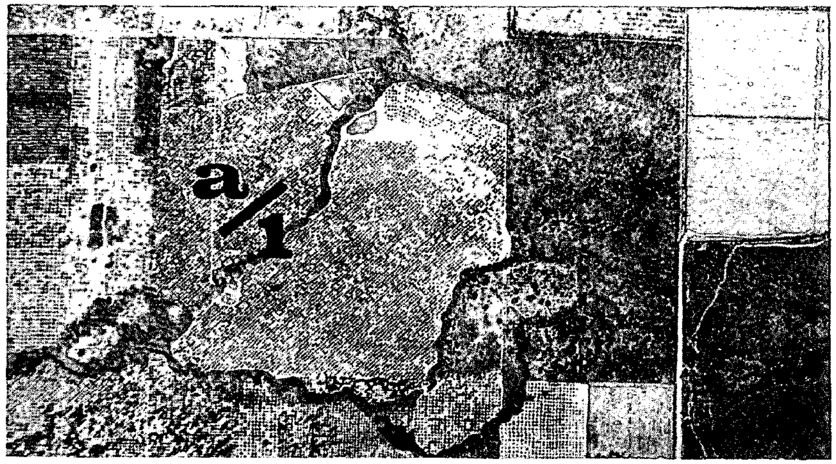
Pines are fire adapted species, as indicated by thick bark, specialized phenological patterns (e.g., growth) and the production of combustible needles. Fire is also shown to stress hardwoods in this ecosystem, causing heavy mortality and preventing their assumption of dominance. In addition, fire releases the repair specialist species which are adapted to germination in burned or otherwise severly stressed areas. Some of these species also fix nitrogen and, as a group, act as a multiplier on the whole system. The rapid-growing producers, in particular, provide food and cover to a diversity of consumers associated with the pineland ecosystem. The consumers are shown to have an important role in the system through their mineral cycling work.

Pinelands, like many other ecosystems, exist in a precarious balance with their environment. Any shift in environmental conditions, particularly the frequency of fire, permits hardwoods to invade and replace pine as the dominant species.

To date, a considerable amount of work has been done on delineating and describing the naturally occurring terrestrial ecosystems of Florida. This work however, has been done on a regional scale and information. is lacking for the detailed description and delineation of systems on a relatively small area. It is possible that, in classifying the state, as in our Ft. Myers study, one may use aerial photos, remotely sensed data such as multispectral scanning, and ground observation to depict local ecosystems on a map. The procedure involves obtaining recent aerial coverage and becoming acquainted with the tone, texture and patterns thereon. Once the observer is familiar with the visual variation apparent on the coverage sheets, he may then enter the field and correlate homogeneous areas with what he observes in the field. Once this simple one-for-one correlation is made, all similar patterns on the coverage sheet can be identified. In this way then, the ecosystems of interest can be delineated, the areas calculated and the importance of some attribute related back to the regional system.

[1]from *Models for Planning and Research for the South Florida Environment Study*, Lugo, Snedaker, Bayley, Odum, August 1971.

Figure 3a. PASTURELANDS AND CITRUS FARMS



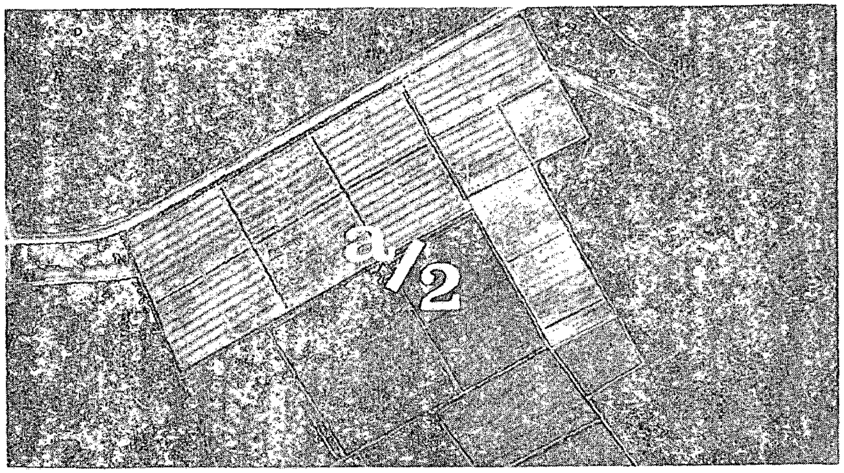
AGRICULTURAL SUBSYSTEMS

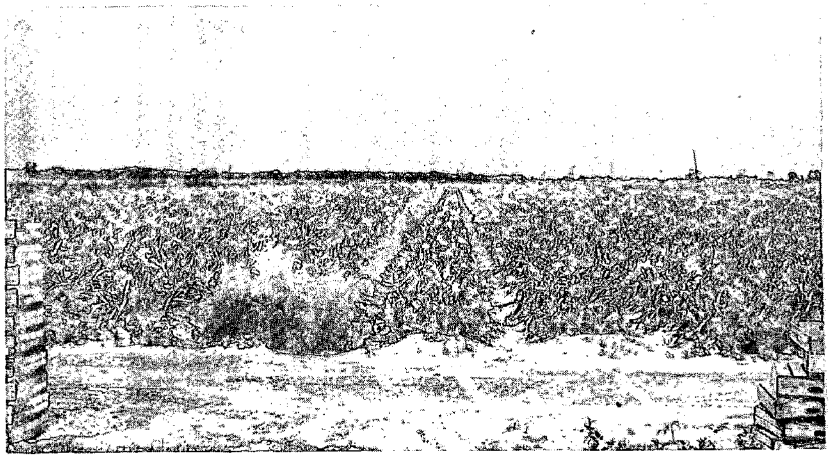
Agricultural areas are examples of man-modified terrestrial systems. Maps of agricultural land use have long been made as parts of studies and administration in agricultural economics and other resource inventories and planning. Because these are well known in common educational experience, it is not necessary to write descriptions of these subsystems. In our study area, we delineated two subsystem types:

PASTURE LANDS AND CITRUS FARMS A/1

These areas are not differentiated because of their similar appearance on aerial photographs.

Figure 3b. FLOWERS AND TRUCK FARMS



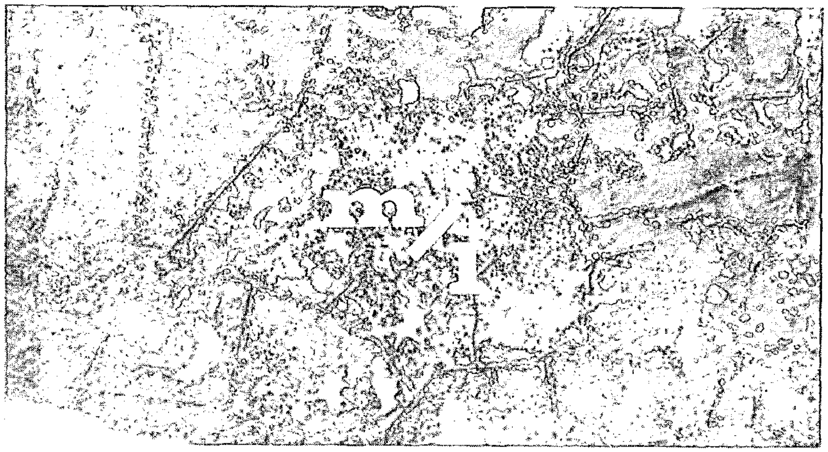


FLOWERS AND TRUCK FARMS A/2

These areas are not differentiated because of their similar appearance on aerial photographs.

Figure 4a. MARSHES

MARINE SUBSYSTEMS [1]



Following are descriptions and photographs of the marine subsystems found in our study area.

MARSHES M/1

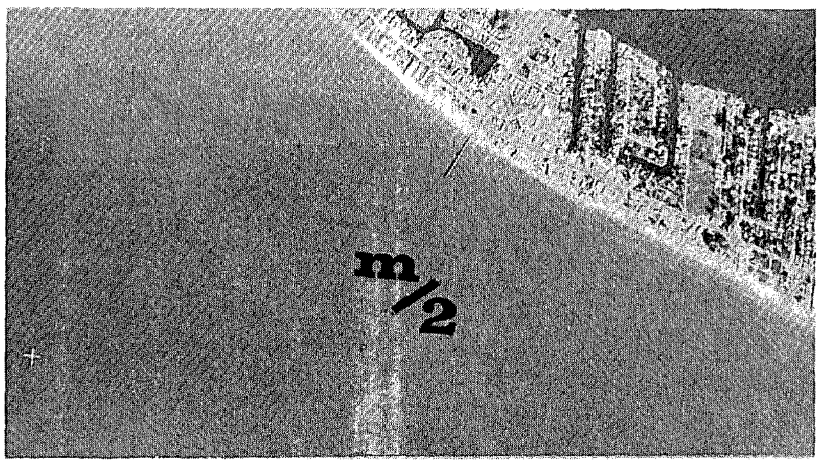
Where there are broad intertidal flats of soft sediment not too strongly stressed with waves and winter cold, grassy marshes develop in the estuarine salt waters that flood the grass usually twice a day leaving the systems standing free in air part of the day. With green vegetation out of the water, but with roots in wet rich sediment, marshes are among the most productive of organic matter of all systems. The alternating tidal exposure does have some aspects of stress requiring special adaptations. Marsh grass and the animal populations of oysters, snails, and fiddler crabs are capable of maintaining both submerged and emergent existence. Marshes can take nutrients and wastes out of tidal water.

Many special adaptations exist in the marsh. For example, some tiny microscopic diatoms burrow into the mud when the tide is in and then surface on the mud during outgoing tide, there receiving light for their photosynthesis. The phenomena turns black mud a golden brown within minutes as the cells emerge.

The marshes have been shown to export much plant matter to the estaurine waters where slow decomposition begins after which the soup of organic food supports much of the food chains. Consumption by clams, oysters, and shrimp remineralizes the fertilizer elements which are released to the marsh grass completing the cycle. Recognized now by a court decision in Massachusetts, the marsh is an inherent and necessary part of many estaurine ecosystems. Removal of the marsh would be tantamount to removing the most productive part of the farms from a system of farms and cities. Marshes increase in importance southward in the United States because the coastlines of intermediate tide and wave energy and other factors of geological history develop broad sedimentary platforms. Winter stress on intertidal zones is also less and although the tops die back in winter, the root systems are available for a fast spring growth. With their productive structures above the water, these systems may have more capability for survival under some waste stresses and thus may have more capacity to serve as self-purification than some other waters that are dependent on clear water or are not already adapted to some stress. The patterns of two main types of grass, *Spartina* and *Juncus*, is almost universal on the east coast.

[1] These descriptions are based on information found in *Coastal Ecological System of the United States.* A source book for Esturine planning edited by H. T. Odum, D. S. Copeland, Elizabeth McMahan in the report to the Federal Water Pollution Control Adminstration, Contract RFP68-128 from institute of Marine Sciences, U. of N.C. 1969.

Figure 4b. SHELF WATERS AND NEUTRAL EMBAYMENTS



SHELF WATERS AND NEUTRAL EMBAYMENTS M/2

Washing the outer archipelagos and along zones of Florida where there is little freshwater discharge are plankton waters of the Neutral System.

In some salinity classifications, an estuary without river inflow or without an excess of evaporation was said to be neutral, one in which a bay was filled with water exchanging with the open sea without salinity change. Neutral embayments and coastlines with steep fall-off have waters that move in from the sea without much modification except that the waters are no longer the deep scattering layer migration and have a bottom below. Also at the coast, waters receive a different kind of vertical stirring as tidal wave energies are absorbed among islands in channels or reflected off shores. The neutral system is a high salinity plankton system that has more diversity than most estuarine systems, but is dominated by recognizably different species. With clearer waters than most estuaries, the photosynthetic zone is deeper, and variations in salinity and temperature less.

The neutral waters are close enough to be affected markedly by land influences, such as waste outfalls, should they develop. The neutral system in such instances is readily transformed into a new type.

With more stability of temperature and salinity due to the depth and sources from the open sea, neutral shorewaters probably have the highest diversities and complexity of components of coastal plankton systems of the temperate latitudes.

Whereas high diversities tend to favor little mass and yield of any one component, the phenomenon of local species clusters and the movement of the high pulse stocks of shrimp and migrating fishes of the estuaries back into the high salinity zones, makes commercial concentrations available there too. The coupling of a stable salinity system to a pulsing one leads to pulses in both.

The coastal neutral waters are also the zone of migration of coastal fish migrations northward in the spring and early summer and back in the fall, supported in the southward migration by the populations emerging from the bays. The neutral system is thus a giant switching system of the network of food distribution and processing of the planetary migration with estuarine system in which man's small trawlers participates.

Figure 4c. MARINE MEADOWS AND SHALLOW NURSERY

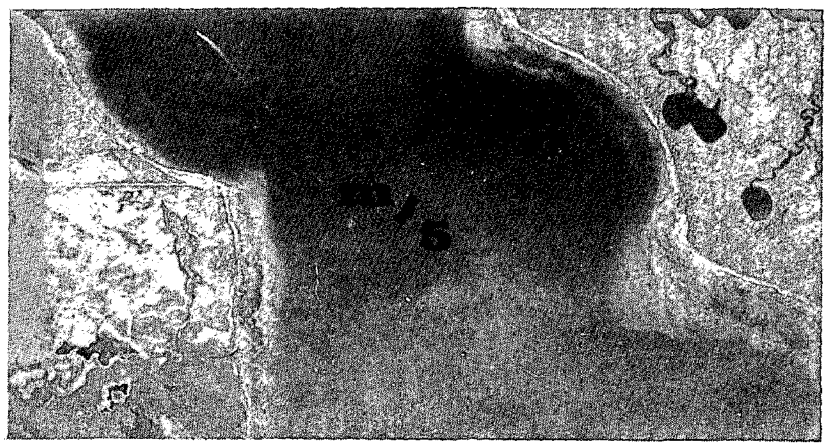
MARINE MEADOWS AND SHALLOW NURSERY M/3

In coastal waters where there are sediments, some current, and good light penetration, one finds the underwater meadows of turtle grass and other plants. The broad expanses of green meadows of vascular plants and benthic algae support a very high rate of production that is aided by the currents that accompany this ecological system. There are many bottom animals in these grasses, including filter feeders that work towards maintaining plankton too dilute to be a shading competitor. In full tropical form the tropical turtlegrass beds resemble the temperate eelgrass, but are much more diverse, have little of the sharp seasonal cycling, and often develop white sediments because of the predominance of calcium carbonate precipitating animals, like sea cucumber and urchins, maintained in the grass system. At its more northern zones in Texas its turtle grass beds resemble the eel grass more.

OLIGOHALINE SYSTEMS (Freshwater-Saltivator Mixing Zone) M/4

Studies the world over have shown that the minimum diversity of species is found in river estuaries in the zones where the salt ranges from freshwater to a few parts per thousand. It is not this *particular salinity that* is the species' restricting stress, for there are special estuaries of this salinity in Florida, and elsewhere, in which the waters are spring fed and very steady; *these estuaries great diversity* does develop, with complex mixtures of animals one might otherwise regard as marine, and animals one might regard as freshwater types. In the usual estuary the 0.5 to 8 parts per thousand range is the zone where there is the most fluctuation of irregular surges of river water during high rains, followed by surges of salt water back *during exceptional tides* and low river discharge. In northern latitudes there is the additional stress of very different land runoff temperature contrasting with less variable marine waters. The *oligohaline* regimes thus are fluctuating regimes with only a few species of plants and animals. Clam bed and bottom subsystems are usually important. The heavy shelled *Rangia* dominates the oligohaline zones to the south. In a state like Louisiana with predominant phenomena of the large river discharge of the Mississippi the oligohaline regime is the main estuarine phenomenon and *Rangia* clams *are the main* animals inshore from the better known oyster reefs, the latter marking the seaward margin of the oligohaline zone as we define it. The oligohaline *regime* has some freshwater and some marine fishes participating, especially during temporary periods of salinity stability.

Figure 4e. MEDIUM SALINITY PLANKTON ESTUARY



MEDIUM SALINITY PLANKTON ESTUARY M/5

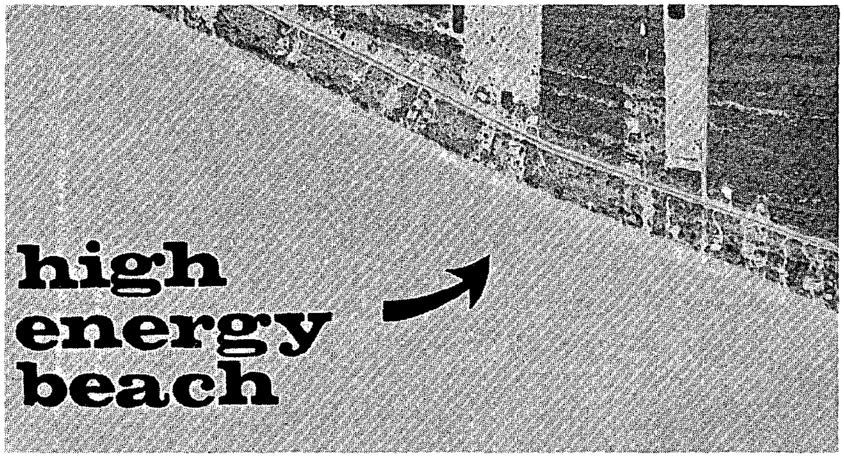
The image most people see when one says "estuary" is the medium salinity, moderate depth bay, which has much fishing but not much visible evidence of anything else. The bays draw support from food chains of invisible microscopic plankton supporting the characteristic populations of crabs, fish, and commercial shrimp. Many of our largest estuaries are predominantly of this type, although they are often fringed and bordered by smaller subsystems of other types. High nutrient levels and good stirring mechanisms generally produce a high photosynthetic rate wherever clarity of water is maintained, although it is lower than in systems like the marshes which have less water depth to absorb light.

In winter, with low light, and well-stirred waters due to tidal shifting and some turbidity from rivers, the plant cells spend much time in the shade and stop making much food. In the spring as light conditions increase, the critical condition at which the plant cells can make a net gain is reached and there is a sudden bloom of some of the diatoms that sets off the seasonal production sequence. During the winter season, organic matter issues from marshes, rivers, and other storages that keep some of the animal life going. With the rising burst of plankton growth there are some releases of larvae from clams, oysters and barnacles, and little water-fleasized copepods develop. The micro-crustacean zoo plankton *Acartia* predominates this system throughout the east coast. Reproductions and migrations of shrimp and fishes that eat the zooplankton are timed to coincide with the increased yields of these small components so that the rise in stocks and consumption takes the rising production. Most of this is entirely invisible to the man in the boat above, unless he measures the photoplankton, some index of its activity such as oxygen production, pulls a zooplankton net, or has some way to estimate the rising stocks of fishes and shrimp.

The middle salinity estuary has species with some ability in their kidney systems to deal with salinity fluctuation, some ability to switch food intake from organic matter to plant plankton base, and an effective temporal program for migration and reproduction so as to hook the need for more food to the timing of appearance of more food.

Whereas the bottom clams and the special subsystems of the bay margins are contributors, the main system is one of plankton and plankton eaters. As the sunlight begins to decline after July, the population growth and reproduction declines and soon many populations migrate out again decreasing their load.

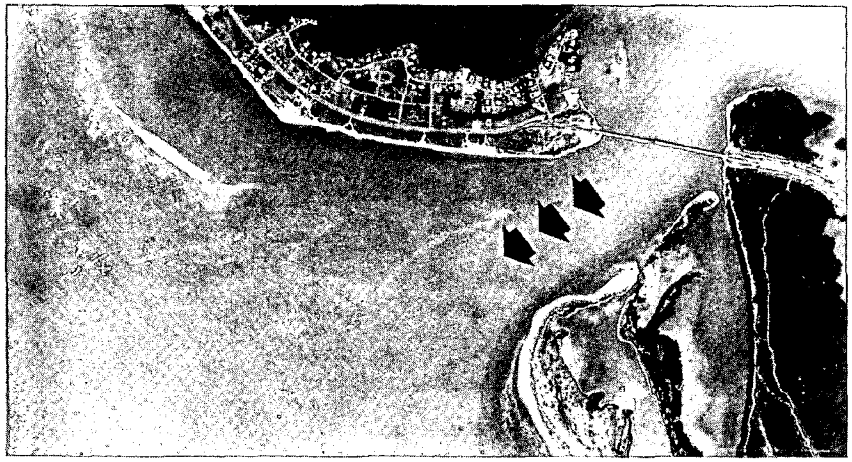
Because the source of energy of this system is from photosynthesis of microscopic plant plankton, from invisible organic contributions from the rivers that support bacteria as intermediates, and from energetic services of tidal currents, rarely do persons not trained in marine science understand the basis for this system and its management. The food chain is out of sight and thus out of mind. The need for maintaining effective plankton populations is not understood by the untrained resource manager. Since all the species draw from some of the same energy pools, rises in or falls in one species must be accompanied by compensating changes in others. This system, like the others, must be managed as a whole, not species by species, or with commercial fish separate from sports considerations, etc.

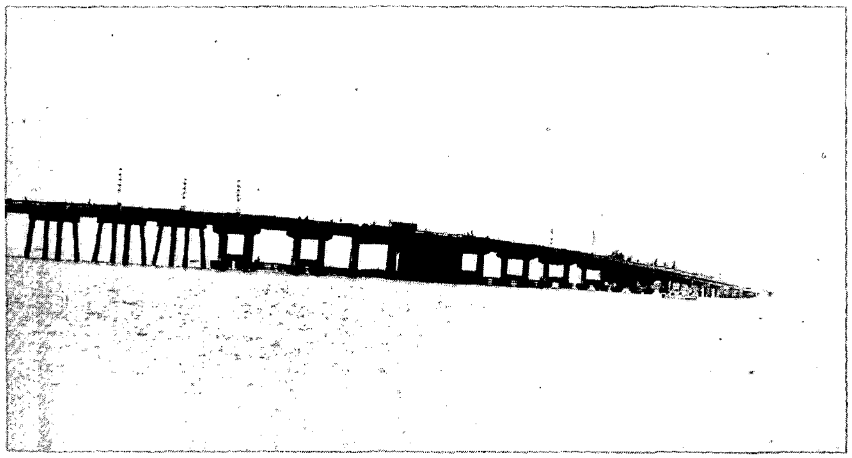


HIGH ENERGY BEACHES

Where wave energies are high, sandy beaches become the most common coastal system on the front shoreline which receives breaking waves. Sand grain sizes are self-organizing in dependence on the energy of the waves. Surging waters are received filtered, and returned to the sea. Very characteristic burrowing *Hippa* crabs, *Donax* clams and interstitial cosmopolitan beach fauna participate in the massive sand filter in the process of filtering organic matter. The beach line provides organization to passing water masses and serves many reproductive cycles in which eggs are deposited at the beach. The characteristic long shore current supports many migrations. The sand may be quartz-dominated along the northern shores or calcareous sand where terrigenous supply is low and available hard matter is from coral reefs or other calcareous substrates, which increase towards the tropics. Winter stress on the beaches due to high wave energies and cold eliminate much of the biota, but just seaward in the surf zone, and exposed at low tides, may be surf clams. Of all the systems receiving pollutions of surface floating wastes, the beaches are most affected, although the capacity of a high energy beach for processing and mineralizing wastes is also large. Where wave energies are somewhat less, additional species such as sand dollars become important and latitudinal differentiation appears.

Figure 4g. HIGH VELOCITY CHANNELS





HIGH VELOCITY CHANNELS

Especially where large tidal waves are absorbed in archipelagos and inlets with deep channels, some characteristic ecological patterns develop on the current scoured bottoms and in the highly turbulent plankton waters. Even though the salinities are high and the waters much like the open sea in character, the absorption of the energy of the world tidal wave into large tidal currents provides a special energy source and a stress. The scoured bottoms develop reef-like growths of encrusting animals and plants. Estuarine plankton associations, not characteristic of the open sea, develop in the moving waters. With food transported in abundance to any organisms that can hold on, the density of attached life is large, although not diverse. The large eddies in the channel waters support microscopic phytoplankton of large individual size. The eddies and effects of the earth's rotation produce gyrals and other means by which floating and swimming animals and plants can slide back and forth with the waters. Adaptive behavior also permits populations to develop within the zone, with reproduction balancing losses. The great turbulence permits little opportunity for phenomena of stagnant waters to develop. Aeration rates are high because of the rapid removal and stirring downward of surface waters. The high current velocity channels are often between ecological systems of much greater diversity seaward and landward. The stress at the zone of contact between estuary and gulf may produce low diversity.

OSYTER REEFS

Wherever there are strong current systems bringing suspended material that may serve as food, filter feeding animals may concentrate into dense, exposed cities protected by hard masses of their skeletons. The reefs built by various species of oysters are the most common types, but reefs of animal consumers also include great sheets of mussels, serpulid worms and other animals. Oyster reefs are consumers requiring organic food in particulate form. The conditions for consumer reefs are very different from coral reefs, which are mainly based on their use of light in photosynthetic food production within their tissues. Oyster reefs develop in the intake pipes of industrial plants that use salt water for cooling, on bars where waters circulate in estuaries, on the sides of rocks on pilings, or on bottoms of ships. Because of their concentration of life and structure, the reefs have been of great importance as food for man, and the shells have become important in calcium carbonate industries such as road building and concrete manufacture. The management of oyster reefs has not always been done with the understanding that the reef is based on the continuous circulation of a much larger area of water than that over the reef itself. The planktonic form and the organic matter from rivers that contribute support to the reef are large in volume. The foods dispersed in a bay are controlling the amounts of reefs. One cannot manage a bay for oysters without managing the inputs of suspended foods and the release by oysters of minerals that return to the plankton as a necessary step for growing more food for the oysters.

Because oysters are built with shells, have wide salinity tolerance, and have abilities to suspend operations for long periods, they are adapted to great variations in water level, salinity and temperature in the river mouth estuaries or in the intertidal zones. Where stresses are less, more diverse communities replace the oysters, doing so by spread of drilling snails and action of diseases that eliminate the oysters, as the conditions become more stable enough for the competing communities. Although the diseases and carnivores are often the agent of replacement of oysters by more diverse ecosystems in the course of a season or in year to year changes, the ultimate causes are related to the changes in regime that allow more stable, higher salinites and more uniform temperature conditions that foster the complex systems. Many disease epidemics have their ultimate cause as the stress of wastes or interruption of food resources.

The management of oyster reefs has to be related to the programming of river control, towards maintaining oscillations, and insuring adequate volumes of suspended food particles. Leasing bottoms may not be enough to provide good management, unless the whole bay system in leased and managed, as it is now done in a few states.

Salt water mussels form enormous reefs especially in northern latitudes, where they hang on the rocky substrates. Since they form rigid structural mats of animals, they too are consumer reefs. Among the most interesting of ancient geological records are those left by ancient consumer reefs that begin now to yield their information about ancient estuaries as we learn how to interpret the whole estuarine system's interactions from the nature of the fossil reef subsystem.

BLUE WATER COASTS

The deep blue waters of tropical seas have a characteristic pattern of deep light penetration, sparse plankton-based food chains associated with a generally low nutrient availability, and some fast recycling of nutrients by tiny cells and many diverse specialists among the animals. Blue tropical waters of this type bathe the Hawaiian Islands, Puerto Rico and the southeast coast of Florida in the Gulf Stream. The blue water system has the stresses of vertical mixing and low nutrients, but has little stress in temperature and salinity or other ranges. Such waters become the province of this summary of coastal systems where lands drop off steeply into the sea and blue water flows along the shore. Except for the special condition of low concentrations of nutrients, the blue waters have less stress than most plankton waters. With deep mixing, there are adaptive problems of maintaining plankton within the light zones. Although sparse in mass, the small plankton are in vast diversity with many shifting combinations possibly forming delicate adaptations to slight differences in conditions of these tropical waters. The low nutrient character makes these systems very sensitive to change by wastes. Fairly clear green waters from the open seas bathe other portions of the United States at other latitudes, but the plankton populations there are seasonably programmed, and different in character.

At this stage in the classification and study of emerging subsystems associated with characteristic wastes and disturbances by man, we can only include those types that have been studied enough to identify the presence of something new in the pattern of existing subsystems. No doubt the number of emergent new waste type identifications will grow as efforts to identify them increase, and as industries spread.

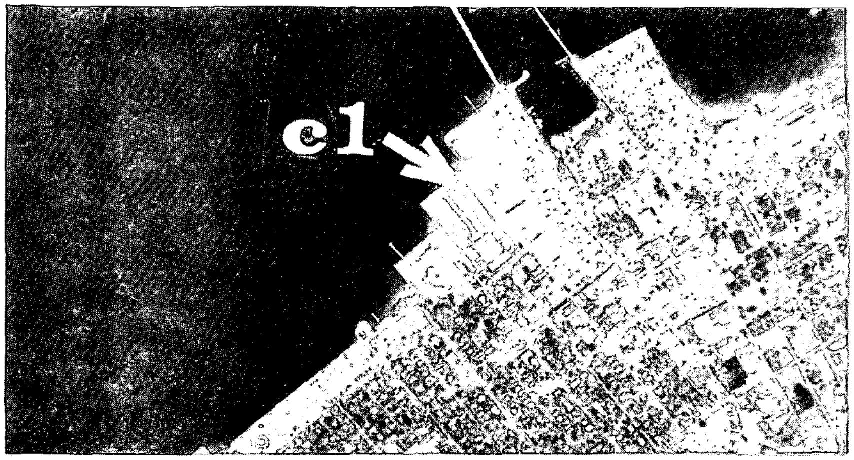
Although the types of waste and disturbance, which are changing the estuaries of America are of many types, most are multiple-waste channels. Apparently, decisions as to the location of waste outfalls by towns and industries have been much influenced by the presence of other waste outlets. With passing patches of man's effluents the mixtures might seem to be of endless variety. However, the alternating shock of contrasting chemical solutions do develop some common properties, even though different kinds are represented.

The only man-modified marine system isolated in our study area is:

WASTE OUTFALL GENERATED SYSTEM

The discharges of raw sewage and the rich effluents from primary or secondary treatments inject high levels of organic matter, and cause enormous increases in the trace nutrients required for phytoplankton photosynthesis. The nutrient ratios of such elements as nitrogen and phosphorus in the wastes of a city have some basic properties which vary depending on the industries using the same effluent system. These wastes tend to support both producers and consumers of types not found in the unmodified marine system. The small red annelid worms at the end of ocean outfalls of sewage are one characteristic pattern. Although more attention has been paid to the survival of disease organisms in affected estuaries than to the nature of the emergent new system, the growth of cities will tend to convert more and more estuaries to a type of system compatible with these flows. Case histories already studied produce bases for characterizing these emergent systems.

FIGURE 5a: CENTRAL BUSINESS DISTRICT



URBAN SUBSYSTEMS*

The subsystems of man's development, as seen from aerial photographs and maps which indicate flows of energy, patterns of architectural complexity, and densities of population and urban structure, may be classified into system types which can be outlined and mapped as one does the vegetation types of natural areas. In this study, urban subsystems were delineated primarily from aerial photographs at 1'' = 2000' and substantiated by field acquired knowledge of the areas on the ground. Delineating the subsystems of the urban fabric in this fashion requires new terminology and definitions which describe the physical features of the urban area as the resultant of the patterns and frequencies of the energy flows within the urban system. A brief discussion of these definitions is contained in Section V, DEFINITIONS OF TERMS.

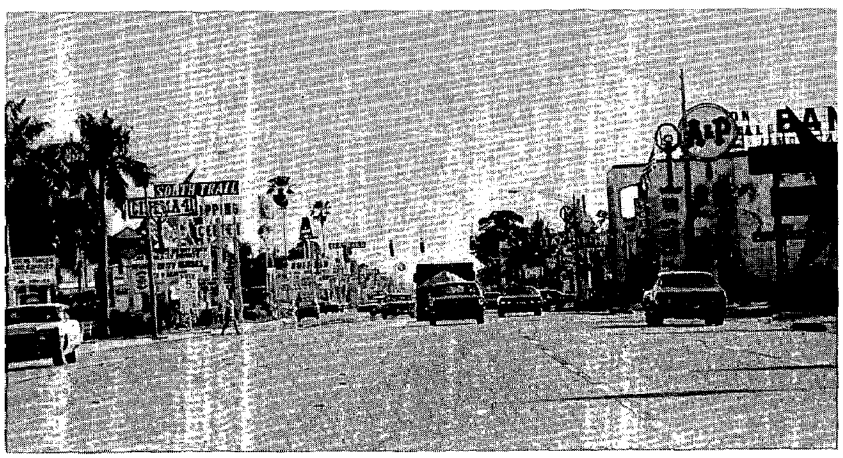
The urban subsystem types as defined in the Lee, Charlotte, and DeSoto Coastal zone are as follows.

CENTRAL BUSINESS DISTRICT C/1

The central business district is a subsystem with high energy flows, a high power density, a high population flux, and a regular urban structure to open space texture. It requires high energy flows for maintenance of structure and, if this is not provided, will generate decay and blight. It also requires high energy flows to provide facilities for public circulation systems and safety, e.g. police, fire and health protection. It has the highest urban structure density in the city, and the least available access to a rural open space.

*These definitions of terms and subsystem descriptions are based on information found in *Towards a General Theory of Planning Design*, L. Peterson, et al, Southeast Florida Planning Team, Department of Architecture, University of Florida, in publication.

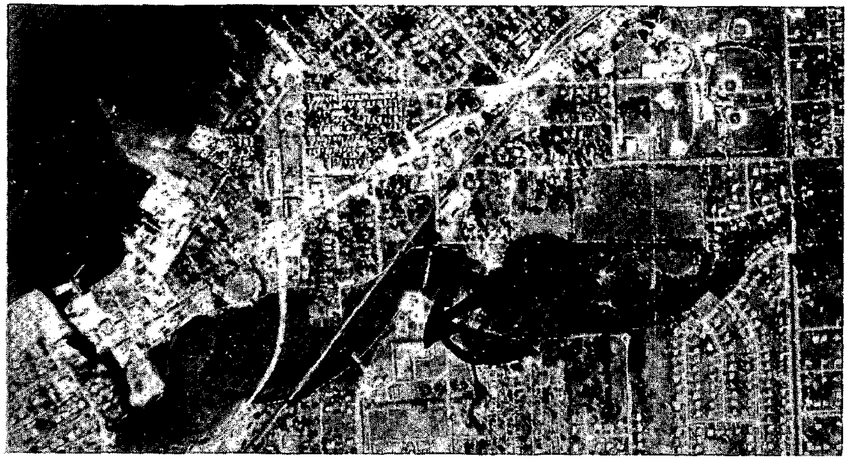
FIGURE 5b: COMMERCIAL STRIP



COMMERCIAL STRIP C/2

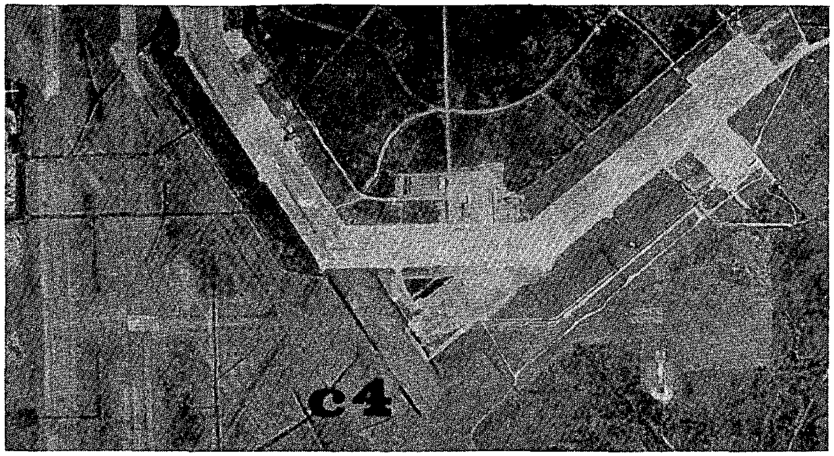
The commercial strip develops adjacent to a high energy traffic arterial moving a high density population flow. There is a high energy exchange in input and output of goods, service and information. Maintenance energy is moderate, the urban structure edge index is low, and the structure to open space texture is regular.

FIGURE 5c: CITY SERVICES



CITY SERVICES C/3

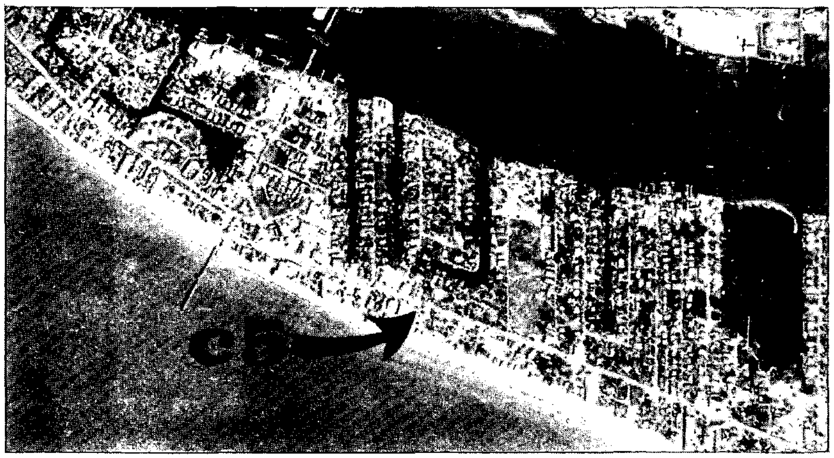
City service and utility locations are subsystems with a high energy input and output and a high power density. There is a high thermal exchange in power production and inefficient operation means that energy lost must be absorbed by surrounding subsystems. If they cannot absorb this energetic "noise" as quickly as it is produced, then the energy is "stored" by the system and easily recognizable as "pollution" by man.



TRANSPORTATION TERMINALS C/4

Transportation terminals are elements which focus regional scale, or larger, activities comprised of the termination, dissemination, or shift in transportation mode of people and goods into and out of the urban area. These locations have large potential amplifier value in the urban energy budget, in that they provide access to transportation links of global scale. Airports, harbors and marinas, railroad stations, and bus stations are included in this classification.

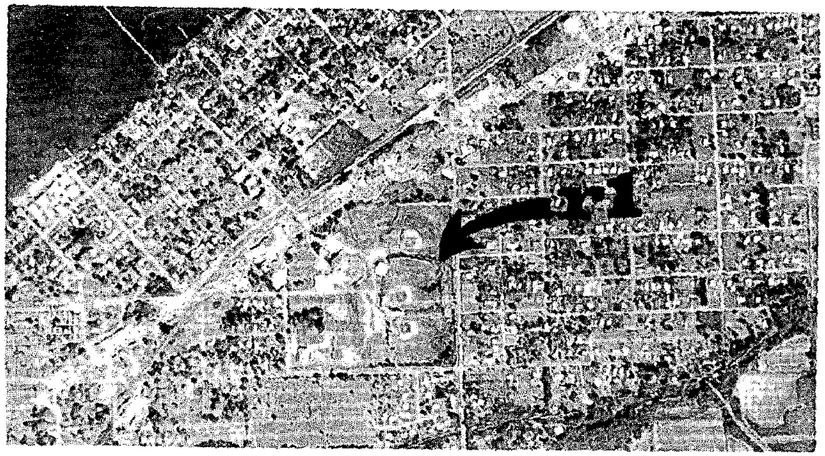
FIGURE 5e: BEACH STRIP

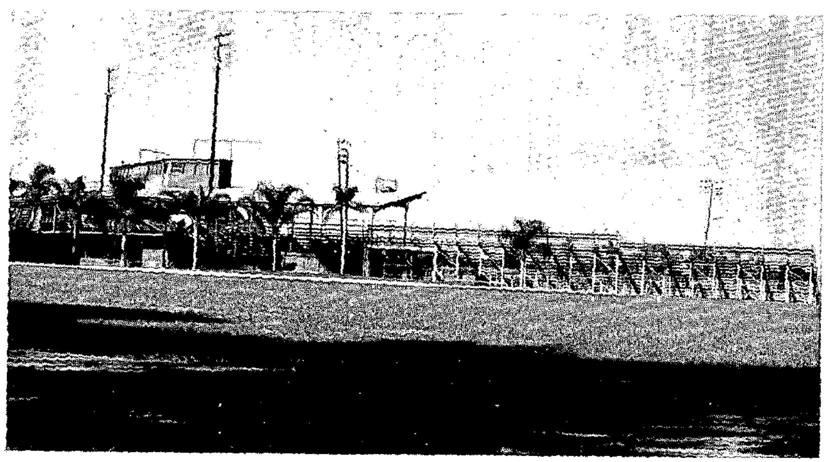


BEACH STRIP C/5

The beach strip commerical development is a classification of those areas reliant upon access to the ocean and beach. These areas have a high transient population density, high urban structure density, a high power density, and require high energy for maintainance of structure, grounds and beach areas.

FIGURE 5f: PUBLIC RECREATION AREA

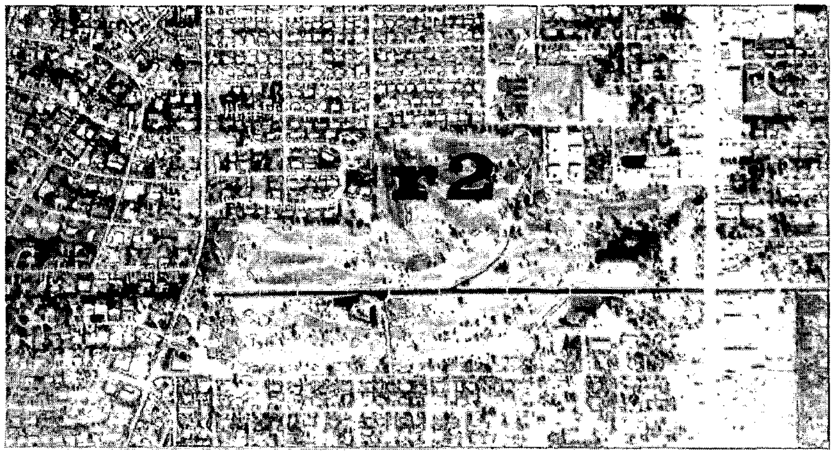




PUBLIC RECREATION AREAS R/1

Public recreation areas usually require an energy subsidy to arrest succession and augment nutrient flows because of detritus removal. Additional energetic costs are trash and garbage removal and maintenance of public facilities.

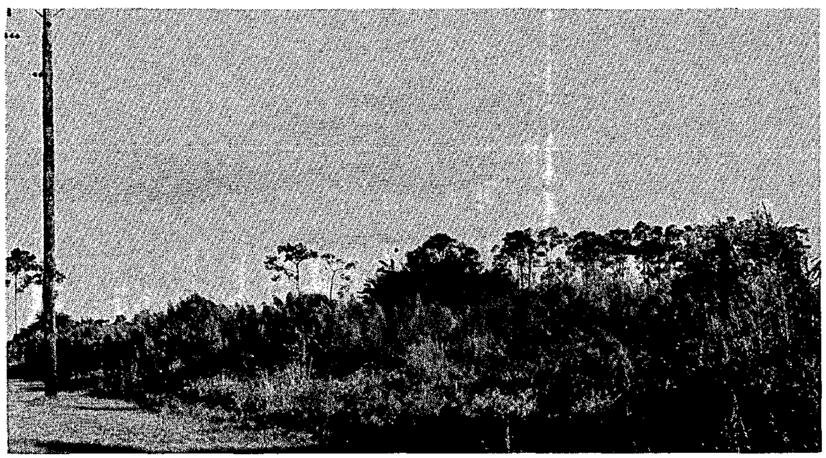
FIGURE 5g: PRIVATE RECREATION AREA



PRIVATE RECREATION AREAS R/2

Private recreation areas require high energy maintenance in equipment and grounds upkeep. They have a high power density for the population density served.

FIGURE 5h: NATURAL OPEN SPACE



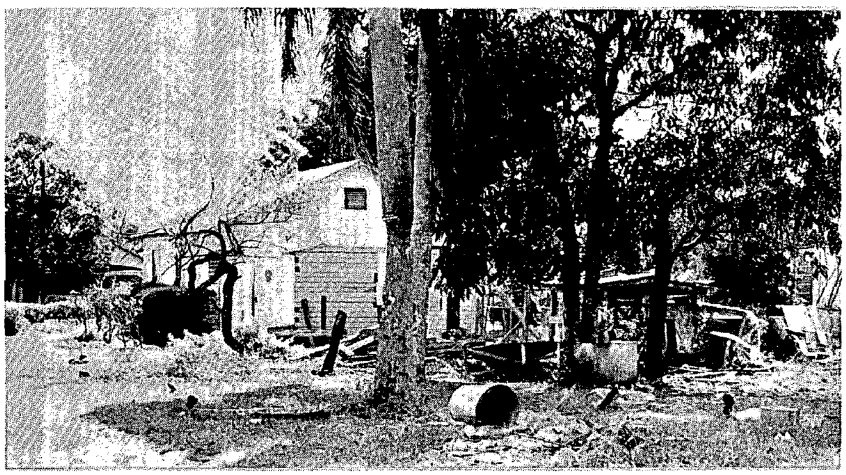
NATURAL OPEN SPACES R/3

Natural open spaces require no energy subsidy for maintenance. They absorb energy stresses from adjacent subsystems and can process some types of stresses more efficiently than man, at no energy charge to society.

FIGURE 5i: STABLE HOUSING

STABLE HOUSING H/1

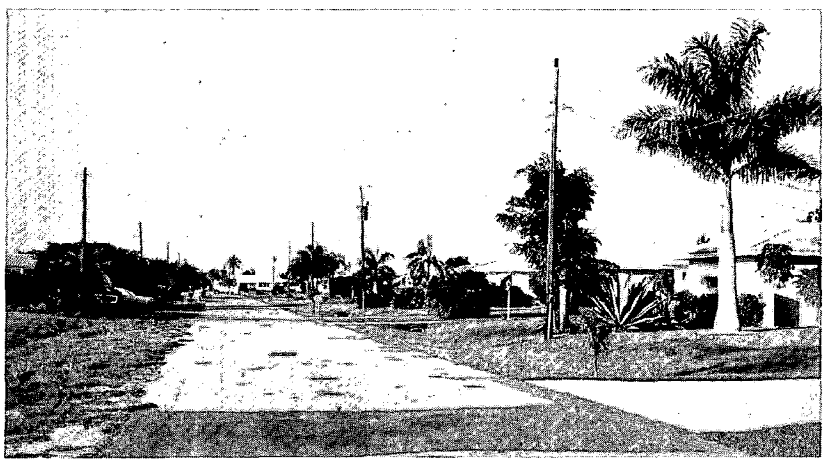
Stable housing subsystems require high energy flows for maintenance. They are diverse in structure and vegetation types and have a relatively low power density. They usually exhibit an irregular structure to open space texture.



SENESCENT HOUSING SUBSYSTEMS H/2

Senescent housing subsystems usually have a medium power density and high energy flows but not to replace the deteriorating structure. They have a low urban structure edge index, a diverse structure to open space texture, and a high urban structure density.

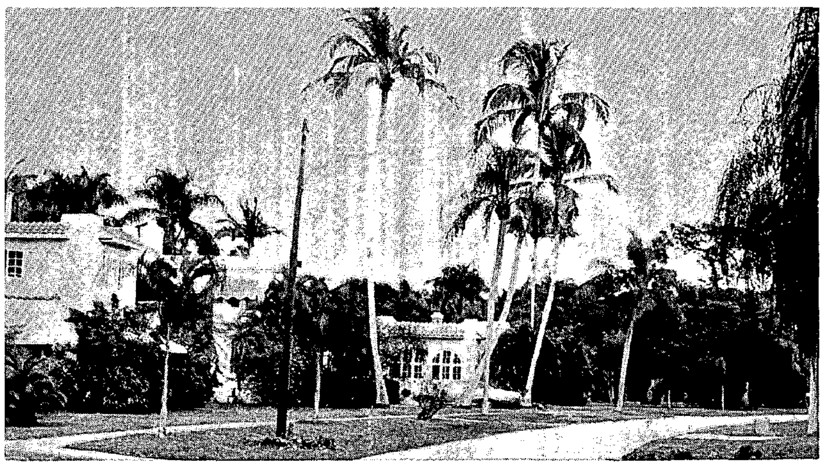
FIGURE 5k: MATURE RESIDENTIAL



MATURE RESIDENTIAL H 3

Mature residential subsystems have high power densities, and medium maintenance energy flows. They have a regular urban structure to open space texture. The urban structure edge index is high, and the urban structure density is low.

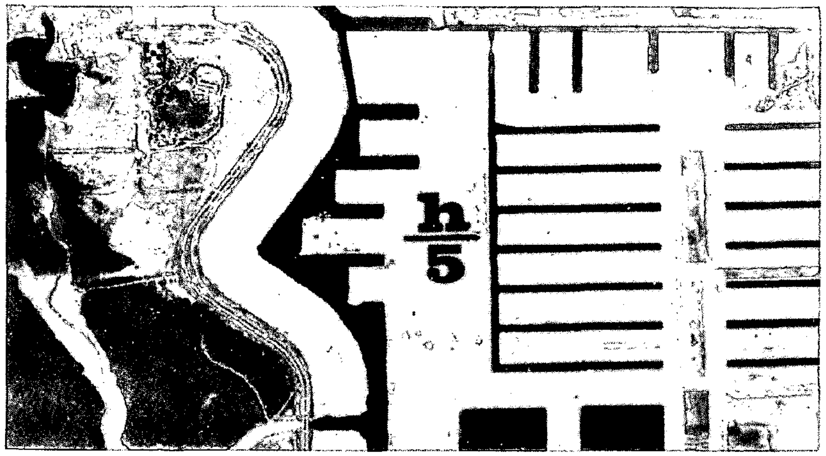
FIGURE 51: HIGH MAINTENANCE RESIDENTIAL

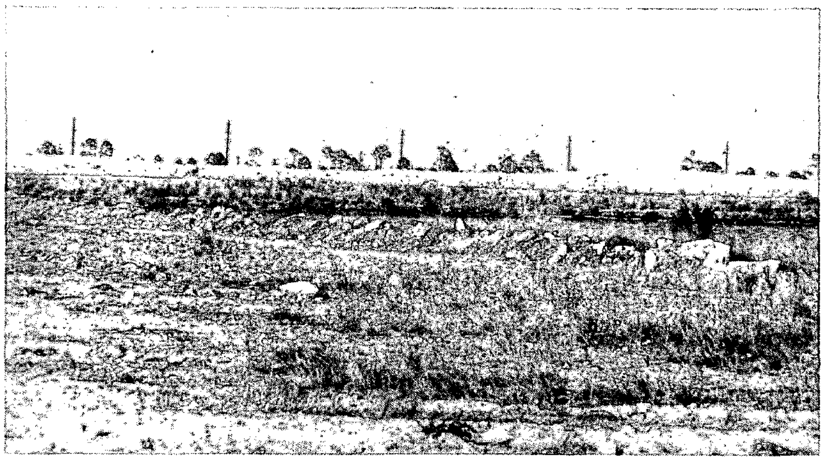


HIGH MAINTENANCE RESIDENTIAL H/4

High maintenance residential subsystems have high energy flows, high power densities, high urban structure edge index, an irregular structure to open space texture and a low urban structure density.

FIGURE 5m: CLEARED AND PREPARED WITH CANALS

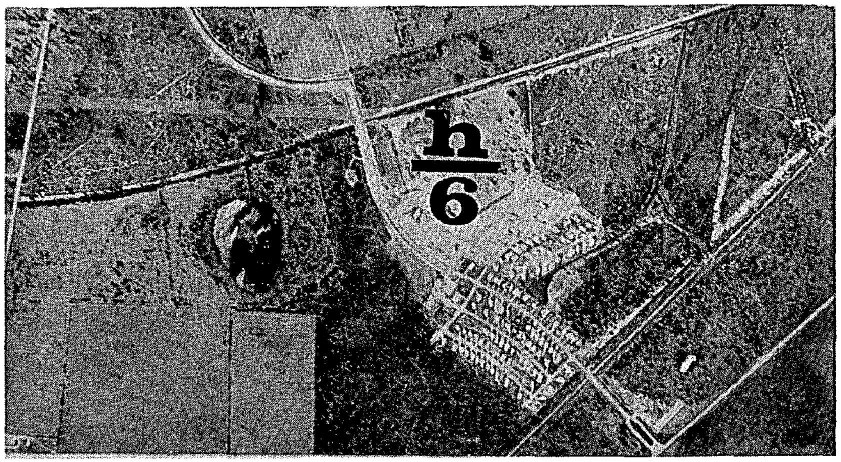


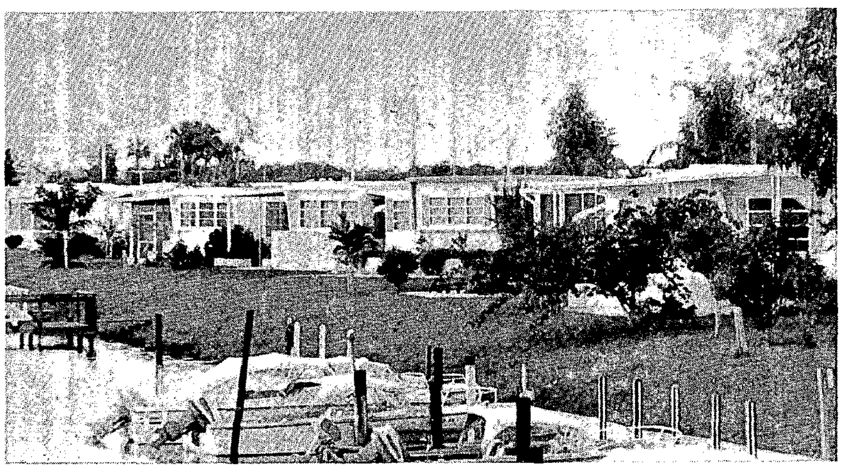


CLEARED AND PREPARED WITH CANALS H/5

This subsystem includes those areas which have been cleared and prepared for residential development, and include canal configurations. The characteristics are similar to D/1, in that they are subject to wind erosion by wind and water, and often have city services installed (streets and power lines) which require maintenance.

FIGURE 5n: MOBILE HOUSING

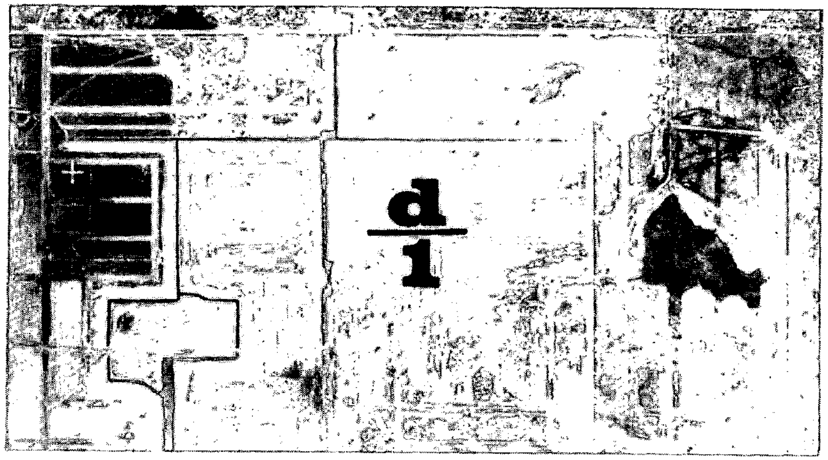


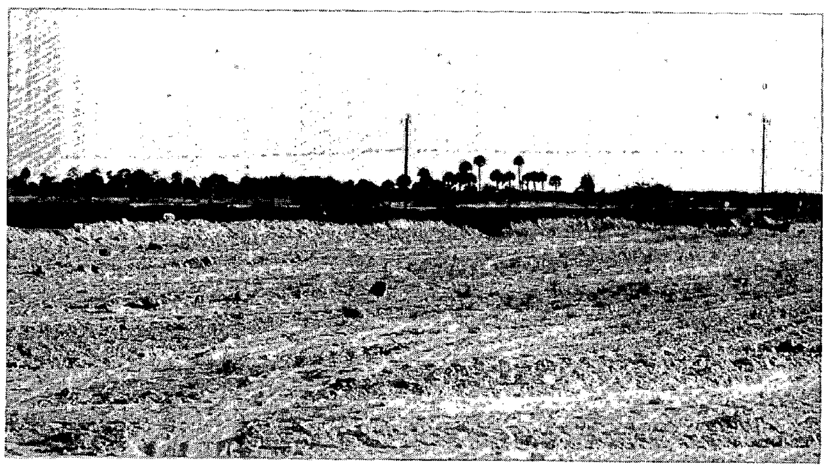


MOBILE HOUSING H/6

Mobile housing subsystems have high energy flows, a low urban structure edge index, a regularized structure to open space texture, and a high structure and population density. Rapid deterioration of units leads to a high unit regeneration rate.

FIGURE 5o: DREDGED AND/OR SCRAPED

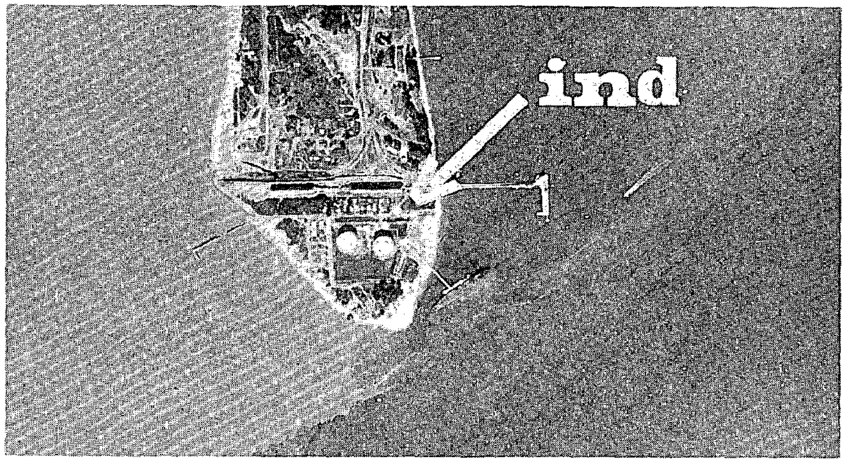


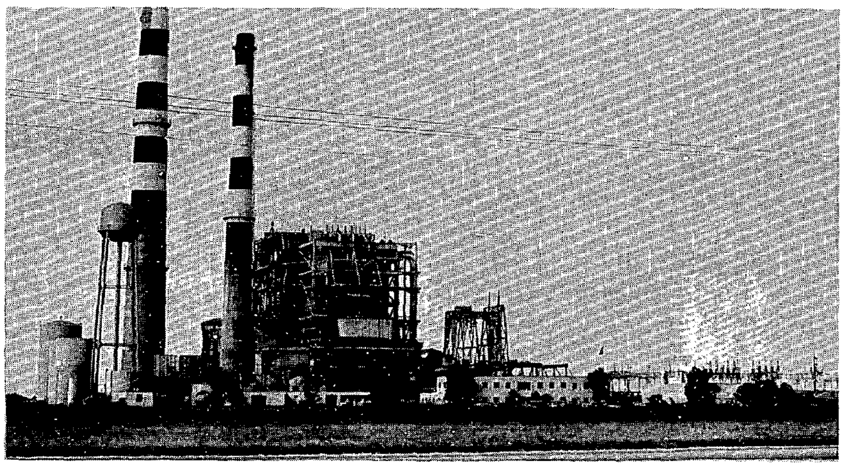


DREDGED AND/OR SCRAPED D/1

Land areas which have been either dredged and filled or scraped of vegetation, and which show patterns of potential housing development are in this subsystem. Having no urban structure or vegetation, they are subject to erosion by wind and water, and often have city services installed, e.g. streets and power lines, which must be maintained to prevent deterioration.

FIGURE 5p: INDUSTRY

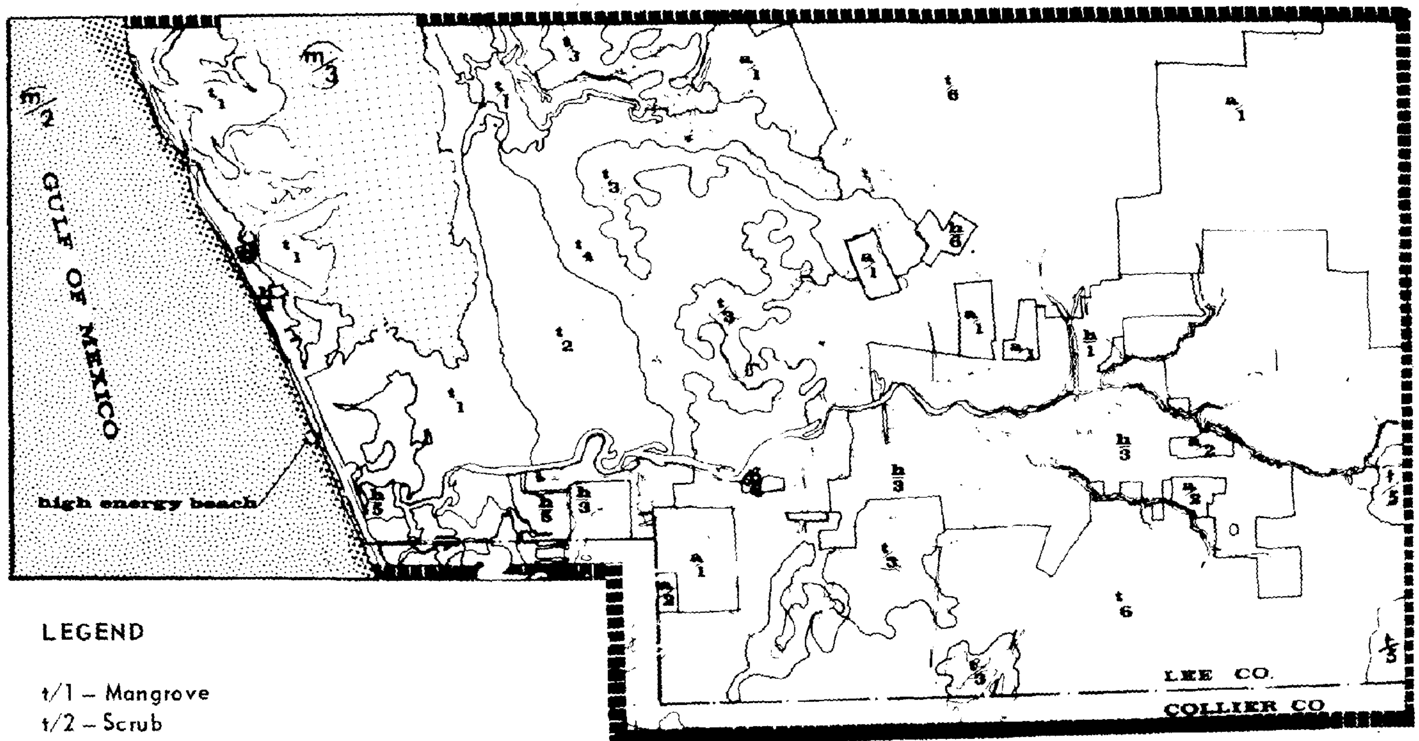




INDUSTRY IND/1

Industrial areas are high energy processes, or are subsystems with high energy inputs and outputs or high amplifier values.

FIGURE 6. SUBSYSTEM MAP EXAMPLE



LEGEND

t/1 – Mangrove
t/2 – Scrub
t/3 – Dune transition
t/4 – Hydric Hammock
t/5 – Cypress Dumes and Strands
t/6 – Pine Lands
a/1 – Pasture Lands and Citrus
a/2 – Flower and Truck Farms
h/1 – Stable Housing
h/2 – Senescent Housing
h/3 – Mature Residential
h/4 – High Maintenance Residential
h/5 – Cleared and Prepared with Canals
h/6 – Mobile housing

SCALE – 1" = 1 mile

2. Mapping Subsystems

The identification of subsystems existing in an area, and the location geographically of those subsystems, are two steps which may happen simultaneously. Data and mapping materials must first be accumulated to provide the information for identifying and locating the systems:

Terrestrial Systems: Aerial photographs, descriptions of potential subsystems, energy diagrams if possible, geological survey maps, and ground observation provide the necessary information for mapping these systems.

Marine Subsystems: Navigational charts that have depths, salinity measurements that include seasonal ranges, aerial photographs, descriptions of potential subsystems and energy diagrams if available, some ground observation, and remote sensing study of underwater plants if available, are used for mapping marine subsystems.

Urban Subsystens: *Aerial photographs, maps showing energy flows,* population density and structure density and patterns, coupled with descriptions of typical subsystem descriptions (many of which correlate conventional zoning divisions) are required to map this group of subsystems.

Generally, the systems are identified, located, then drawn on a transparent sheet, using the aerial photographs for the locations. A step-by-step procedure for accomplishing this is given in Section IV, D. Figure 6 shows an example of a subsystem identification and location map; the complete set of subsystem maps are contained in Atlas Appendix I and, in a reduced size, in Section VII, Map Appendix, in this volume.

3. Diagramming Interactions

a. Energy network diagram (model)

The main components and causal controls of a subsystem can be shown in a diagram of energy flows of a system using the symbols illustrated in Figure 7. In the energy diagram for the system of shallow water marine grassy meadows (Figure 9), causal actions that are part of the normal life of the system in its interaction with natural forces of weather are shown by the pathways; some are amplifier actions, some have time delay effects, and some involve complex interactions and feedbacks. The action of sun, waves, natural fertilzer flows, and food chains are natural flows. Also shown in the network are the actions of man that might be considered, such as dredging, filling, harvesting, polluting and fishing.

The energy flows are a measure of the value of each component. In general an energy flow that displaces existing patterns and values is hardly measureable at one percent, becomes serious at 10% and disastrous to existing patterns 50% to 100%.

b. Matrix

The system may also be represented in columnar tables sometimes called *a matrix*. The system of the marine grassy meadows in Figure 9 is given also in the tabular form in Figure 10. The existing stocks, structures, and flow process pathways are given along the left side. The possible additional actions and new pathways due to man's actions are given across the top. Then at the intersection is given symbol indication of some idea of the positive or negative effect of that interaction which must be considered to avoid unexpected actions.

These piece by piece considerations of actions and factors help one to understand the system and its interactions with man. Where effects have been identified and there are still conflicts of interests as to which of two competing alternatives should be considered, the magnitude needs to be evaluated on an energy basis and then converted to dollar estimates using a factor such as 10,000 calories/dollar.

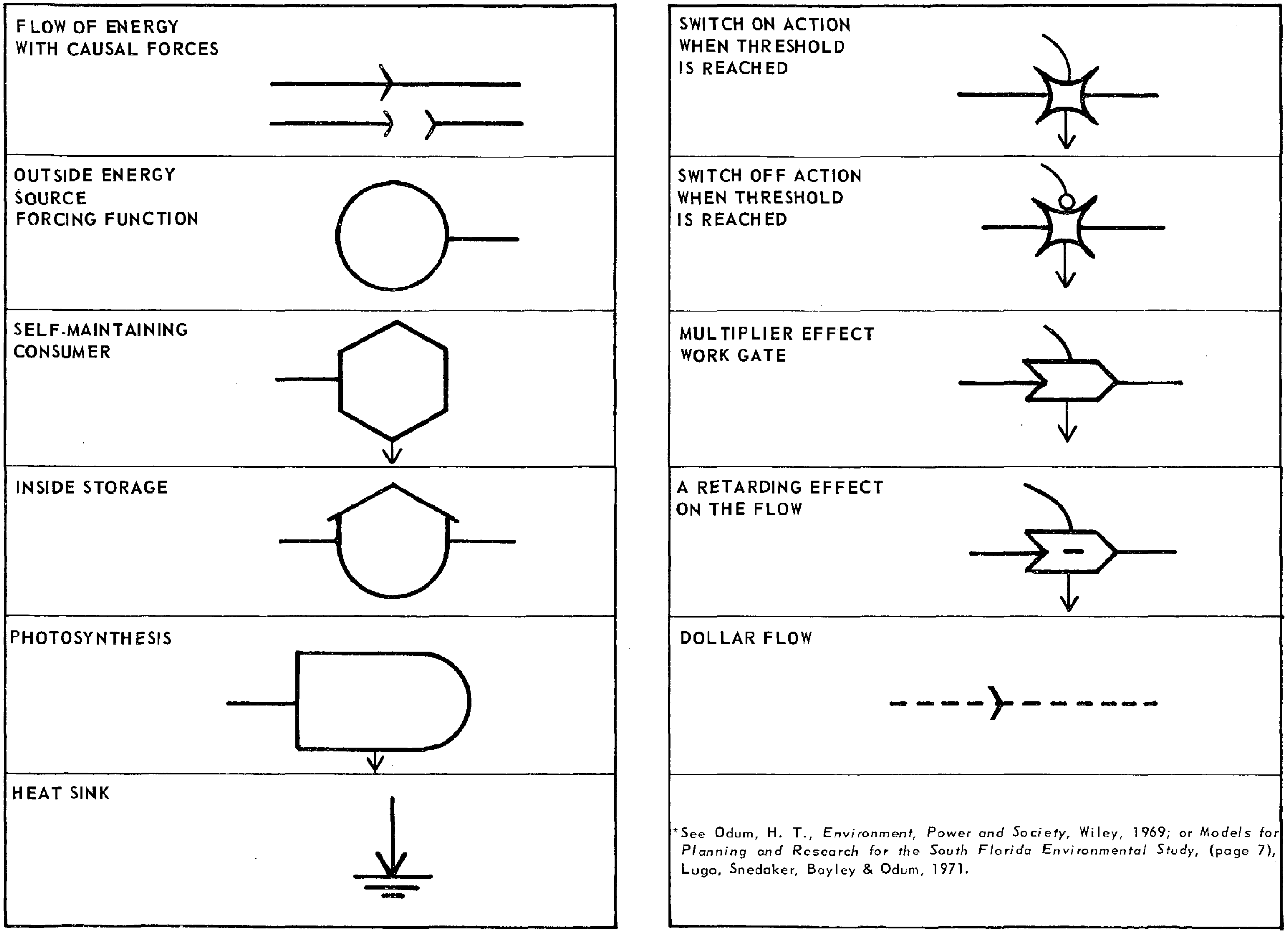
Network diagrams have now been done for most of the main eco-system types of Florida at least on a preliminary basis. These can be found in:

1. "Models for Planning and Research for the South Florida Environmental Study," by A. E. Lugo, S. C. Snedaker, S. Bayley, and H. T. Odum, August 1971
2. "Energy Circuits in Chemical Cycles", Model Symposium on Chemistry of the Sea, H. T. Odum, 1971
3. "Towards a General Theory of Planning Design," Southwest Florida Planning Team, Department of Architecture, University of Florida, in publication

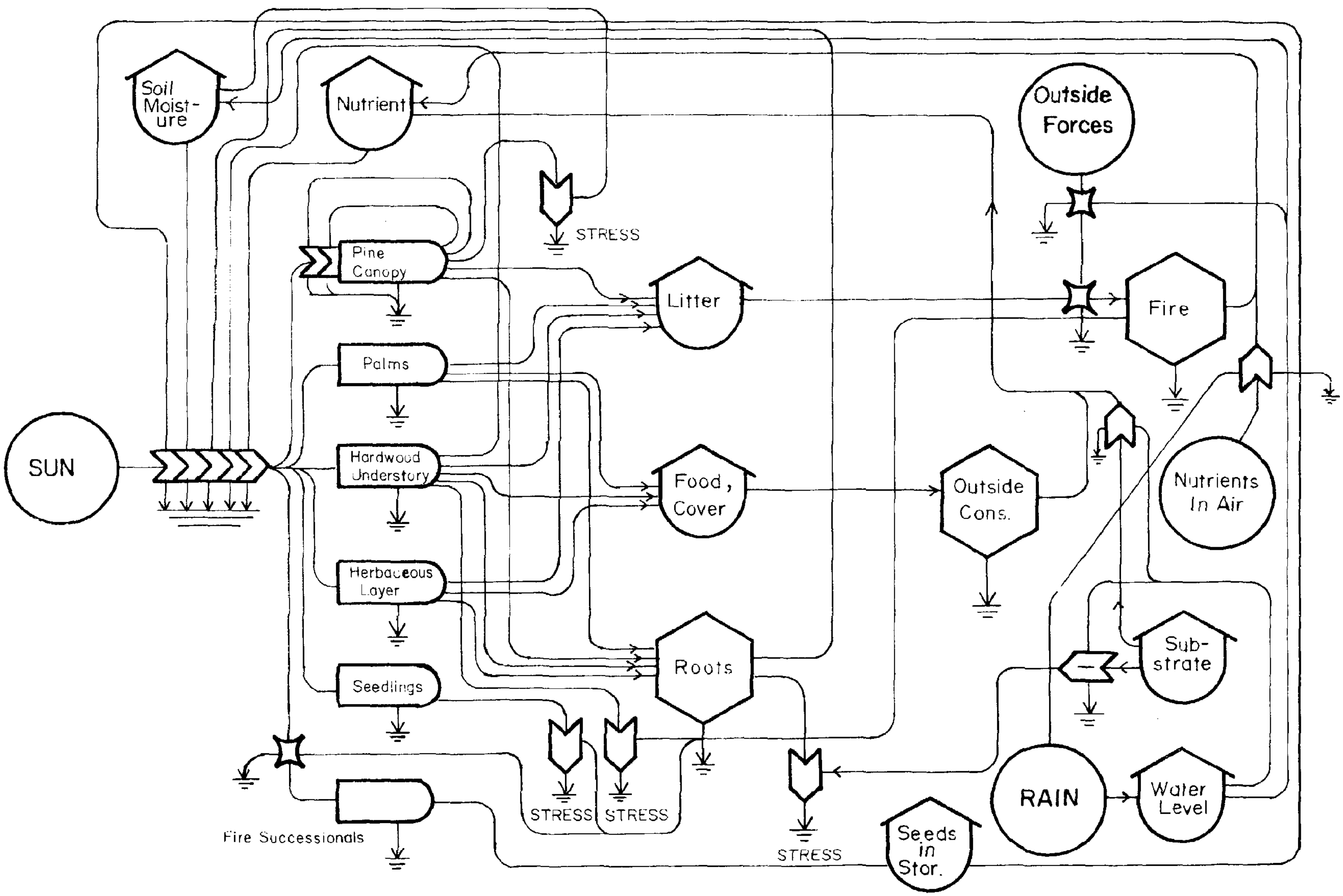
Thus it is possible now to give some consideration to all the factors and processes that have so far been included in these diagrams. In addition to the Marine Meadows Model and Matrix, energy diagrams of a terrestrial ecosystem (*Pinelands, Figure 8*), and an urban subsystem (Commercial Strip, Figure 11), have been done as a part of this study.

For a complete explanation of energy network diagrams, see *Environment, Power and Society*, H. T. Odum, Wiley-Interscience, 1971.

FIGURE 7: SYMBOLS FOR ENERGY NETWORK DIAGRAMMING*

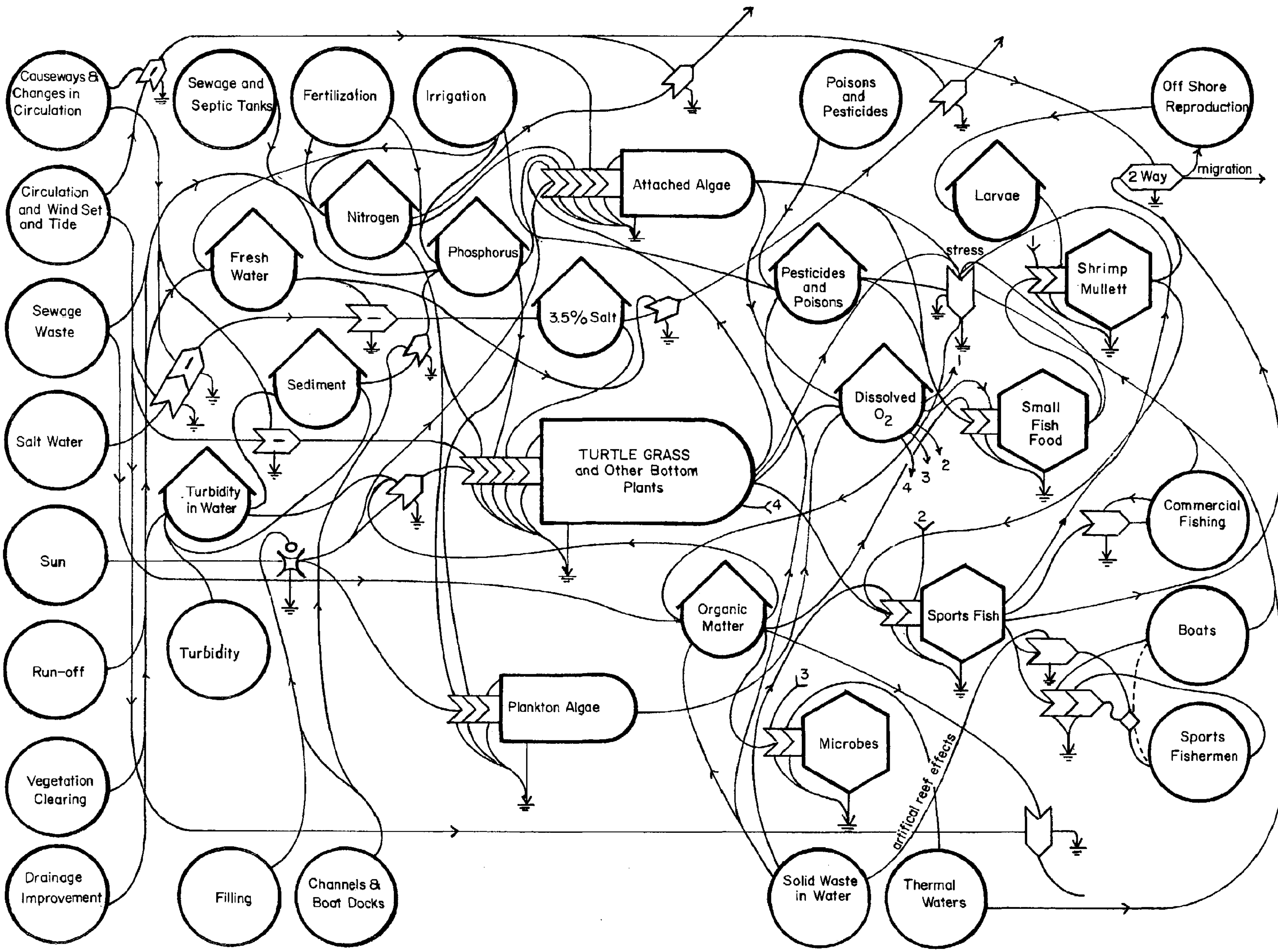


*See Odum, H. T., *Environment, Power and Society*, Wiley, 1969; or *Models for Planning and Research for the South Florida Environmental Study*, (page 7), Lugo, Snedaker, Bayley & Odum, 1971.



*See *Models for Planning and Research for the South Florida Environmental Study*, A. E. Lugo, S. C. Snedaker, S. Bayley, & H. T. Odum, August 1971.

Figure 9. MARINE MEADOWS MODEL



marine meadows matrix

system properties / development actions	Roads, Parking, and Buildings	Vegatation Clearing and Logging	Irrigation	Ground Water Withdrawl	Chemical Pesticides	Fertilization	Drainage Improvements	Septic Tanks	Sewage Outfall	Solid Wastes	Plowing and Cultivation	Channels	Boats	Boat Docks (fuel)	Causeways, Bridges	Dredge & Fill	Thermal Wastes	Commercial and Sport Fishing
Phosphorus	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Nitrogen	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Turbidity	+	+	+	O	X	+	+	+	+	+	+	+	+	+	+	+	+	+
Attached Algae	±	±	±	—	—	±	±	+	+	±	±	—	±	—	±	—	±	—
Turtle Grass	±	±	±	±	—	±	±	±	±	±	±	—	—	—	—	—	—	—
Plankton Algae	±	±	+	X	+	+	±	+	+	±	±	+	+	+	+	+	+	—
Toxic Residues	+	+	+	O	+	O	+	X	+	+	+	+	+	+	+	+	+	+
Organic Matter	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Small Fish Food	X	+	+	±	+	+	X	+	+	±	+	—	±	—	—	—	±	+
Larvae	X	X	X	+	—	X	—	X	—	—	X	—	X	—	X	—	—	—
Shrimp, Mullet	X	X	X	±	—	—	—	X	—	X	X	—	—	—	X	—	—	—
Sports Fish	—	X	—	X	—	—	X	X	—	+	X	±	—	+	+	±	—	±
Salt Water (salinity)	—	—	—	+	O	O	—	—	—	+	—	+	O	O	—	±	—	O
Circulation	O	O	+	—	O	O	+	+	+	—	+	+	+	—	—	±	+	O
Oxygen Variation (range)	+	+	+	—	+	—	—	—	—	+	+	—	+	O	+	—	—	+

+ Stimulant
— Depressant
O No Effect
X Further Study Needed

general notes:

It is very difficult to represent the energy network diagram by the use of the matrix. The matrix is a lineal tool and lends itself to describing only limited kinds of systems. The energy network diagram however, if modeled on the analog computer identifies the interactions of all components of a system, including secondary, tertiary, and indirect effects of the model.

A plus, or stimulant, to any system (or component) may not be a positive value to that system. Over stimulation may have long term adverse affects to a system, subsystem, or cause negatives elsewhere.

4. Identification of Values and Sensitivities

The sensitivities of the systems can be read from the energy network diagrams (Figures 8, 9 , 11) as the points of intersection between one of the causal actions of man and the inside features of the system. Many of these interactions are multiplier actions, so indicated by the multiplier symbol. The system is particularly sensitive when the coefficient for the multiplier action is large such as a poison interacting with a fish population. Not only are the fish displaced, but the pathways in which the fish are multipliers are also changed by large factors. Ultimately, the pathways of the diagrams were chosen from experience of observed situations of interaction. The diagrams are a shorthand way of summarizing at a glance these experiences of the past along with our theories as to how and why the interactions developed.

The sensitivities of the network are also represented in the tabular matrix form (Figure 10) which has an intersection between forcing functions on the sides and the system components inside the energy diagrams. A serious short coming of the matrix, however, is its inability to illustrate the true dynamic nature of the behaviors of a growing system. Since energy is continually flowing in all pathways and storages of the system, the matrix, at best, can only show primary interactions in a two dimensional array; and these interactions may or may not be of significance to understanding the behaviour of the system.

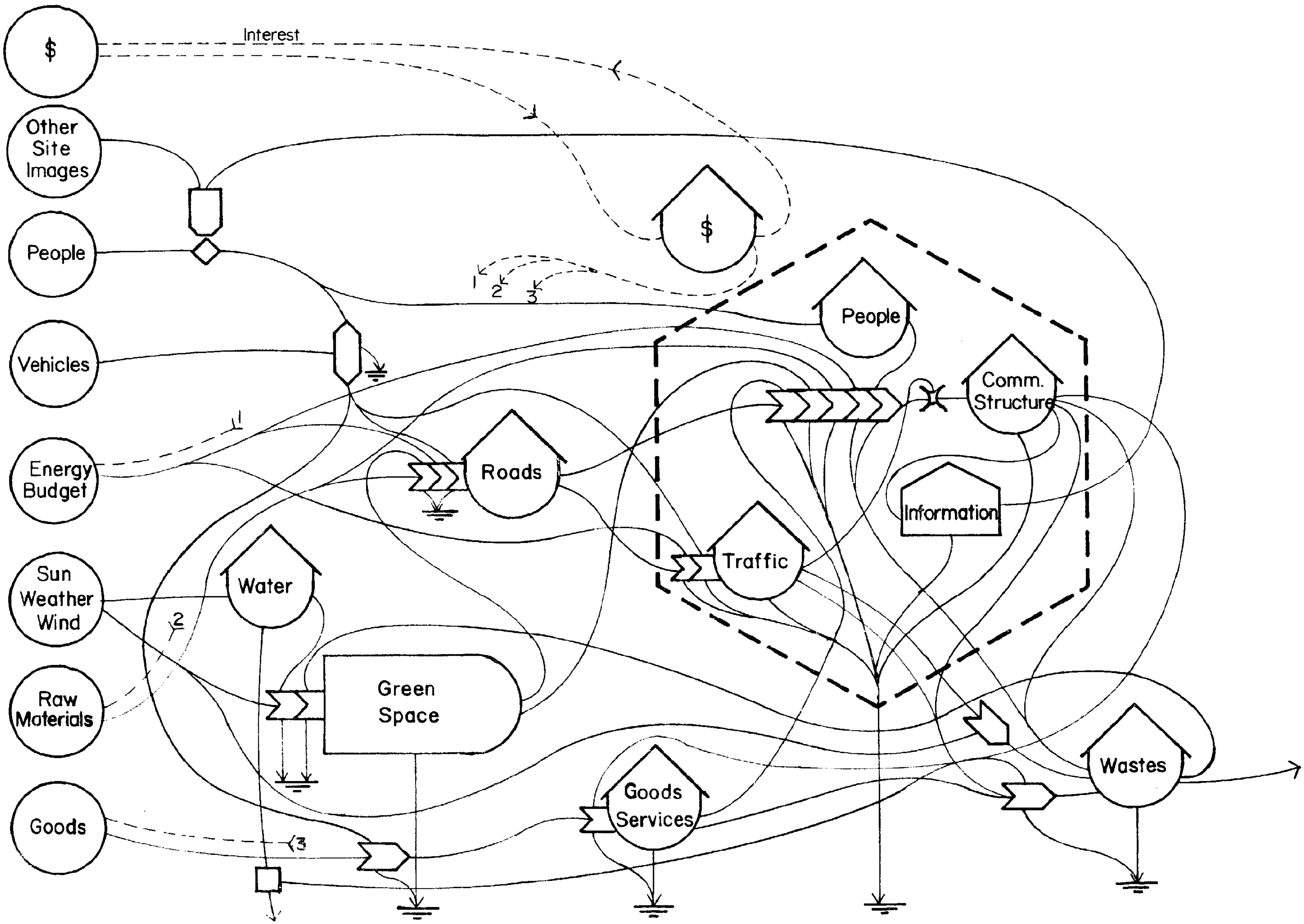
Based on the energy analysis, the consideration of sensitive pathways and the magnitudes, it becomes possible to provide some guidelines for retention of value while adding new uses where this is deemed more valuable on an energy basis considering the stresses introduced. For example, consider the marine meadows: (Figures 9 , 10).

Since the main energy bases for these rich nursery waters are the moderate currents plus sunlight, no action should cut off or divert the currents or cause turbidities that will shade out the productive bottoms. Dredging, silting, adding wastes with high BOD that grow bacteria turbidity, or heavy nutrient fertilization that adds algal shading, will damage this system. Dredging or filling will alter this system, which requires a set depth in relation to sun and waves. The system can probably take considerable boat traffic, growing back the grasses eliminated by propellers. There are many areas that could be made more fertile if waters were shoaled back to their predredging levels, or if access to currents and gentle wave motions could be restored or developed anew. These fertile meadows have the power of absorbing considerable nutrients as long as the concentration is not so great that the planktonic turbidity algae take over. The shallower beds are more resistant to the shading but less resistant to the disturbance by boats, dredging, etc. The rich beds are the nurseries for many species that when larger, occupy the deeper waters. Thus no kinds of toxins to animal life should be added. One of the best ways to test the stress on the beds is to make a diversity count. The general productivity may be estimated by oxygen measurements or biomass of green stuff per square foot.

Whereas considerable knowledge exists on the levels of energy flow in the work of ecosystems in contributing to value, the model in Figure 16a suggests that the work done depends on the interactions with other systems in the region. Thus, the metabolic energies considered alone may be misleading. In general, the wetland systems have metabolic work process rates of 30 to 70 kilocalories per square meter per day, whereas the drier systems with limiting factors such as water, holding the metabolism down to 5 to 30 kilocalories/m^2/day. These energies are as high as those of residential districts but less than high energies of industrial districts, heavily-traveled highways, and downtown business districts. The capital energy values of the systems with big trees may be very high, derived from multiplying the rates by the age of the system required for replacement. In any particular case, the pathways of interaction may be calculated, although little of this has yet been done. Very high physical energies are involved in values of beaches, strong tidal channels, and in river ecosystems.

A map of existing metabolic values should be used with caution. It is not a map that indicates values of developments or areas which will increase in value if developed. Zones of high metabolic values need to be saved, but these high value zones may also be the ones which have high amplifier value with some development activities of man that do interfere with the system (to which they are relatively insensitive.)

Figure 11. COMMERCIAL STRIP MODEL



5. Bibliography: Coastal Resource Subsystems

Lugo, A., Snedaker, S., Bayley, S., Odum, H. T., *Models for Planning and Research for the South Florida Environment Study,* August 1971.

McHarg, Ian, *Design with Nature,* Natural History Press, 1969.

Odum, H. T., Copeland, B. J., McMahan, E. A., *Coastal Ecological Systems of the United States,* report to the Federal Water Pollution Control Administration, 3 vols., 1969.

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Peterson, L., et al, "Towards a General Theory of Planning Design," Southwest Florida Planning Team, Department of Architecture, University of Florida, in publication.

B. REGIONAL HYDROLOGICAL SYSTEM

1. The Hydrological Cycle and its Processes

Development of any coastal zone constitutes a manipulation of the most sensitive part of the total (global) hydrological cycle (Figure 12), namely, the one that pertains to the direct exchange of fresh and saline water between land, aquifers, and ocean. For this reason, and since the hydrosystem of any zone, coastal or inland, is of great, if not vital importance to all life systems (including man's activities) in that zone, it is important that the hydrological system be defined and mapped, and its sensitivities determined, when development of the coastal zone is proposed. For an in-depth discussion of the hydrological cycle and the hydrological processes, the reader is referred to Butler (1), Eagleson (3), Linsley et al. (6), Meinzer (7), and de Wiest (8, 9) in the bibliography.

The system of water inflows, storages, and outflows may be represented by five processes, each of which is an important route or storage of water. The processes and the quantitative information describing them are listed as follows:

1. GROUND WATER RUNOFF
   - 1.1 Quality (Salinity)
   - 1.2 Quantity
     - a. Potentiometric Head
     - b. Aquifer Extension and Permeability
     - c. Surface Permeability and Slope
2. SURFACE RUNOFF
   - 2.1 Runoff Coefficients
   - 2.2 Surface Water Divides
   - 2.3 River Discharge
   - 2.4 Floods
3. EVAPOTRANSPIRATION
4. PRECIPITATION
5. STORM TIDES

These hydrological processes may not all be of great importance in the planning stage. For instance, it may be expected that the influence of increased evaporation due to paved areas during rainstorms in the coastal zone may be neglected completely when it is compared to the influence of such paving on the natural recharge, and thereby on the salinity, of the coastal aquifers. Likewise, development or preservation will have insignificant influence on the precipitation. This may be verified by the fact that the spatial variation of precipitation over the state of Florida is less than 20%, and that this relatively small variation cannot be correlated with present development in the state.

The data relating to the listed processes that must be known in order to estimate the relative impact of development on the hydrosystem of the coastal zone may be categorized as follows:

A. Ground Water Salinity

B. Potentiometric Head

C. Surface Runoff Coefficients

D. Floods

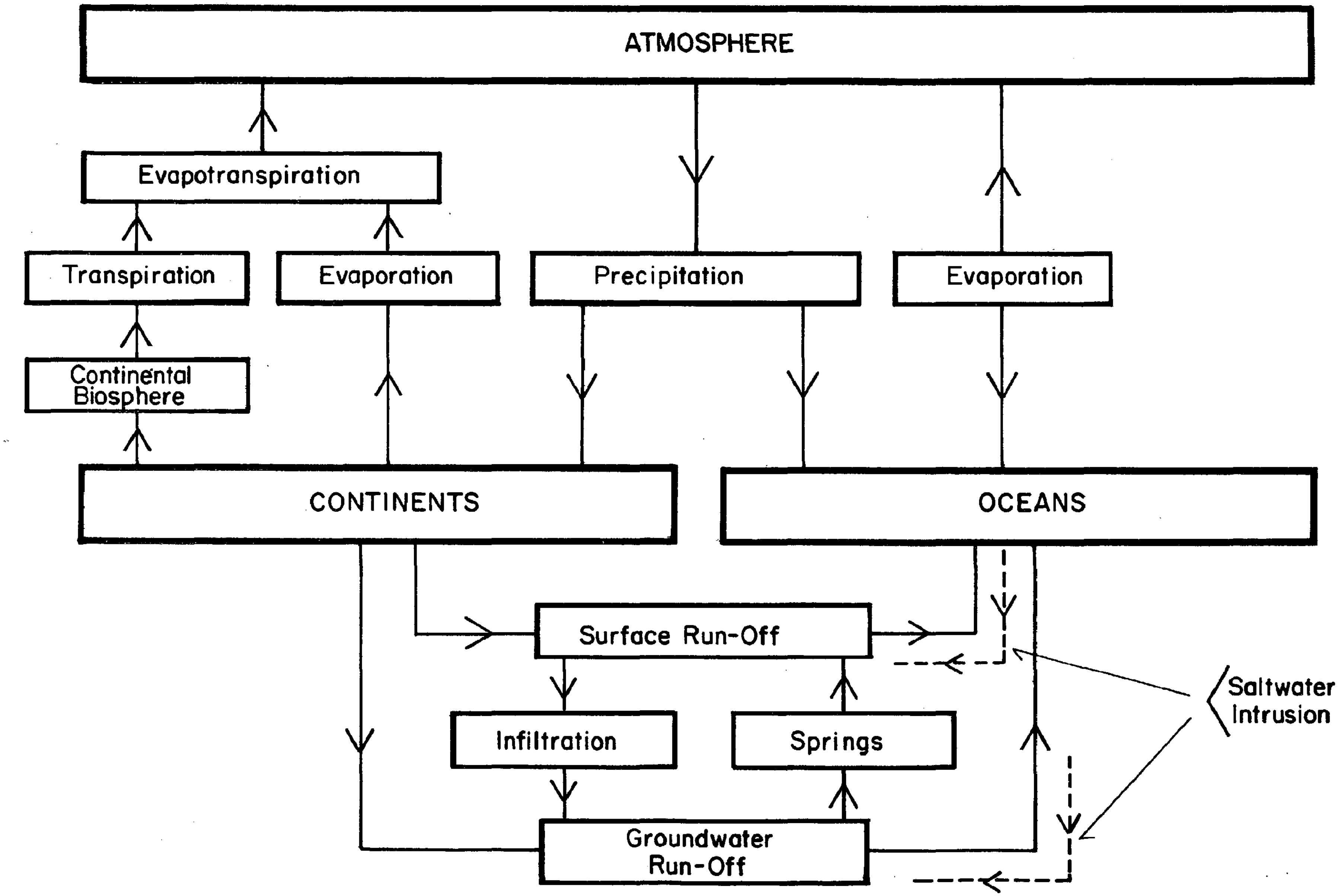
E. Storm Tides

These data are to be presented on five individual maps of the coastal zone that is being considered. These maps are shown in Figure 14 where the method developed in this study is demonstrated on a ficititious coastal zone and in Figures 15a, b, c, d, and e for the coastal zone of Lee, DeSoto, and Charlotte counties. Maps of these counties are identified by prefix L, D, and C, respectively in the following Section 4, on transparent paper and placed on top of each other, after criteria for development of preservation have been drawn on each map. From the composite map it will be possible to identify areas that should be preserved, conserved, or may be developed. Inasmuch as hydrological and geohydrological zones, i.e. areas with constant or nearly constant hydrological parameters, usually are extensive, it is recommended that the method be applied on the macroscale, i.e. when coastal areas of a substantial size, such as are involved.

2. Sources of Data

In developing the five maps required for characterizing the hydrological system and its processes, data are needed which are often found in technical papers and reports of water management agencies of the state or the federal government, industrial reports, county surveys, and university studies. The sources of data relating to the five maps outlined

FIGURE 12 GLOBAL HYDROLOGICAL CYCLE



above, and used in the evaluation of the coastal zones of Charlotte, Lee, and DeSoto Counties are as follows:

Map A – *Ground Water Salinity:* U.S. Geological Survey, Florida Division of Geology Reports.

Map B – Potentiometric Head: U.S. Geological Survey, Florida Division of Geology Reports.

Map C – Surface Runoff: U.S. Department of Agriculture, Aerial Photographs; U.S. Soil Conservation Service; U.S. Geological Survey, Florida Division of Geology Reports.

Map D – Floods: U.S. Geological Survey, Ocala, Florida; U.S. Soil Conservation Service, Gainesville, Florida.

Map E – Storm Tides: Corps of Engineers Report, U.S. Army: "Flood Plain Information, Charlotte and North Lee Counties", Florida May 1968.

3. General Criteria for Evaluating Harm to the Hydrological System

For each of the processes of the hydrological system, criteria for evaluation of possible harm due to development actions by man may be listed as follows:

1. Ground water runoff

1.1 Quality

a. No development with pumping for water supply or drainage should be permitted in regions with relatively high salinity of the groundwater, since such development will further increase the saltwater intrusion in the aquifer substantially. In other words, lowering of the potentiometric head should be avoided in such regions. Exceptions are cases where saltwater intrusion is prevented by establishment of a fresh water "barrier" of high potentiometric heads between the ocean and the site where drainage of the aquifer takes place. Such a "barrier" may be created by a series of recharge wells.

b. Aquifer recharge with waste water (in some cases not even after tertiary treatment) should not be allowed in aquifers with high permeability. An analysis should always be made of the seepage time from the recharge area to the nearest or most exposed water supply well.

c. Developments using septic tanks should be avoided in regions with a coarse top soil connected to an aquifer or a water course, to avoid contamination of otherwise potable groundwater or surface water. Such developments should also be avoided in regions that are subject to flooding due to rainstorms or storm tides from the ocean.

1.2 Quantity

a. In areas where the potentiometric head of the aquifer(s) is low, developments that include pumping of the aquifer(s) should be discouraged in order to avoid excessive saltwater intrusion into the aquifer(s). Exceptions are as given in 1.1.a.

b. A low value of the runoff coefficient is usually the indicator of a natural groundwater recharge area. Developments with excessive paving should be prevented in such areas, since paving virtually will stop the natural recharge of the groundwater supply. If developments involving roofing and paving are considered absolutely necessary in these areas, they should be located at the greatest possible distance from any water course on the beach, in order to avoid the storm water draining directly into a body of water from which it may never return to the groundwater or another freshwater resource. By forcing the storm water to flow the longest possible stretch over permeable land at least partial aquifer recharge may be accomplished. The runoff coefficient, which to a large extent depends on the permeability of the surface deposits, the land slope, the extension of existing pavement and housing, and the nature of the vegetation, is used in this study as a measure for potential natural groundwater recharge.

2. Surface runoff

2.1 Floods

Areas that are exposed to frequent floods due to rainstorms, etc. should not be developed. Chemical-industrial facilities should especially be barred from such areas, since a flooding of such a facility in most cases will result in serious pollution of estuarine and coastal waters. Also, nuclear and conventional power plants should be barred from these areas unless special precautions against contamination of the environment are taken.

3. Evapotranspiration

This parameter is probably of minor importance for the decision making in the development of the coastal zone.

4. Precipitation

This parameter is of minor *direct* importance in this study. It is, of course, of great indirect importance through fresh water flooding as mentioned previously.

5. Storm tides

Development, especially of chemical-industrial and nuclear facilities, should be avoided in areas subject to frequent flooding from the ocean due to hurricanes, storms and tides, for the same reasons that development should be excluded from areas that are exposed to frequent fresh water flooding.

4. Map preparation and map criteria

The five maps needed for the final evaluation of a coastal zone as far as the hydrosystem is concerned are prepared as outlined in the following. The recommended values of the five mapped parameters that define areas where precautions should be taken are, of course, subject to change in individual cases, depending on the degree of conservation and/or preservation that is desired.

The maps are all prepared at the same scale on transparent material (mylar for example). On each map, the region in which there is some potential for harm due to development should be uniformly colored with a translucent dye (grey), which must have the same density on all five maps.

Each map will show one of the following:

Map A: Ground Water Salinity (Figures 14 and 15a) Contours of constant chloride content should be drawn for instance, for values of 50, 100, 250, and 500 ppm (parts per million). The region including, say 250 ppm and higher values of the salinity should be colored. This is the region where most developments may be of harm. In cases where developments not incorporating artificial lowering of the groundwater table are considered, and when the water supply is piped in from outside the coastal zone, Map A may be omitted.

Map B: Potentiometric Head (Figures 14 and 15b) Contours of 1, 5, and 10 feet of potentiometric head should be drawn. The critical region is the one including, for instance, 5 feet and less. This region should be colored. However, the limiting value of the potentiometric head must depend on the type of development. In cases where heavy pumping of the ground water resources is involved, the suggested 5 feet limit may not be sufficient, but values in excess of 20 feet may be proposed. This is in part due to the high sensitivity of the location of the saltwater/freshwater interface to drawdowns of the groundwater table. A one foot drawdown of the groundwater table may in many cases result in a forty feet *rise* of the saltwater/freshwater interface. The adverse consequences of such a rise seem to be obvious. If the proposed development does not interfere with the natural groundwater table(s), this map may be omitted.

Map C: Surface Runoff Coefficients (Figures 14 and 15c) Contours of constant runoff coefficients should be drawn for values of 0.2, 0.4, 0.6, and 0.8. Since the runoff coefficient is a function of the permeability of the topsoil, the percentage of pavement of the considered land, and the slope of the terrain, the preparation of this map will require three other maps showing the distribution of:

a. permeability of the topsoil (Map C1) (Figure 15c1).
b. percentage of pavement (Map C2) (Figure 15c2).
c. slope of terrain (Map C3) (Figure 15c3).

The final surface runoff map is prepared by use of these three maps and Figure 13, which shows how the runoff coefficient depends on the aforementioned parameters and the rain intensity. Since the accuracy of Figure 13 exceeds the requirements of the present study, it is proposed that the fairly slight influence of the rain intensity be neglected, and that the four bands shown in the figure be represented by the circled values 0.2, 0.4, 0.6, and 0.8 respectively. Aerial photos may serve as an aid in the preparation of Map C, Howe (5). In some cases the evaluation of the runoff coefficients may require the services of an engineer specializing in the fields of hydraulics and hydrology.

The region including, for example, coefficient 0.2 and lower, should be colored. This may be considered as a potential groundwater recharge region.

Map D: Floods (Figures 14 and 15b) The boundaries of floods due to rain storms in the drainage area of any watercourse entering the coastal zone corresponding to 10, 25, and 50 years frequency of occurence should be drawn. In cases where this information is not directly available (based on observations), the preparation of Map D may require a complete flood routing analysis of the watercourse as described by Chow (2) and Henderson (4). It is recommended that such an analysis be carried out by a hydraulic engineer. The analysis will require runoff data from, in most cases, large areas outside the coastal zone, showing the substantial influence inland areas have on the coastal zone.

The region flooded, for instance, by a 10 year storm, should be colored.

In cases where the region is so flat that well-defined contours corresponding to the aforementioned flood frequencies cannot be established, it may be recommended to let Map D be represented by a completely grey area in the final analysis. This has been done in the case of the coastal zone of Lee, Charlotte, and DeSoto Counties.

Map E: *Storm Tides* (Figures 14 and 15e)
The boundaries of floods from the ocean due to storms and tides having statistical frequencies of occurrence of 10, 25, and 50 years should be drawn. The regional flood by, for instance, a 10 year storm tide should be colored.

5. *Overlaying Maps*

When the five maps are placed on top of each other, various regions can be noted where two or more colored areas overlap. The more overlapping, the more susceptible to harm is the region. There are two approaches to weighing the degree of harm. The first is to manually count the number of overlaps and apply the following scale:

NUMBER OF COLORED OVERLAYS	CLASS
0 (clear)	A – development
1 – 4	B – conservation (development with environmental safeguards permitted)
5	C – preservation

The second approach is to illuminate the composite maps with a uniform light source from behind and survey the resultant light flux passing through the overlays with a photo cell. In this case, the degree of harm is inversely proportional to the amount of light passed through the composite, and can be appropriately scaled.

Figure 14 demonstrates the weighing scale outlined above. The region shown in the figure is fictitious and for illustration only. This method is applied on the coastal zone of DeSoto, Lee, and Charlotte counties as shown on the maps of Atlas Appendix II (and in Section VII, MAP APPENDIX, in a reduced size). The reduced maps of Lee County from this Atlas are shown in Figures 15a through 15f.

FIGURE 13 EVALUATION OF RUNOFF COEFFICIENTS

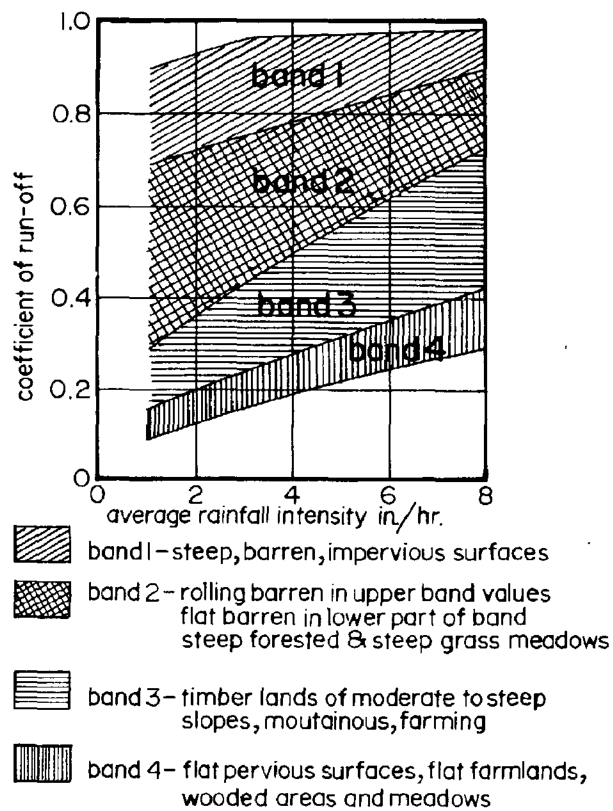


FIGURE 14 MAPS AND OVERLAYING MAPS

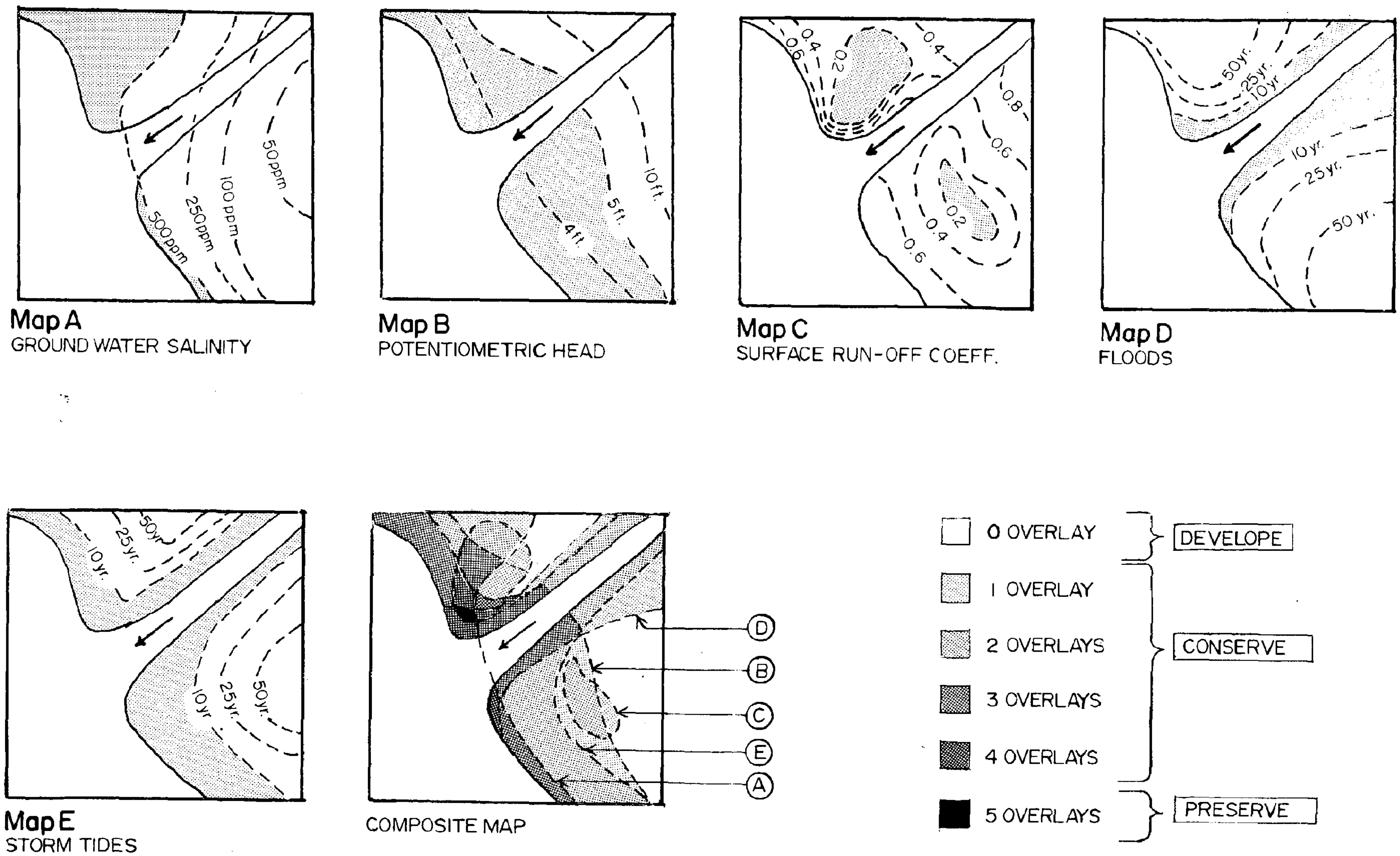


FIGURE 15a: GROUNDWATER SALINITY

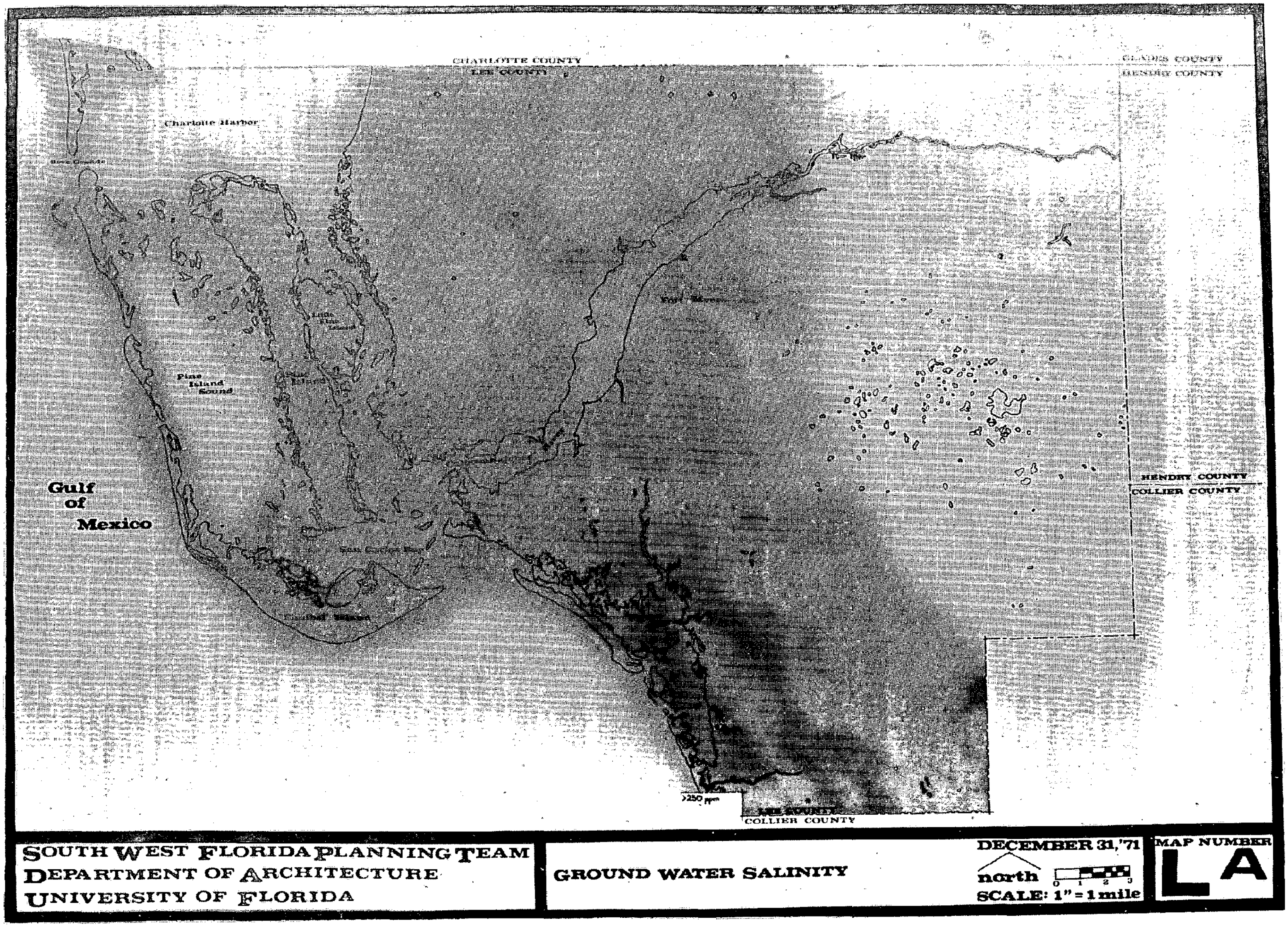


FIGURE 15b: POTENTIOMETRIC HEAD

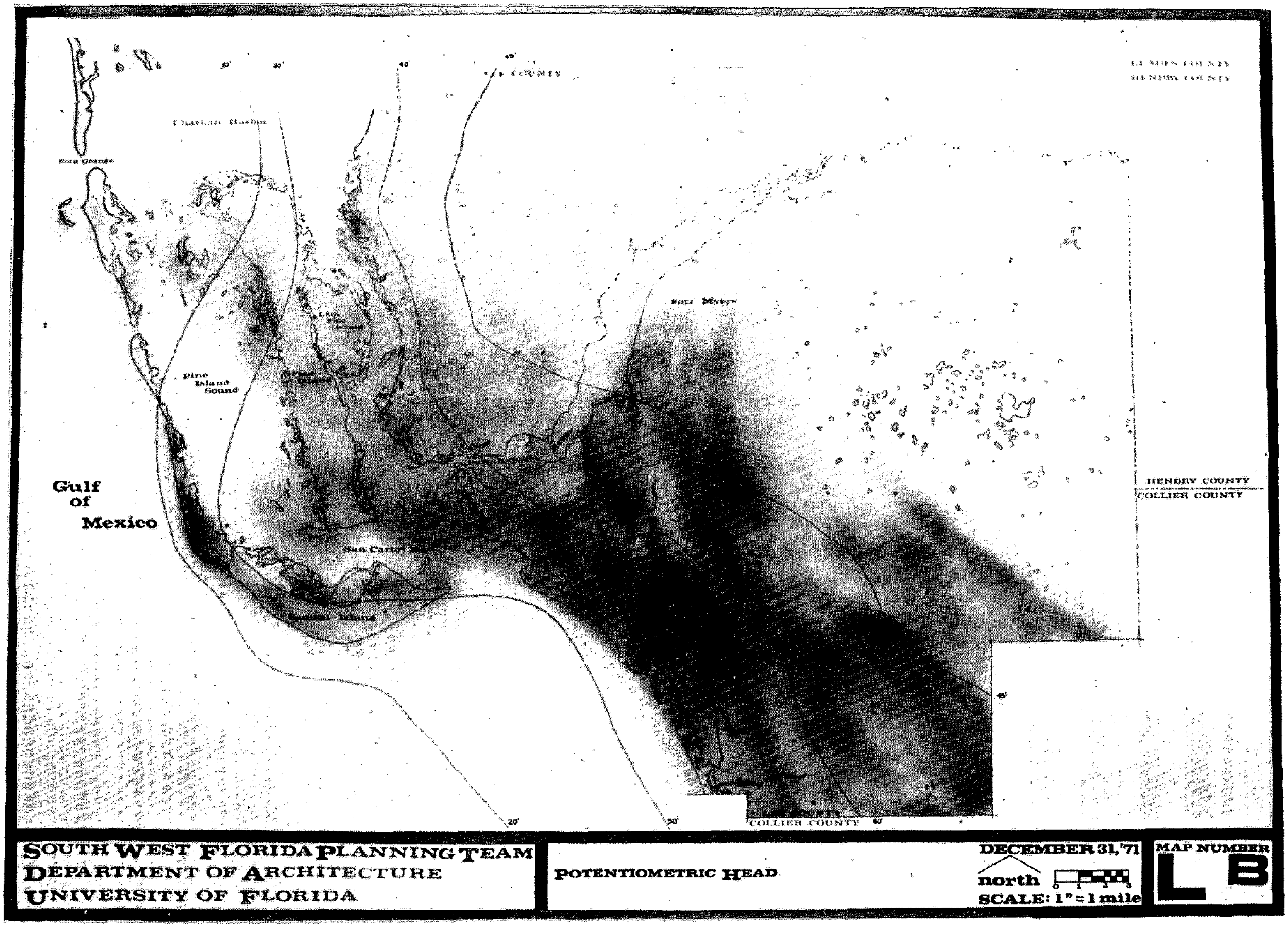
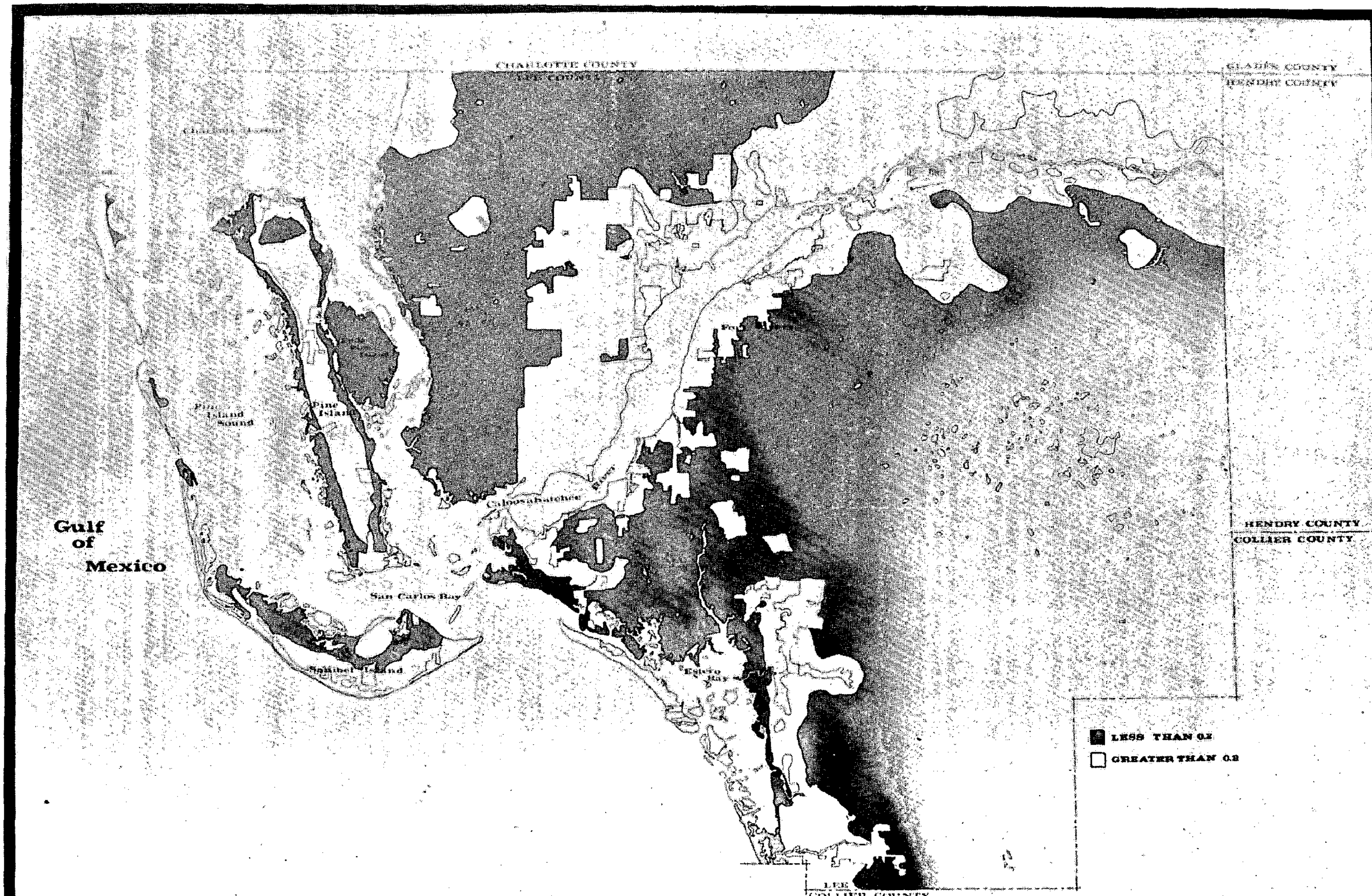


FIGURE 15c: SURFACE RUNOFF



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE RUNOFF COEFFICIENT

DECEMBER 31,'71
north
SCALE: 1"=1 mile

MAP NUMBER
LC

FIGURE 15c1: PERMEABILITY OF THE TOP SOIL

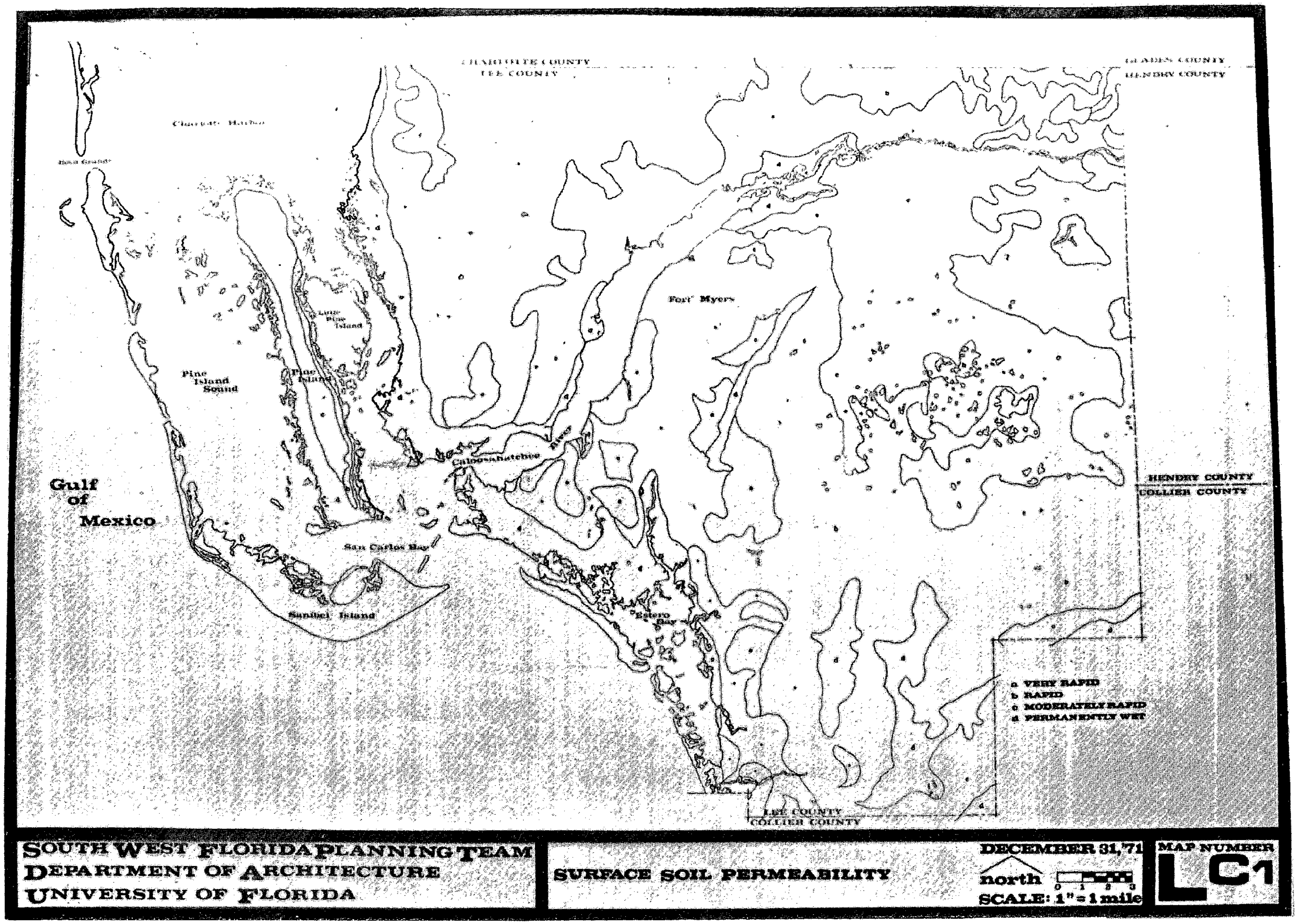


FIGURE 15c2: PERCENTAGE OF PAVEMENT

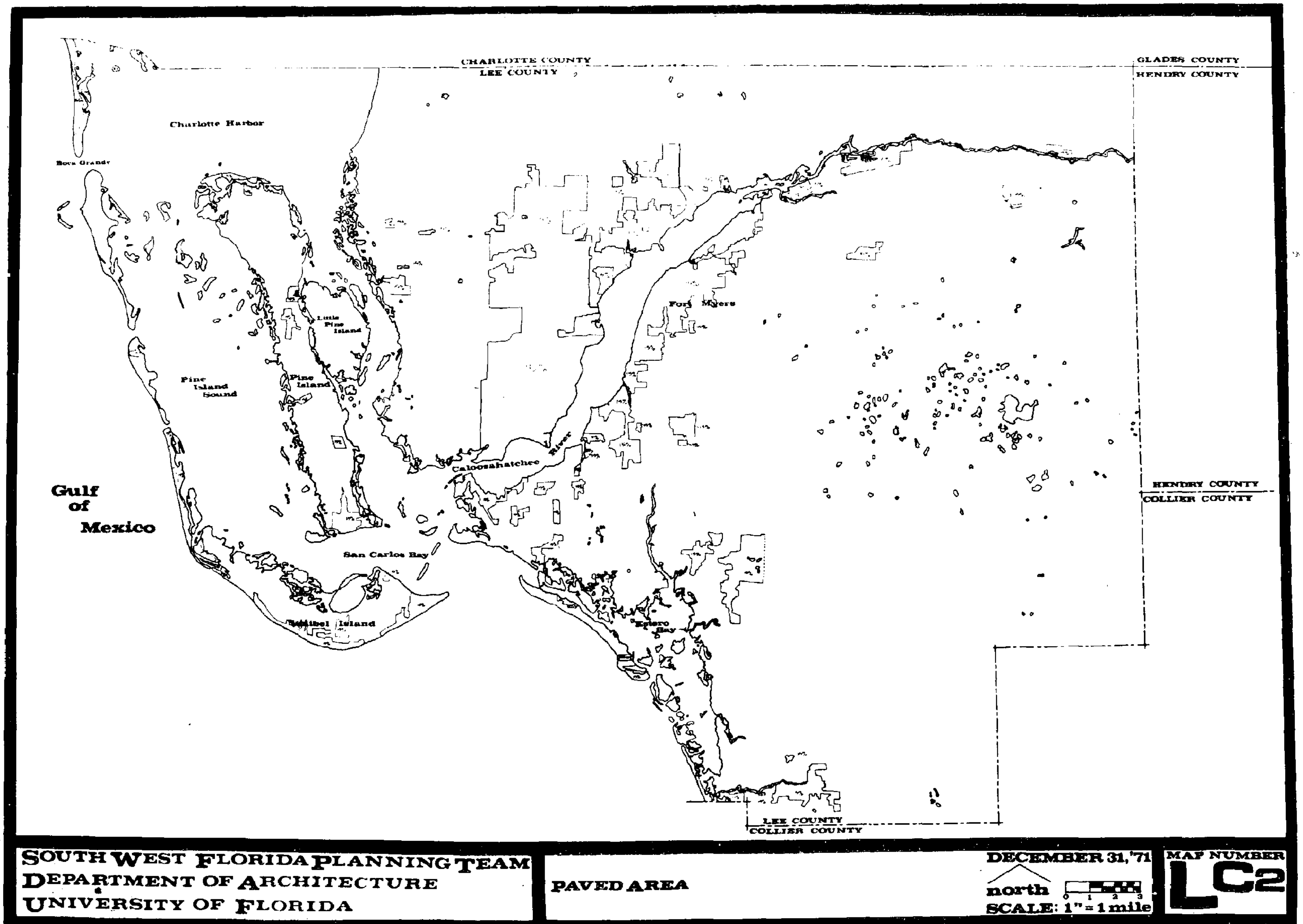


FIGURE 15c3: SLOPE OF TERRAIN

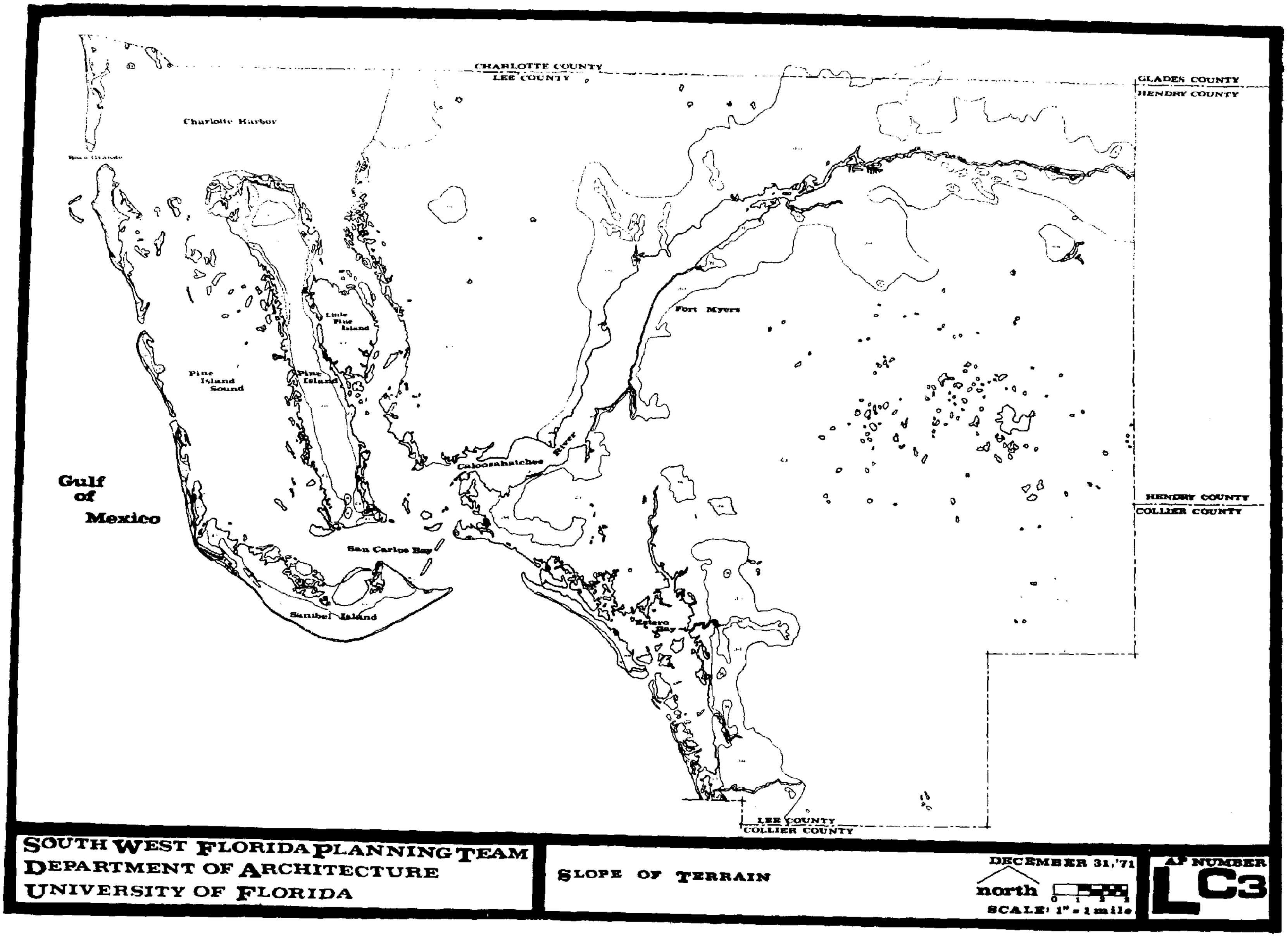
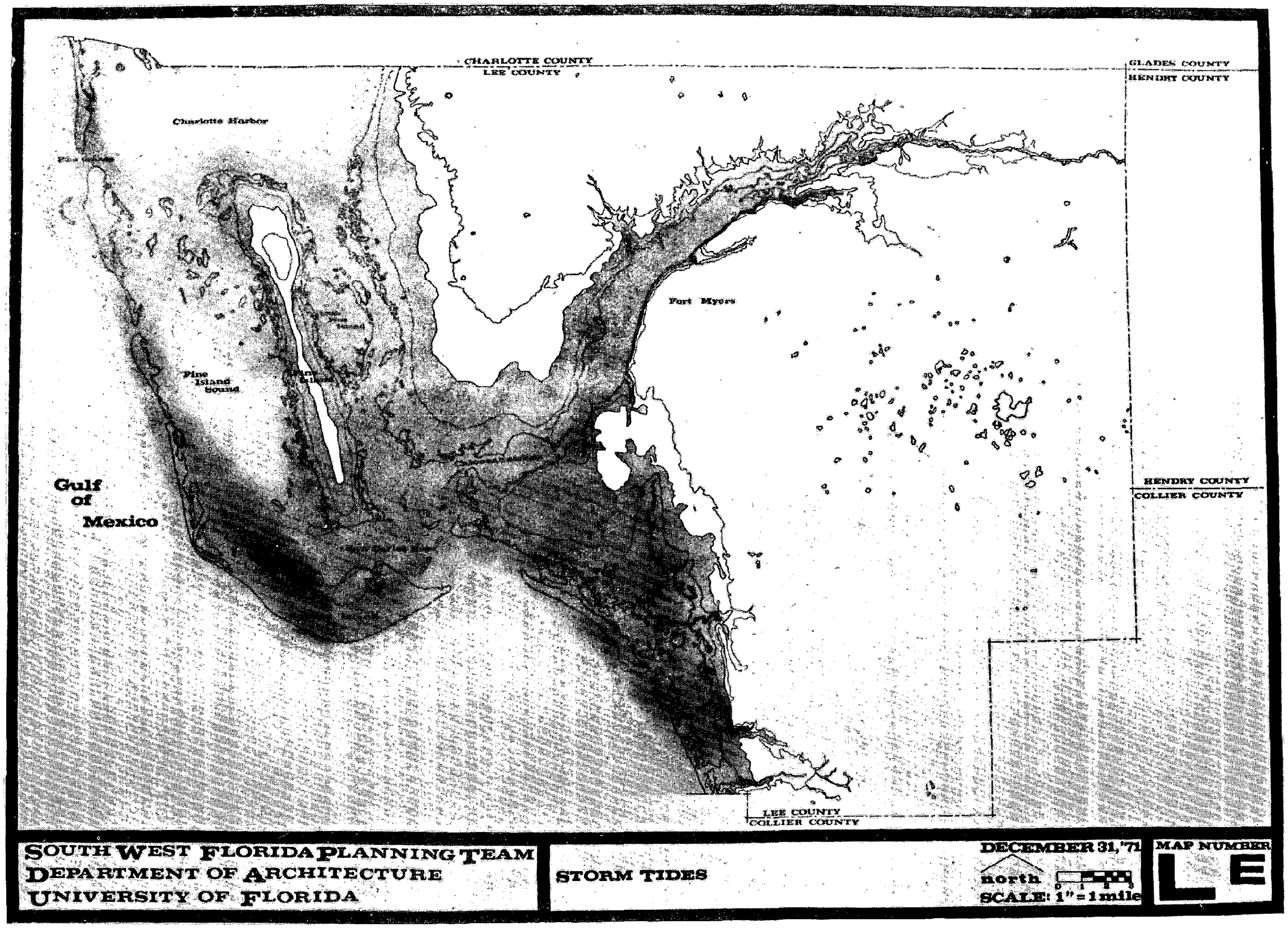
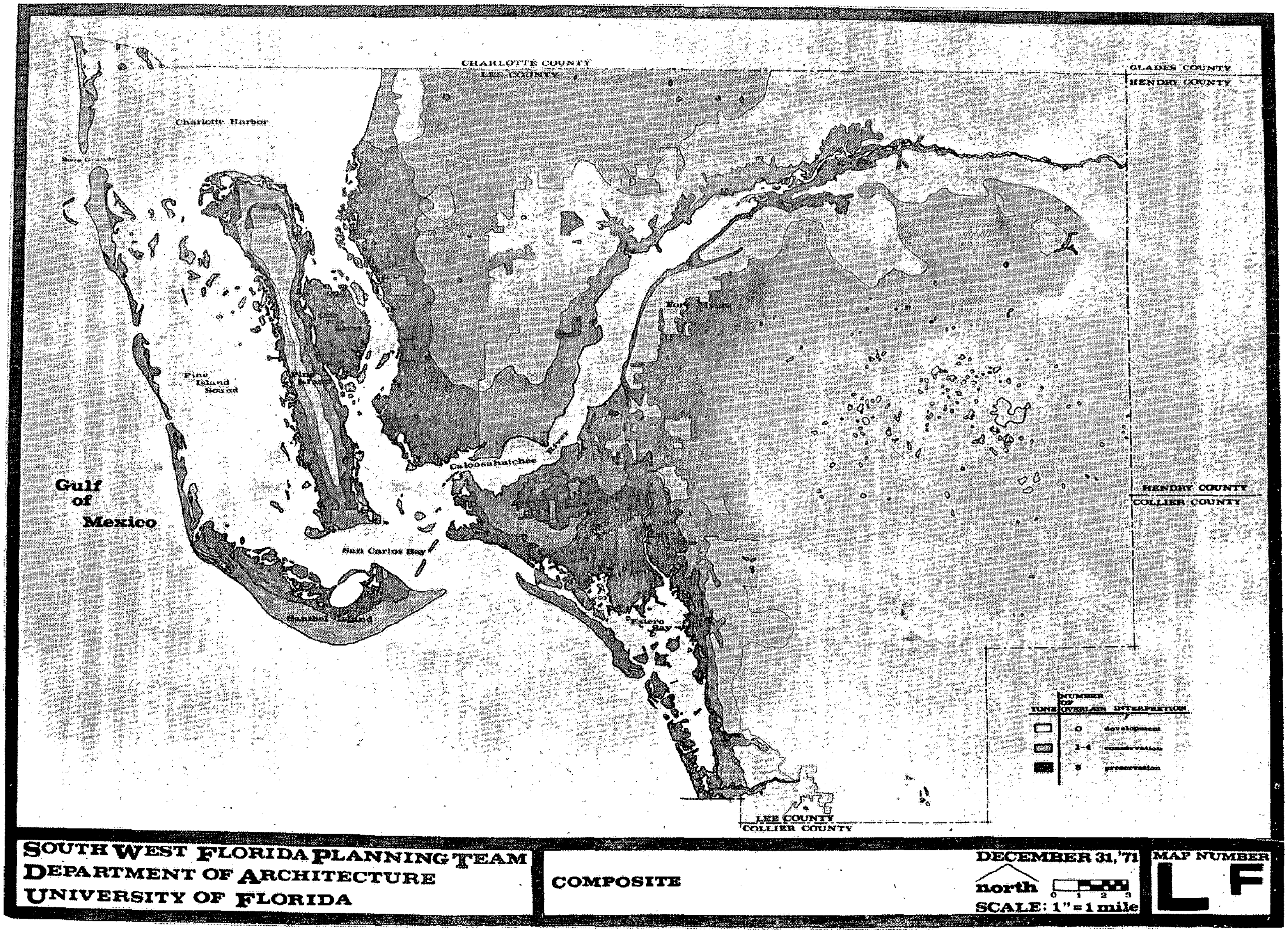


FIGURE 15d: FLOODS

This map is not needed in the present example. It is to be represented by a completely grey area.


CHARLOTTE COUNTY
LEE COUNTY
GLADES COUNTY
HENDRY COUNTY
Charlotte Harbor
Fort Myers
Pine Island Sound
Gulf of Mexico
HENDRY COUNTY
COLLIER COUNTY
LEE COUNTY
COLLIER COUNTY
SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA
STORM TIDES
DECEMBER 31, '71
north
SCALE: 1" = 1 mile
MAP NUMBER
L E


CHARLOTTE COUNTY
LEE COUNTY
GLADES COUNTY
HENDRY COUNTY
Charlotte Harbor
Pine Island Sound
Pine Island
Gulf of Mexico
Caloosahatchee River
San Carlos Bay
Sanibel Island
Estero Bay
HENDRY COUNTY
COLLIER COUNTY
TONE
NUMBER OF OVERLAYS
INTERPRETION
0 development
1-4 conservation
5 preservation
LEE COUNTY
COLLIER COUNTY
SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA
COMPOSITE
DECEMBER 31, '71
north
0 1 2 3
SCALE: 1" = 1 mile
MAP NUMBER
L F

6. Bibliography: Hydrological System

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C. OVERALL INTERDEPENDENCE AND REGIONAL PLANNING

1. Energetic Bases of Values for Planning

In Figure 16a, is an energy diagram that shows the bases of societal value including those accompanied by money transactions and the great majority which are not. The following discussion explains the several flows of this diagram that require consideration in land decisions to maximize regional, state, and national values.

The overall criterion for value may be the long range stability and survival of the whole nature/man system, and a decision about land management may be a good one that fosters a mosaic of patterns and interactions of man and nature that has survival ability. The structures of the region and the flows of work are derived from two types of causal sources, those of the natural inputs of sun, wind, waves, geological phenomena, etc. on the left, and those of special development by man deriving energies from outside power of fuels, electricity, immigrations, manufactured goods, etc. (these latter often called economic development) on the right in Figure 16a.

The whole regional system's ability to survive and stabilize under competitions of alternative subsystems probably maximizes when the total energies are maximized into system-stabilizing services and structures. Clearly this occurs when the energies of the natural sector are combined with those of the outside support and especially when the two are blended to yield additional interactive flows in which one serves to release the other's latent potentials into the service of the overall system. There is then balance and inter-designing of the two, which contribute to survival and stability.

Whereas, it is possible to develop an area with a man-derived (fossil fuelbased) system and to maintain it almost exclusively with outside power inflows, such a system does not generate as much service per unit of scarce fossil fuel as one also employing nature's original energies. If and as man's fossil energies become more and more scarce, exclusively fossil fueled systems may lose their ability to compete economically with systems that are better designed in a mosaic to use both kinds of energies.

Whereas, money transactions occur only in the right hand part of the system the economic vitality of that part of the system thus depends on the energy inputs from the left. If these are stressed or eliminated, the right hand system has to do more money costing.

Natural inputs necessary to maximize the regional values are decreased when land is transferred from the natural sector to the developed sector B, or when developments begin to stress (drain energies) from the natural sector as at S. The money costing increasing substitution at technology (T) for natural life support actions at L are negative characteristics that are competitive only when the outside energies are in ample supply during a period of expanding economics. When there is shortage in the supply of P the best overall system clearly has a balance of distribution of land in the two systems using both W and A. If either A or B is eliminated the combined system is less valuable.

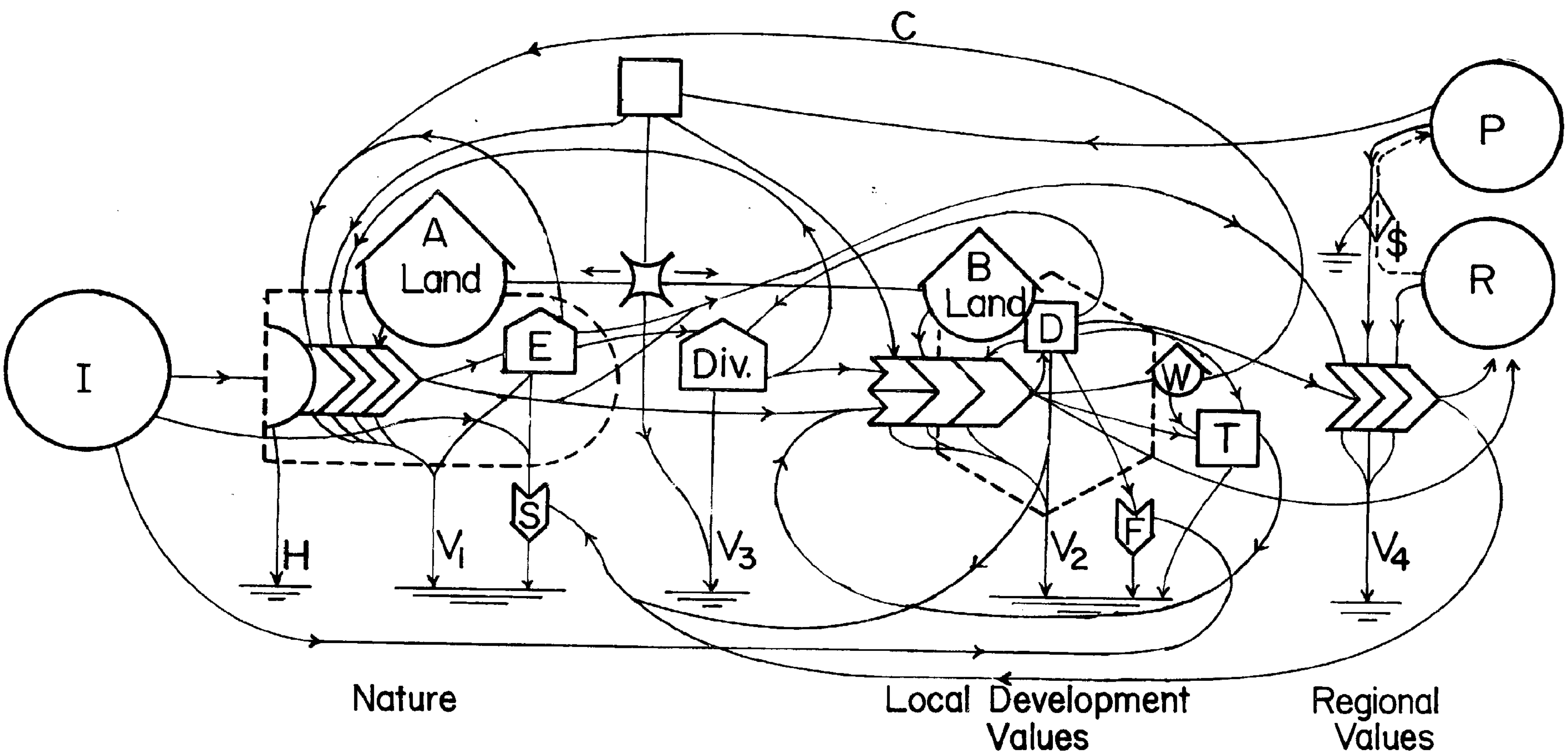
At this time unfortunately the optimum ratios between land areas in various natural (not subsidized by man) and unnatural (subsidized by man) use are not known. Yet available knowledge clearly indicates that conventional ratios are highly undesirable.

In our opinion the State would assume an unwarranted and dangerous risk if it were to permit land use patterns to develop which do not afford a positive interrelationship between all parts of the regional system. It is our judgement that the State should foster a land use pattern in which man-subsidized areas (urban, suburban, and intensive agriculture) occupies less than half of the land, square mile by square mile; the other portion should be in unsubsidized state (natural or in very low intensity use by man; areas which have their own self-maintaining ecosystems generating natural values).

Also included in Figure 16a is the stress of the natural systems on the man-developed components at F such as hurricane tides and floods. Maximization of total regional value requires that developments be guided so that they not only do not stress the natural systems, but also do not allow the natural systems to stress the man made systems.

In addition to local values in each land use there is the special value of interactive values that emerge when there are several systems in close proximity. Interactions increase as the square of the number of subsystems adjacent to interact. If, as we believe, the interactions are positive in generating survival value, interactions values are maximized where there is an intricate mosaic with high diversity of components including the man made and natural ones. Examples of such interactions are tour-

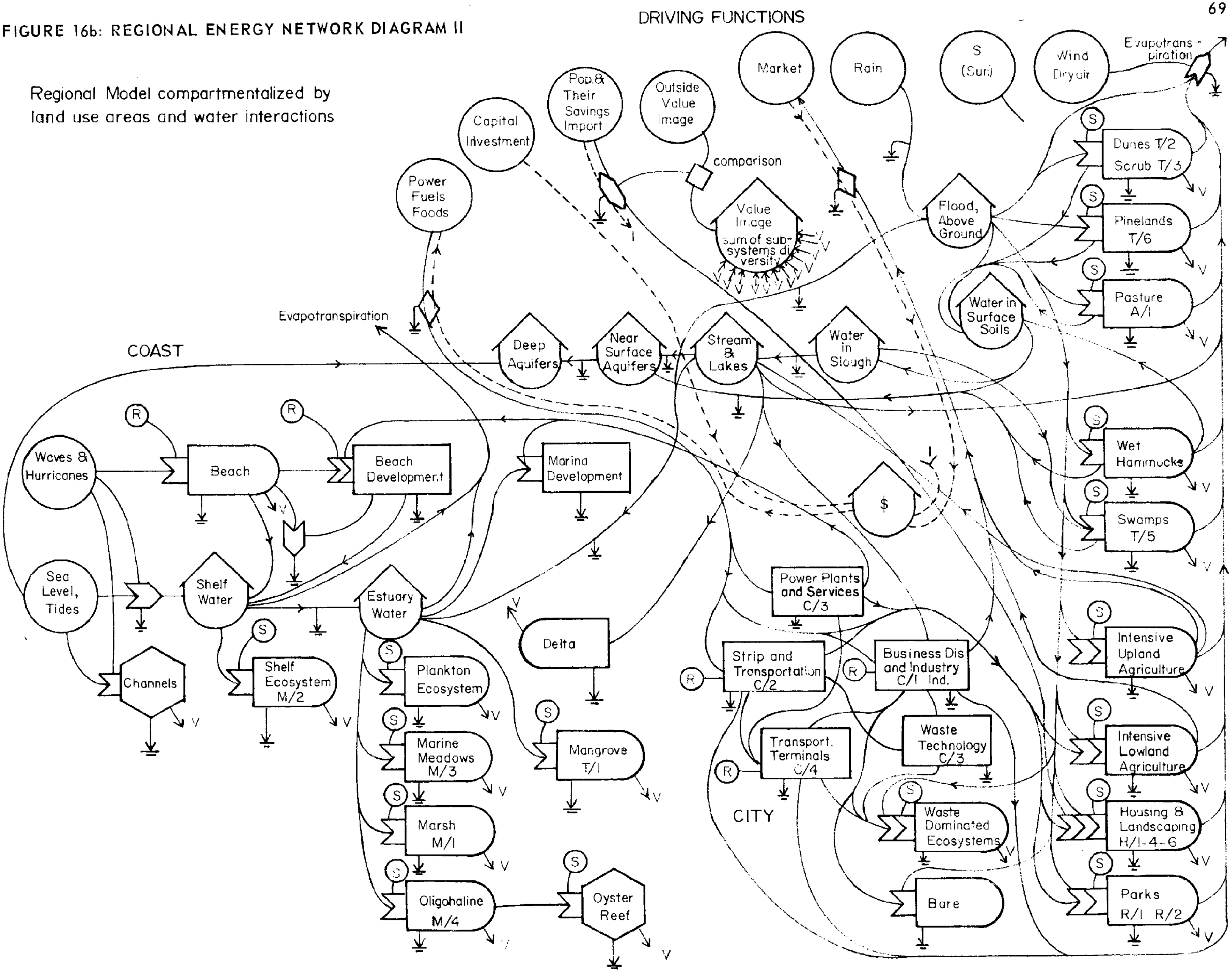
FIGURE 16a: REGIONAL ENERGY NETWORK DIAGRAM I



Model of main kinds of energy flows developing or detracting from value including natural values (V_1), local development values (V_2), local interactive value (V_2), I, Sunlight, weather and natural inputs. W, Natural climatic energy drives including water; A, Natural lands; E, natural systems; B, Developed lands; DIV, Diversity of mosaic of subsystem areas; P, outside energy inputs based on outside power; R, Pressure of outside regional users; F, stress on developments by natural energies such as floods; S, stress on natural systems by developments; M, land and power management policies determining the partition of natural and developed lands; V_3, values emerging from interactions of local subsystems; T, technology for substitution of natural areas when L is small due to diminishing system E; C, recycled wastes (W).

FIGURE 16b: REGIONAL ENERGY NETWORK DIAGRAM II

Regional Model compartmentalized by land use areas and water interactions



ism, high quality of residential life buffer actions of life support, the favorable fertilization of weak eutrophications of the sea and utilizations of the sea by the land systems. Thus, in Figure 16a, the interactive components of value are indicated by V3.

If there is a subsystem that is becoming very scarce in a region, its value for use and interaction by the others becomes much increased. Examples are the increased values of beach access as existing beaches become prompted or polluted. Each class of a natural subsystem achieves very high values as it becomes scarce since it is a genetic resevoir, a recreational focus, and a seeding basis for system use in the future. The value that a subsystem has when in short supply extends far beyond local situations. Thus, cypress swamps which were relatively unusual in Florida now have high values as multipliers far beyond their local considerations because they are scarce on a larger scale.

In Figure 16b, the action of land management agencies is shown at J controlling the partition of land between A and B and providing energy controlling subsidies to the natural systems at K. In the past the total money involvement at L has been the conventional criterion whereas the preceding discussion suggests the correct criterion is the sum of total self serving work, V, in ratio to P. Any actions that increase S, F, T, unnecessarily will decrease the above ratio. In other words the criterion for land management is proposed to be the maximization of the flows of self-serving energies calculated in units of calorie equivalents such as food and fuel.

In considering different areas, some natural systems have higher energy flows than others and thus may be contributing more to the system of the whole. These systems can take a higher percent of interaction with man before they are stressed, but if eliminated by overuse by man, the value loss is the greater. Examples are beaches, and coastlines. In some areas the natural energies are small as in the very dry areas, the systems being water limited from full flow of natural metabolism. Low energy systems are easily trampled by man and there is the tendency to regard them as low value. On a regional basis, however, they have high values in the water system for aquifer recharge and as they become scarce, have a high value in the wildlife and recreational usages. The same difficulties with drying make the costs of their use in such systems as housing high, requiring irrigation and land management by man from regional supplies. Development of such lands changes their role from a plus to a negative on the water system.

2. Regional Model of Sensitivities – Principles

Whereas the model in Figure 16a gives some principles of maximizing value for any land area including its regional value interactions, a more detailed model of subsystem interactions is needed to indentify the direct and indirect actions that follow from changes in water, land use, and economic developments. Such a diagram for the subsystems of water and land is given in Figure 16. Both Figures 16a and 16b are only qualitative guides at this stage helping the decision maker to understand the kinds of changes that may follow elsewhere in the complex system from changes at a local place. In time, as numerical evaluations are made on specific examples, coefficients will be placed on the flows and multipliers so that quantitative predictions are also shown on the diagrams. Thus, these regional models are impact statements which are qualitative now and may become quantitative later. Ultimately, evaluated models can give simulations to show the kinds of time trends to be expected from trends or proposed actions affecting the forcing functions or internal structure of pathway relationships. At the present stage of the regional model, it may be used to answer the question what kinds of repercussions does the proposed action cause in other parts of the system.

3. Summary of Findings

The following tabulation and map (Figure 17) summarizes our findings. They are based on the hydrological findings reported above coupled with our ecological observations. The ecological considerations are the result of evaluations using the criteria set forth above on the basis of currently existing knowledge. For each subsystem the controlling criteria are given as reasons in the tabulation.

The terms "preserve" and "preservation" are used in the sense defined by the Coastal Coordinating Council: "ZONING CATEGORY: PRESERVATION. No development permitted except in cases of overriding public interest as determined by the Florida Cabinet and/or the Legislature. The subcategories included are those physical features which are essential to preserve the ecological balance, especially of marine life, and protect the physical integrity of the coastal zone, thereby enhancing the amenities, aesthetics and quality of life for residents and tourists. Preservation zoning is deemed to be of statewide significance and therefore, a state-level responsibility."

The terms "conserve" and "conservation" are used to indicate that an

RECOMMENDATIONS REGARDING PROTECTION FROM INTENSIVE DEVELOPMENT IN THE COASTAL ZONE OF LEE COUNTY ACCORDING TO A REAL EXISTING SUBSYSTEM

Symbol	Name of System	Recommendations	Main Reasons
M/1	Marshes	Preserve all; reconstitute those lost	a-f
M/2	Shelf Waters	No development possible	g
M/3	Marine Meadows and Nursery	Allow no development	h, i, b, c, q
M/4	Oligohaline System	Reduce pollution and conserve. Consider changing water regimes to more steady pattern or couple fish harvest to existing sharp pulse of salinities	j
M/5	Medium Salinity Plankton System	Leave alone, don't dredge	g, k
M/6	Tidal Channels	Leave alone, don't jetty	g, k
M/7	Sewage Waste Zones	Keep dilute, sanitary, and filtered through land systems first	l, m
M/8	Intertidal Beach	Don't develop, allow room for accretions and recessions; allow no rock constructions; remove existing ones	n
	Above Tide Beach	Don't develop, keep vehicles off	n, o, d, e, f, g

REASONS:

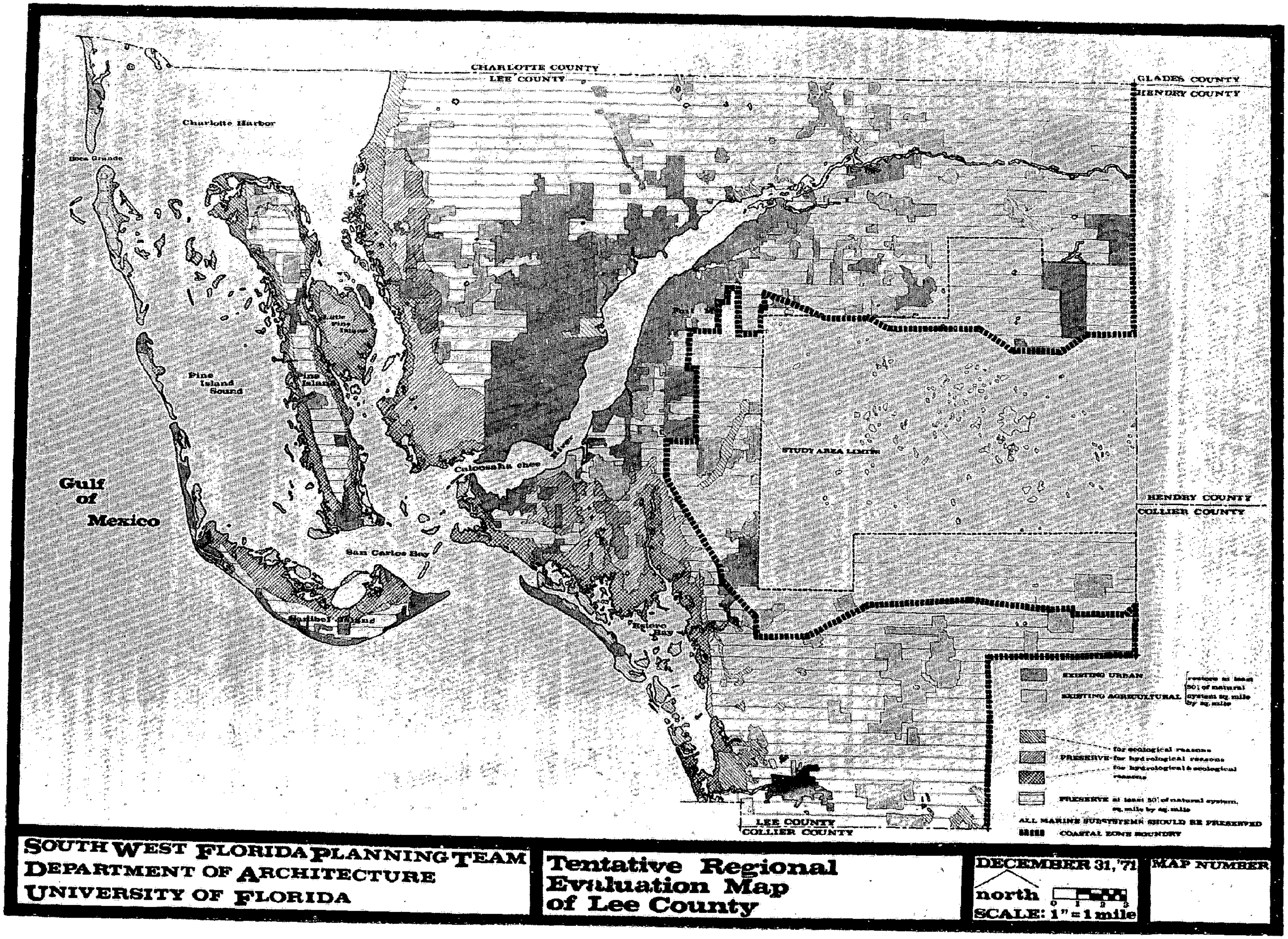
a. coastal protection; b. nursery function; c. waste amelioration; d. shore protection; e. coastline panorama; f. regional diversity value; g. too expensive to protect developments; h. nursery important to other systems; i. high existing productivities; j. existing regime erratic flushing of freshwaters alternating with saline conditions; k. maintain self-generating current and wave equilibria on sediments and organisms; l. health values; m. excess fertility produces instability and detrimental values of low oxygen; n. regional beach values depend on continual steady pattern of beach maintenance by currents and transport; o. self-maintaining vegetation is delicate; p. beach dune fresh waters serve to protect salt water intrusion and normal beach slope equilibria maintain sea front protection; q. recreation and fishing; r. recharge needed without paving; s. dry soils if developed, require excessive irrigation to use; t. wildlife and diversity; u. regional water storage; v. scarce regionally; w. diverse land production values; x. buffer all developments

Symbol	Name of System	Recommendations	Main Reasons
T/1	Mangroves	Preserve all; reconstitute those lost	a, b, c, d, e, f, g, h,
T/2	Scrub	Preserve the bands along coast, preserve at least half of larger inland areas	o, d, e, p, r, s,
T/3	Dune Transition	Preserve at least half, if any development is permitted do not disturb vegetation	o, d, e, p, r, s,
T/4	Hydric Hardwood and Hammock	Preserve all of these wetlands	c, f, g, u, t
T/5	Cypress Domes and Strands	Preserve all	c, f, g, u, t, v
T/6	Pinelands	Preserve, square mile by square mile, at least 50% of land in natural state (not subsidized self maintaining) condition.[1] Any developments to be conditioned on hydrological considerations as shown on map in figure 17.	s, t, x, c, f, t
A/1 A/2	Pasturelands and Citrus and Flowers and Truck farms	Provide, square mile by square mile, at least 50% of land in natural (not subsidized, self-maintaining) condition.[1] Areas with high concentration of pesticide runoff requires special study. Any developments to be conditioned on hydrological considerations as shown on map in Figure 17.	f, w, x, c
H, C, & R	Urban and Housing Areas	Provide, square mile by square mile, at least 50% of land in natural (not subsidized, self-maintaining) condition.[1]	c, f, i, t, u, w, x
D	Bare and Scraped Areas	Don't leave bare; provide, square mile by square mile, at least 50% of land in natural (not subsidized, self maintaining) condition.[1] Any developments to be conditioned on hydrological considerations as shown on map in Figure 17.	i, c, f, w, x

Note: We also suggest that additional natural zones be established regionally of sufficient size to providefor the perpetual survival of a *full* spectrum of all species of wildlife. Additional research is required to identify such areas.

1 Certain low intensity agricultural activities, which are low in subsidy or runoff, after appropriate study and with appropriate safeguards may prove able to perform as natural areas.

FIGURE 17: TENTATIVE REGIONAL EVALUATION MAP OF LEE COUNTY



area is not suitable for conventional intensive development and that after thorough study it may prove possible to admit limited developments designed with strong environmental safe guards.

4. Suggestions for Planning and Protection Measures

It is now well established that all the Earth's land/water areas must be subject to communal concern and require various measures of communal protection from uses which would be detrimental to the communal good. The State of Florida, through the Coastal Coordinating Council, has a large portion of the responsibility for instituting appropriate protection of Florida's coastal zone. As a State Agency, the CCC must of course represent the State's immediate interests, but it cannot neglect the larger interests of the Nation and the World.

Florida's coastal zone is in particularly urgent need of protection for the following reasons 1) Developmental pressure in the coastal zone is steadily increasing. 2) Developments in the coastal zone tend to be predesigned (planned) by a developer and thus are not self-designing. Shortcomings in their design are at first latent and not experienced by the developer who divests himself of the property, but will be experienced with unusual rigor by the inhabitants as the developments are consummated. 3) The natural ecosystems and the hydro-systems of the coastal zone, by virtue of their indispensible role in the world ecosystem, are highly valuable to man. 4) These systems are relatively easily destroyed by conventional developments.

From whatever viewpoint, the State, the Nation, or the World, environmental coastal measures needed to be based on knowledge of the societal values of future environmental alternatives not yet available. Short of such knowledge, our suggestions for planning and protection are based on the research performed in this project and our various previous experience. They represent only certain viewpoints and do not purport to constitute a complete set of appropriate control principles.

First, let us submit that the so-called coastal zone, although a useful concept in certain respects, is arbitrarily delimited from ecological and hydrological view points. Both the ecological and hydrological systems transcend its boundaries and need to be considered as wholes. It is entirely possible to have coastal zone control measures rendered futile by inappropriate developments inland.

a) *Exclude certain uses from coastal locations*
These would be uses which do not require coastal locations. Emphasis should be placed on those that are especially destructive of the environment and those incompatible with major appropriate uses. Examples of such uses are: certain industrial and agricultural uses and certain types of urban developments. Such uses would constitute misuse of a land resource in short supply. Further study is required to identify such uses and developments.

b) *Exclude uses from areas unsuitable for such uses*
For example, urban/suburban developments should not take place in areas subjected to flooding, in areas with poor drainage, or in areas with poor water supply. Areas which are exposed to river flooding or hurricane storm flooding need to be protected from developments so that there are not economic losses from high maintenance and replacement costs as well as loss of portective services of the natural ecosystems adapted to the special energies. Beaches, swamps, and stream margins are examples. Such areas are identified on maps in Atlas Appendix I and II to this study and in Section VII, Map Appendix. Another example is areas with poor soil bearing capacity. Areas with such limitations may be appropriate for other uses according to the principles set forth below.

c) *Preserve and/or conserve areas having particular value in existing state*
This category would include those areas found at the high value end of the value spectrum in our tentative table of value for the subsystems, calculated from energies, shown in Figure 11. The locations of the subsystems are shown on maps 1 – 12 in Atlas Appendix I, and reduced in Section VII, Map Appendix. Other areas of important value in their existing state are areas of critical function in the hydrological systems, as identified by the hydrological maps in this study.

Some areas are important parts of the regional water system. Some of the sandy uplands serve as recharge and if developed cause runoffs or require irrigation for vegetation, both effects detrimental to the water system. Sandy dune areas along the coast maintain local water storages and block salt-water intrusions provide storm wave and flood protections. Freshwater swamps provide water storage and time delays preventing floods and water loss to the sea. For each foot of above sea level water table maintained there is 40 feet of freshwater lens maintained in the rocks below keeping out salt water intrusions from below.

A subsystem which is rare in the region, a remnant, is a contributor to the regional diversity, to gene pools, to repopulations, to recreation, to aesthetic enjoyment, and to historic values, and merits preservation. Examples are cypress remnants, coastline panorama subsystems, and reefs.

A natural subsystem area merits preservation if it contributes to the diversity of system types available in the radius of an individual movement as in a residential district. These systems have special value if they buffer, insulate, and diversify urban developments, absorbing storm runoffs, do recharging, support wildlife, etc. This category of areas of high value in existing state also includes areas of aesthetic value in their present state. Panorama of ecosystems is essential to the tourism and residential activities. It is most difficult to identify such areas with reasonable objectivity. At this stage we would propose that areas strongly associated with waters designated for any recreational use should be considered. They could be unequivocably identified as being within a certain distance, such as 1000', from the high tide water line, or an appropriately longer distance from the center line of certain streams. Such a principle could be combined with a principle that areas within view of a normal sized pedestrian standing at the water's edge should be preserved in their natural state.

In discriminating between areas of different warrant for this kind of protection, one finds reasons for the most strenuous immediate efforts in areas still least disturbed by man, richest in wildlife, and suitable for the quietest forms of recreation.

Other candidate areas for preservation measures are those which, by virtue of their location, have particular value for the people of the region. These should be identified in conjunction with planning for the region in accordance with the principles set forth below. It should be noted that many people and economic activities that were attracted by the presence of open land in more or less natural state would suffer from disappearance of open space through their own uninhibited expansion.

It is most important that any attempt thus to preserve certain areas include appropriate restraints on the surrounding areas. Some areas need protection from developments that might provide stress and change on other adjacent systems. By means of energy diagrams and hydrological mapping, the interdependence between various areas may be understood, so that appropriate controls may be formulated. (Please refer to the preceeding Section.)

We believe that substantial contiguous areas should be retained in natural state whether or not they are "suitable for developments." These should be of sufficient size to provide for the perpetual survival of a full spectrum of all wildlife. Such areas may also be used for wild area recreation. Additional research-planning is required to identify such areas.

Protection/conservation areas may be used cautiously. Beaches may be used for swimming, and coastal waters for fishing, but protection/conservation areas should also be protected from damaging recreational facility development and use such as excessive boating, which can disturb the bottom plant life and destroy a marine nursery meadow. Each subsystem has its own tolerance to various recreational activities, as can be seen from the energy diagrams and matrices.

It appears that most protection/conservation areas, together with buffers and scenic easements tend to have their focus in water areas and to extend fingers inland for extended interface with other areas.

d) *Restrain necessary but destructive developments*
Necessary developments (together with their environmental impact zones), which by necessity are highly destructive of the environment into which they are introduced, should preferrable be located in areas where they will result in the least net loss of value.

It is important that the impact on both the site itself and on surrounding areas be considered. The structure of such developments should be designed so as not to destroy the hydrological and ecological processes in their vicinity. Such designs would include ample buffer zones.

Only careful and thorough modelling and analog simulation can assess the impact of these high energy developments on the neighboring subsystems.

Examples of development in this category are airports, disposal facilities, power plants, and high density urban clusters. Highways and harbors should also be subject to this principle.

e) *Seek compatible, natural and man-made system combinations*
Where other developments and uses of various kinds are envisaged, compatible combinations between natural and man-made systems should be pursued.

In certain situations this is a matter of separating incompatible subsystems. In others a one-sided or mutual positive relationship may be achieved.

Two different techniques may be employed to this effect: intermixing, in which case the man-made and natural systems will coexist acre by acre; and juxtapositioning, in which the man-made and natural systems occur essentially separately on relatively large areas. These two techniques may be used in combination.

The following principles are suggested to permit man-made systems to be intermixed with natural systems without causing destruction of the latter:

1) The denisty of the energy flow of the man-made system should not exceed the density of the energy flow of the natural system.
2) The natural systems should be disturbed as little as possible; as much of existing vegetation as possible should be retained; the land should be left as natural as possible.
3) Some of each subsystem should be retained to protect the value of the complexity of the entire system and to permit reseeding of vacant areas. This means that ecosystems which are rare or are becoming relatively scarce require protection.
4) Those ecosubsystems which require a long time for reconstitution should be subject to particular protection. The structure of the man-made systems should be so designed as not to interfere with the processes of the hydrological and energetic natural systems.

If the man-made systems are to be juxtaposed with natural systems without destruction of the latter, the following principles should be employed:

1) A pattern of development must be sought which retains the integrity of the regional eco- and hydro-systems and leaves some of each natural subsystem.
2) The density of the energy flow from the man-made systems adjacent to the natural system should be kept under the density of the energy flow of the natural system. Where this is not possible, a buffer zone should be provided in which the energy flow is dissipated.
3) Areas of particular value in their natural state and subsystems with long reconstitution time should be protected.
4) *The man-made systems should tend to occupy lower value areas* and the higher value natural areas should be appropriately protected.

In any combination of man subsidized (urban, suburban, and intensive agriculture) and unsubidized (natural or in very light use by man) systems we recommend that the former be required to constitute less than half of the land, square mile by square mile. Such a mix use affords reciprocal benefits for both kinds of systems.

6. *All developments and uses allowed should be restrained both during and after construction so that their impact on the natural environment is kept within tolerable limits.*

These limits vary, depending on the ecological and hydrological characteristics of the areas. Ecological energy diagrams and hydrological maps furinsh guidance in respect to required restraints. Most important would be limits on extraction of water, discharge of sewage, and disturbance of the storm drainage system. The latter involves both flooding and aquifer recharge.

6. *Suggestions for Additional Research*

General:

1. Develop energy diagrams for all resource subsystems figuring in Florida, and introduce field verified measurements of significant energy flows.

2. Refine the regional resource model and introduce field verified measures of various flows. This work entails work with both the ecological and hydrological (see below) aspects including separate and integrated mathematical and physical modeling.

3. Refine criteria for planning-management decisions in respect to what alterations the regional system could tolerate. Such research could satisfy some of the state's critical planning-management needs as they emerge on the basis of currently pending state land use legislation.

4. Evaluate wholistically a spectrum of representative samples of potential regional use patterns projected into the future. Knowledge derived from such research would constitute the best possible basis for state planning-management decisions.

Hydrological:

Future research oriented towards the refinement of the methodology which is developed for evaluation of the relationship between hydro-system and development in the present report is highly desirable and should be oriented towards a better understanding and control of this relationship. This goal may be achieved through establishment of models of the aquifers in the coastal zone upon which the constrains of planned developments may be imposed and the effects studied directly. Such models may be either numerical models for digital computer simulation or actual physical models of the Hele-Shaw type which have been used successfully in a recent study of the Long Island Aquifer System.[1] A proposal for development of such a model for Florida conditions has been submitted recently by the writer to the Florida Water Resources Research Center.

Ecological:

The following blank tabulation indicates how emerging data relative to the ecological aspects may be summarized for convenient use in legislation, planning, and management.

D. STEP-BY-STEP PROCEDURE FOR CLASSIFYING AND EVALUATING RESOURCE SUBSYSTEMS AND THE HYDROLOGICAL SYSTEM

This section contains directions in detailed steps. Also, how a regional planning office, for example, would classify subsystems, map them, have evaluations made, and illustrate the evaluations. Sources of information for maps, photographs, subsystems descriptions, existing diagrams, etc., are noted in these steps.

COASTAL RESOURCE SUBSYSTEMS

STAGE ONE: IDENTIFICATION AND MAPPING SUBSYSTEMS

Step one: Obtain United States Geological Survey maps and United States Coast and Geodetic Survey navigation charts of your coastal zone from local USGS and USCGS offices. (scale 1" =2000')

Step two: Overlay USGS maps with mylar (matt finish both sides). Draw in coastline and all land formations. Then draw in all land elevation contours and ocean bottom contours at 3' intervals to 12 feet below coastline. Water depth data may be compiled from the USCGS navigation charts.

Step three: Obtain recent aerial photographic coverage of your area from the U.S. Department of Agriculture Asheville, N.C. (scale 1" 2000') It is important to have these at same scale as USGS maps.

Step four: Trim and mount each section of the aerial photos and code for easy identification in the field.

Step five: Affix to each aerial photo an overlay of clear acetate. Delineate boundaries between each subsystem of the natural and agricultural ecosystems including only those areas greater than 500' radius.

Step six: Identifying subsystem types:

a) Marine: Major marine subsystems can be easily identified from aerial photographs, viz., channels, marshes, beaches, shallow nurseries, etc. Differentiation of open water and estuarine subsystems requires additional data on water depth, from the USCGS maps, and salinity, from U. S. Fish and Wildlife Service Bulletins. Man modified marine subsystems are difficult to identify because data indicating the locations and amounts of disturbances is not easily available. Reports and studies of specific locations and/or types of disturbances must be located for each coastal zone. Correlate this information with the descriptions of marine subsystems found in Florida located in this report: section IV, A, 1,c. Figure 19 shows those marine subsystems found in Florida.

b) Terreserial subsystems:
Identify those subsystems delineated on the aerial photographs and verify by data obtained in the field. Descriptions of terresterial ecosystems in the coastal zone may be found in section IV, A, 1, a. Descriptions of other terresterial subsystems may be found in Models *for Planning and Research for the South Florida Environmental Study*, A. E. Lugo, S. C. Suedaker, S. Bayley, H. T. Odum, August 1971. Agricultural subsystems are easily identifiable and are described in Section IV, A, 1, b, of this report.

c) Urban subsystems:
May be tentatively identified on aerial photographs by delineating the areas having similar texture and edge

Figure 18. ECOLOGICAL SUBSYSTEM EVALUATION MATRIX

Scale of Values and Sensitivity
1 Low
2
3 Medium
4
5 High

Criteria - - - - - - - - - -

ECOLOGICAL SUBSYSTEM	Value in Current State								Sensitivity to Intrusions					Value in Interdependence of Subsystems												Cost of Development & Maintenance				Comments and Recommendations	priority
	energy density	current productivity	health value	recreation	wildlife	coastline panorama	scarcity	composit of above	vulnerable to erosion	delicate self maintaining vegetation	delicate topo. equilibrium	delicate wildlife	composite of above	costal protection	shore protection	nursery function	nursery diversity to other systems	regional diversity	wildlife	wast amelioration	waste storage	aquifer recharge	saltwater intrusion	regional scarcity	composite of above	expense of protecting development	cost of irrigation	cost of development	composite of above		
M1 Marshes																															
M2 Shelf Waters																															
M3 Marine Meadows																															
M4 Oligohaline System																															
M5 Med. Sal. Plankt.																															
M6 Tidal Channels																															
M7 Sewage Waste Zone																															
M8 Intertidal Beach																															
Above Tide Beach																															
T1 Mangrove																															
T2 Scrub																															
T3 Dune Transition																															
T4 Hydric Hardwood & Hammocks																															
T5 Cypress Dome																															
T6 Pine Land																															
A1 Pasture & Citrus																															
A2 Flower & Truck Farm																															
D Bare & Scraped Area																															

FIGURE 19: TABLE OF MARINE SUBSYSTEMS FOUND IN FLORIDA

A classification of coastal ecological systems and subsystems according to characteristic energy sources.1 Those systems found in our study area are marked with an asterisk.

CATEGORY	NAME OF TYPE	CHARACTERISTIC ENERGY SOURCE OR STRESS
Naturally stressed systems of wide latitudinal range		High Stress Energies
	*High energy beaches	breaking waves
	*High velocity surfaces	strong tidal currents
	Oscillating temperature channels	shocks of extreme temperature range
	Sedimentary deltas	high rate of sedimentation
	Hypersaline lagoons	briny salinities
Natural tropical ecosystems of high diversity		Light and Little Stress
	*Mangroves	light and tide
	Coral Reefs	light and current
	*Tropical Meadows	light and current
	Tropical inshore plankton	organic supplements
	*Blue water coasts	light and low nutrient
Natural temperate ecosystems with seasonal programming		Sharp seasonal programming and migrant stocks
	Bird and Mammal Islands	bird and mammal colonies
	*Marshes	lightly tidal regimes and winter cold

FIGURE 19 (continued)

CATEGORY	NAME OF TYPE	CHARACTERISTIC ENERGY SOURCE OF STRESS
	*Oyster reefs	current and tide
	Worm and clam flats	waves and current, intermittent flow
	Benthic vegetation (Eelgrass and benthic algal bottoms)	light and current
	*Olighaline systems	saltwater shock zone, winter cold
	*Medium salinity plankton estuary	mixing intermediate salinities with some stratification
	*Neutral embayment and shore waters	shelfwaters at the shore
Emerging New Systems Associated with man		New but characteristic man-made energy sources and/or stresses
	*Sewage waste	organic and inorganic enrichment
	Seafood wastes	organic and inorganic enrichment
	Pesticides	an organic poison
	Dredging spoil	heavy sedimentation by man
	Impoundment	blocking of current
	Thermal pollution	high and variable temperature discharges
	Paper mills waste	wastes of wood processing

CATEGORY	NAME OF TYPE	CHARACTERISTIC ENERGY SOURCE OF STRESS
	Phosphate wastes	wastes of phosphate mining
	Oil shores	petroleum spills
	Pilings	treated wood substrates
	Multiple stress	alternating stress many kinds of waste in drifting patches
	Artificial reef	strong currents
Migrating subsystems that organize areas		Some energies taxed from each system

[1] This table is exerpted from a recent report to the Federal Water Pollution Control Administration, by Odum, Copeland, and McMahan, 1969.

characteristics. These boundaries can be verified by ground data. This can be acurately done on photographs at a scale of 1" 2000'. Large scale photographs (1" 300') are sometimes available but are not desireable for a macro scale overview. Finely detailed delineation requires additional data and maps not readily available from governmental agencies, viz. energy flow maps, maps of population density and urban structure density, traffic frequencies and densities, etc. Descriptions of many typical urban subsystems are contained in this report, section IV, A, 1, a. More detailed descriptions of urban subsystems, defined according to energy flows and power densities are not presently available; but are being researched by the Southwest Florida Planning Team, Department of Architecture, University of Florida.

Identify and label each ecosystem type on the aerial photo overlays.

Step seven: Assemble the aerial photos into sections corresponding to those sections of the USGS maps. Update and correct USGS overlays. Trace all subsystem types onto the USGS overlays.

HYDROLOGICAL SYSTEM

STAGE ONE AND TWO: Identify processes, locate data, map data and critical areas:

Step one: Get United States Geological Survey Map of region of be studies. 1" 2000'

Step two: Collect data for the following maps:

Map A) Ground water salinity: U. S. Geological Survey, Florida Division of Geology Reports

Map B) Potentiometric Head: U. S. Geological Survey, Florida Division of Geology Reports

Map C) Surface Runoff Coefficients: (includes slope of terrain, percentage of pavement, permeability of topsoil): U. S. Department of Agriculture, Aerial Photographs; U. S. Soil Conservation Service; U. S. Geological Survey, Florida Division of Geology Reports

Map D) Floods: U. S. Geological Survey, Ocala, Florida; U. S. Soil Conservation Service, Gainesville, Florida.

Map E) Storm Tides: Corps of Engineers Reports

Step three: Overlay acetate (or Mylar) sheets on geological survey Map. Trace the following information on the sheets: shade the area critical sensitive to harm from development. The criteria mentioned here are examples of possible criteria:

Map A) Draw contours of constant chloride content for values of 50, 100, 250, and 500 ppm. Shade the area of 250 ppm and higher.

Map B) Draw contours of 1, 5, and 10 feet of potentionmetric head. Shade the region of 5 feet and less.

Map C) (1) Surface soil permeability (map C1) (figure 15C1)
(2) Paved Area (map C2) (figure 15C2)
(3) Slope of terrain (map C3) (figure 15C3)
Using information in these three maps, and figure 13, Surface Runoff, draw runoff coefficient 0.2, 0.4, 0.6 and 0.8. Shade the region of coefficient 0.2 and lower.

Map D) Draw flood boundaries corresponding to 10, 25, and 50 year frequency. Shade the area flooded by a 10 year flood frequency.

Map E) Drawn boundaries of areas flooded due to storms of a 10, 25, and 50 year frequency. Shade the area flooded by a 10 year storm tide.

Step four: Overlay Maps A, B, C, D, and E. Count overlays and reproduce these overlapping gray areas on a clean sheet of mylar shading in five tones of gray to indicate the five possible numbers of overlays.

(or)

Illuminate the five maps from behind with a uniform light source and survey the resultant light flux passing through the overlays with a photo cell.

The darker areas are the ones most sensitive to harm from development.

HYDROLOGICAL SYSTEM AND COASTAL RESOURCE SYSTEMS IN COMBINATION

STAGE THREE: EVALUATION OF COMPILED DATA FOR PLANNING AND MANAGEMENT PURPOSES

This stage requires knowledge presently not fully articulated and therefore cannot be performed by personnel not having an educated understanding of the workings of the phenomena in question. In the above described research project we relied on the professional judgement of the members of the research team.

In principle the following steps are required: The values and sensitivities of the various ecological subsystems need to be assessed in local, regional, and larger contexts. Using such knowledge as exists in respect to the ecology of the area some of which is in the form of energy network diagrams and metabolic energy values we mapped natural ecosystems we knew to be of high value and/or to constitute highly sensitive essential components in the regional system and requiring strong protection measures. We also identified systems which due to their values and sensitivities we judged in need of a less degree of protection (able to accept developments). We then layed that map over the hydrological composite evaluation map and drew a final composite map incorporating both hydrological and ecological considerations.

Further research will yield more articulate and commonly useful value sensitivity knowledge. For suggestions in respect such research see section on suggestions for research.

[1]Collins, M. A. and Gelhar, L. W., "Some steady state and transient characteristics of the Long Island Aquifer System as determined by a vertical Hele-Shaw Model Study." Presented at the 19th Annual Specialty Conference of the Hydraulics Division, ASCE. Iowa City, Iowa, August, 1971.

V. DEFINITIONS OF TERMS

COMPARTMENTS (of a system) – a component of a system having independent properties of stress, action, inherent programs, etc.

ECOSYSTEM – ecological system which in this report, is used to include zones of a city as well as of the countryside.

ENERGETICS – the concepts of energy conservation and flow, sometimes called thermodynamics

ENERGY FLOWS – any action due to a causal force of group of forces; all such processes are accompanied by energy flows. In defining urban subsystems Energy flows are generally classified into two categories – energy for building new structures, and energy for maintenance of existing structures, and are defined in terms of energy flow in a system per unit of time (kilocalories/day).

ENERGY NETWORK DIAGRAM – a model, based on principles of force and energy, that shows pathways of causal relationships, valuable structure, and points of storage.

IMPACT MATRIX – a table where intersections show action of system components and outside influences.

INTRUSIONS – alterations of a system, usually by man, sometimes causing stress.

MODEL – a simplification that contains the important concepts, causal actions, and influence points necessary for the human to grasp a complex phenonema. In this report we use energy network diagrams, impact matrix representations, and simplified maps. Simplified views are the basis for decision making judgments.

PATHWAYS – (of a system) – lines of action and energy effects including flows of fuels, light, material, money, information, and services.

POPULATION DENSITY – the number of persons per unit area.

POWER DENSITY – the energy flowing in a system divided by the spatial area occupied by that system. The energy flow in any system is the total energy flow of its processes from all sources. This additional absorbed energy may be detrimental as "noise"; or stimulative as an energy "boost". In either case, the original system is affected and altered by its presence. Power density is commonly expressed in kilocalories/meter^2/day.

RESOURCE SYSTEM – a system of man or nature which is of significant value for resource planning.

SENSITIVITIES – (of a system, between systems) – large responses to small changes and impacts.

SOCIETAL VALUE – a measure of the ultimate significance to the human community of a subsystem of subsystem alteration. This value includes both direct effects on man and his economy and indirect effects via the various parts of the world's life support system.

SUBSYSTEM, or RESOURCE SUBSYSTEM – a small component of a larger system.

URBAN STRUCTURE DENSITY – a ratio of the volume of useable space defined by architectural structure to the area of land it occupies-meter^3/meter^2.

URBAN STRUCTURE EDGE INDEX – a measure of the complexity of either urban or architectural structure. The number of edges generated and maintained by a system have a direct relationship to the power flows within that system. An edge index can be expressed as edges/building; edges/person; edges/meter^3; edge/kilocalorie/meter^2, etc.

URBAN STRUCTURE TO OPEN SPACE TEXTURE – a measure at macro-scale of the urban pattern's variability within a subsystem. The energetic budget to construct and maintain an *irregular* structure to open space texture is larger than for a *regular* texture. This hypothetical concept is currently being examined in close detail by the South West Florida Planning Team, Department of Architecture, University of Florida.
For this study, only two classifications were made from the 1" = 2000' aerial photographs-irregular and regular texture.

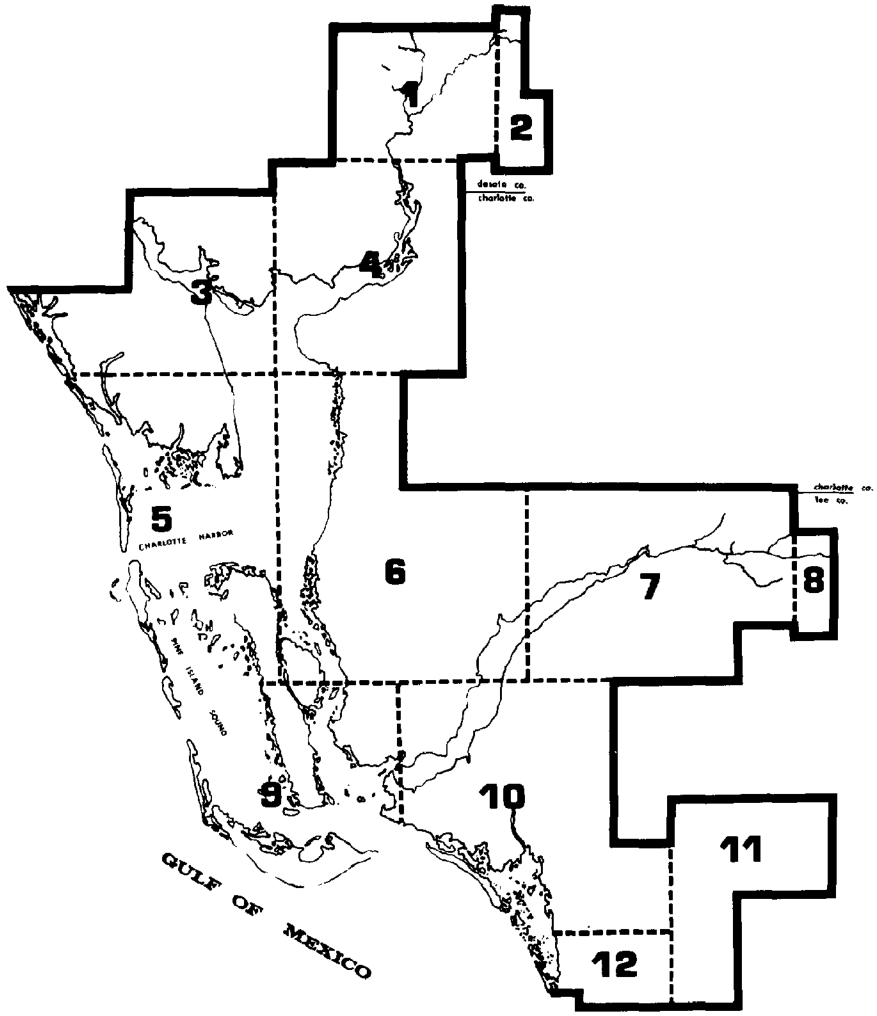
VI. ACKNOWLEDGMENTS

The authors of this report wish to acknowledge the efforts of others who assisted in initiating this study and provided access to the necessary data. Martin Gunderson, past president, Southwest Florida Chapter of the American Institute of Architects, initiated an earlier investigation of the Ft. Myers – Estero Bay area with the Department of Architecture which collected and compiled much of the base data for Lee County. William Hammond, Science Coordinator for Lee County Schools proved a valuable source of data for this study and also helped to establish contact with other agencies in the area. Maurice Bigelow, County Commissioner for Charlotte County, showed enthusiasm and interest in this study and provided access to information and data for Charlotte County.

VII. MAP APPENDIX

Included on the following pages is a reduced version of the full scale map appendixes which are on file with the Coastal Coordinating Council and the University of Florida.

A. Atlas Appendix I: Coastal Resource Subsystem Maps.
B. Atlas Appendix II: Hydrological System Maps.



KEY MAP

LEGEND

NATURAL TERRESTRIAL
- Mangroves T/1
- Scrub T/2
- Dune Transition T/3
- Hydric Hardwood and Hydric Hammock T/4
- Cypress Domes and Strands T/5
- Pine Lands T/6

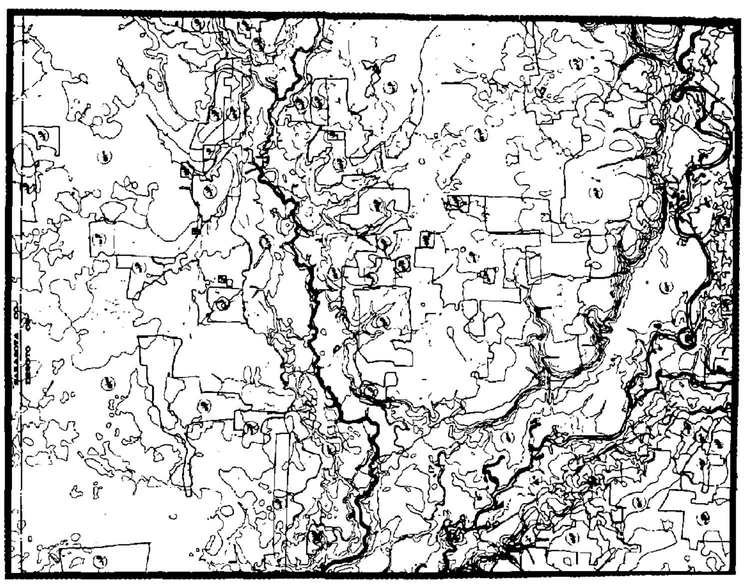
MARINE
- Marshes M/1
- Shelf Waters and Neutral Embayments M/2
- Marine Meadows and Shallow Nursery M/3
- Oligohaline Systems (Freshwater-Saltwater Mixing Zone) M/4
- Medium Salinity Plankton Estuary M/5

URBAN
- Central Business District C/1
- Commercial Strip C/2
- City Services C/3
- Transportation Terminals C/4
- Beach Strip C/5
- Public Recreation Areas R/1
- Private Recreation Areas R/2
- Natural Open Spaces R/3
- Stable Housing H/1
- Senescent Housing Subsystems H/2
- Mature Residential H/3
- High Maintenance Residential H/4
- Cleared and Prepared with Canals H/5
- Mobile Housing H/6
- Dredged and/or Scraped D/1

INDUSTRIAL
- Industry IND/1

AGRICULTURAL
- Pasture Lands and Citrus A/1
- Flower and Truck Farms A/2

- High Energy Beaches
- High Velocity Channels
- Oyster Reefs
- Waste Outfall Generated System



SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE — UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

MAP NUMBER 1

NATURAL TERRESTRIAL

INDUSTRIAL

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

WASTE OUTFALL

0 1 2 3

NORTH

LEGEND

DECEMBER 31 1971
SCALE 1 inch : 1 mile

SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

MAP NUMBER 2

NATURAL TERRESTRIAL
INDUSTRIAL
AGRICULTURAL
URBAN

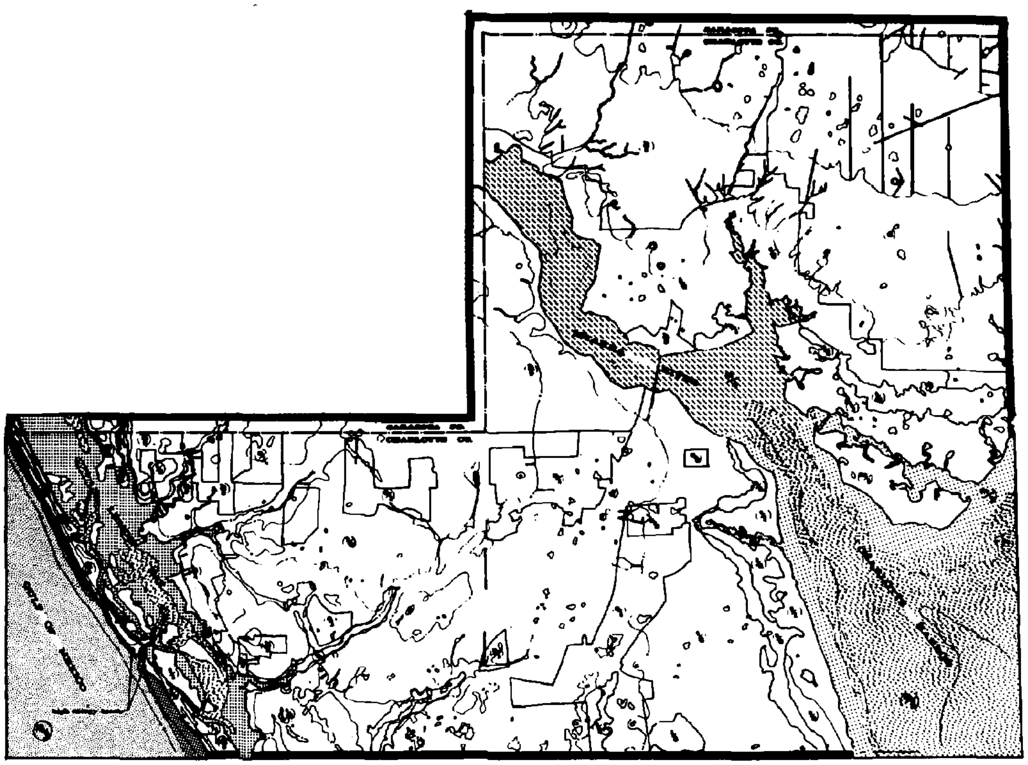
MARINE
HIGH ENERGY BEACH
HIGH VELOCITY CHANNEL
OYSTER REEFS
WASTE OUTFALL

0 1 2 3

NORTH

LEGEND

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

NATURAL TERRESTRIAL
INDUSTRIAL
AGRICULTURAL
URBAN

MARINE

HIGH ENERGY BEACH
HIGH VELOCITY CHANNEL
OYSTER REEFS
WASTE OUTFALL

0 1 2 3

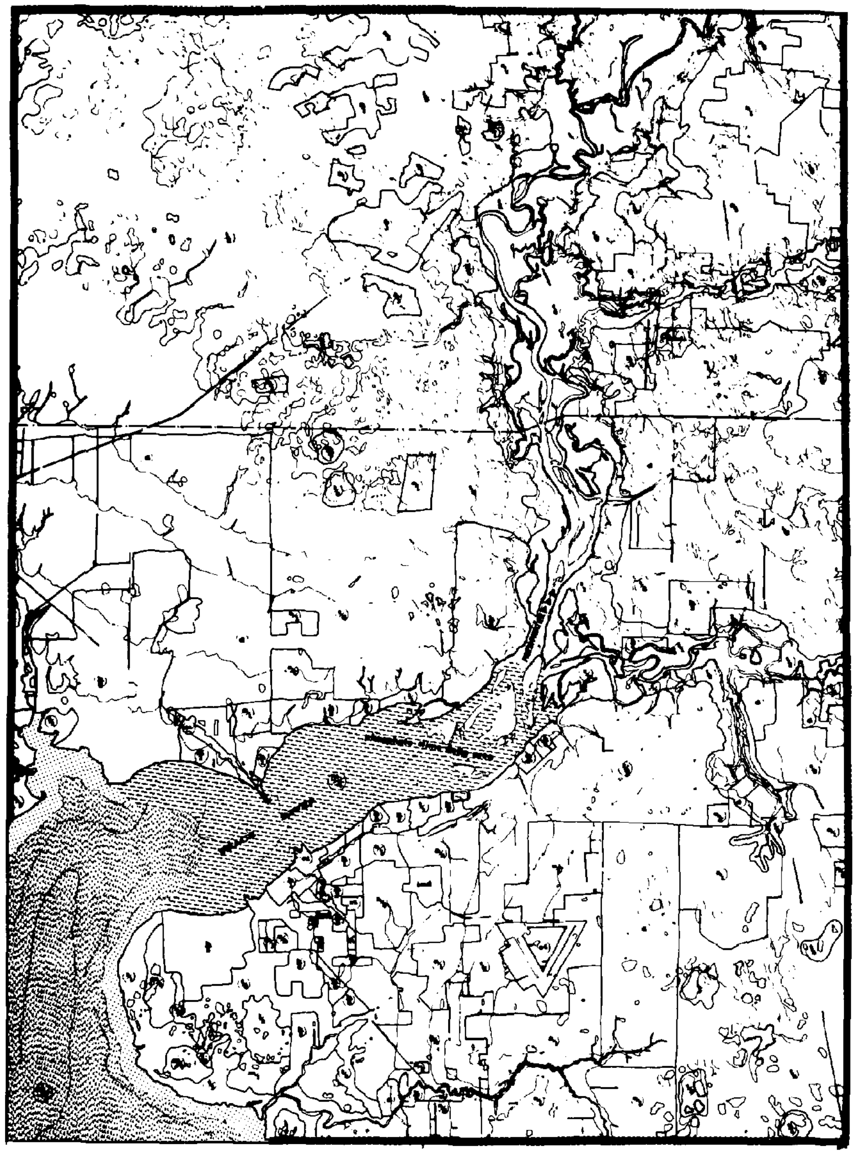
NORTH

LEGEND

MAP NUMBER

3

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

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SUBSYSTEM CLASSIFICATION

MAP NUMBER 4

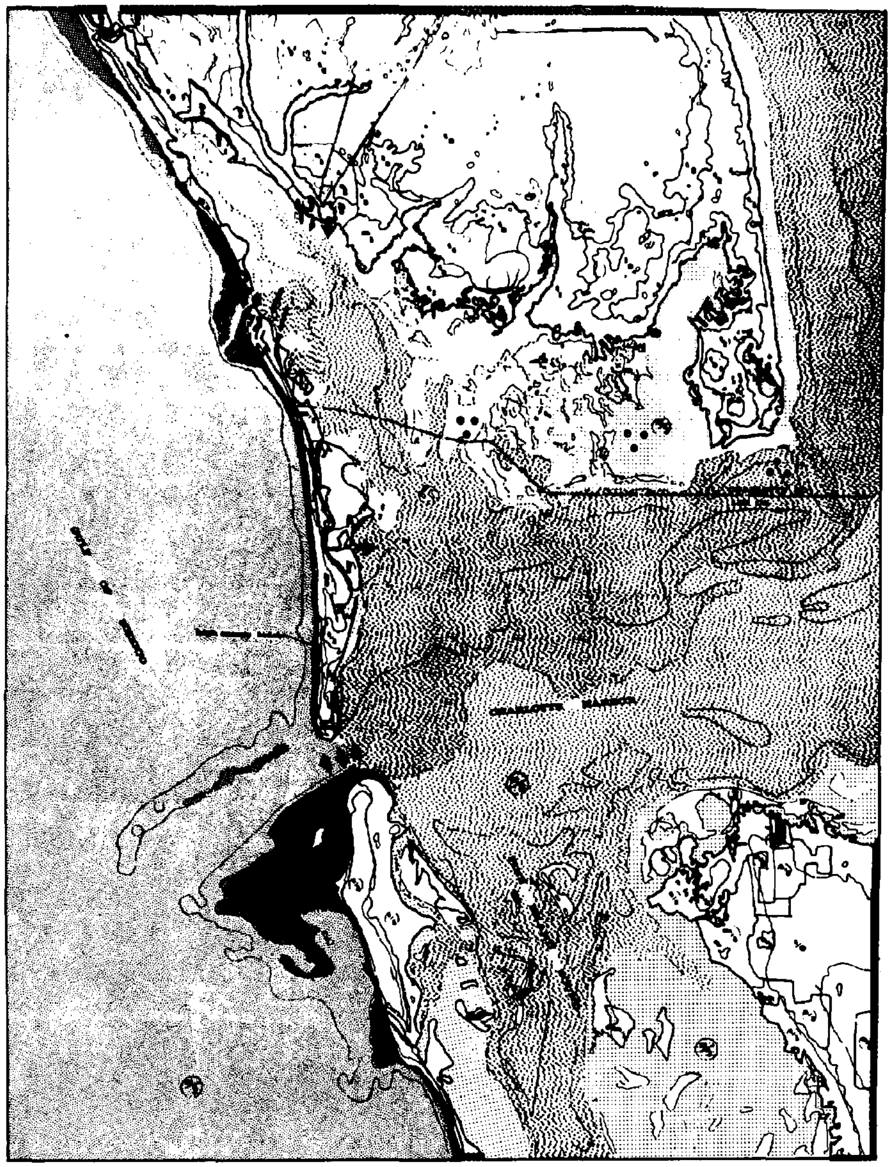
LEGEND

NATURAL TERRESTRIAL
INDUSTRIAL
AGRICULTURAL
URBAN
MARINE
HIGH ENERGY BEACH
HIGH VELOCITY CHANNEL
OYSTER REEFS
WASTE OUTFALL

0 1 2 3

NORTH

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

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SUBSYSTEM CLASSIFICATION

MAP NUMBER **5**

NATURAL TERRESTRIAL

INDUSTRIAL

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

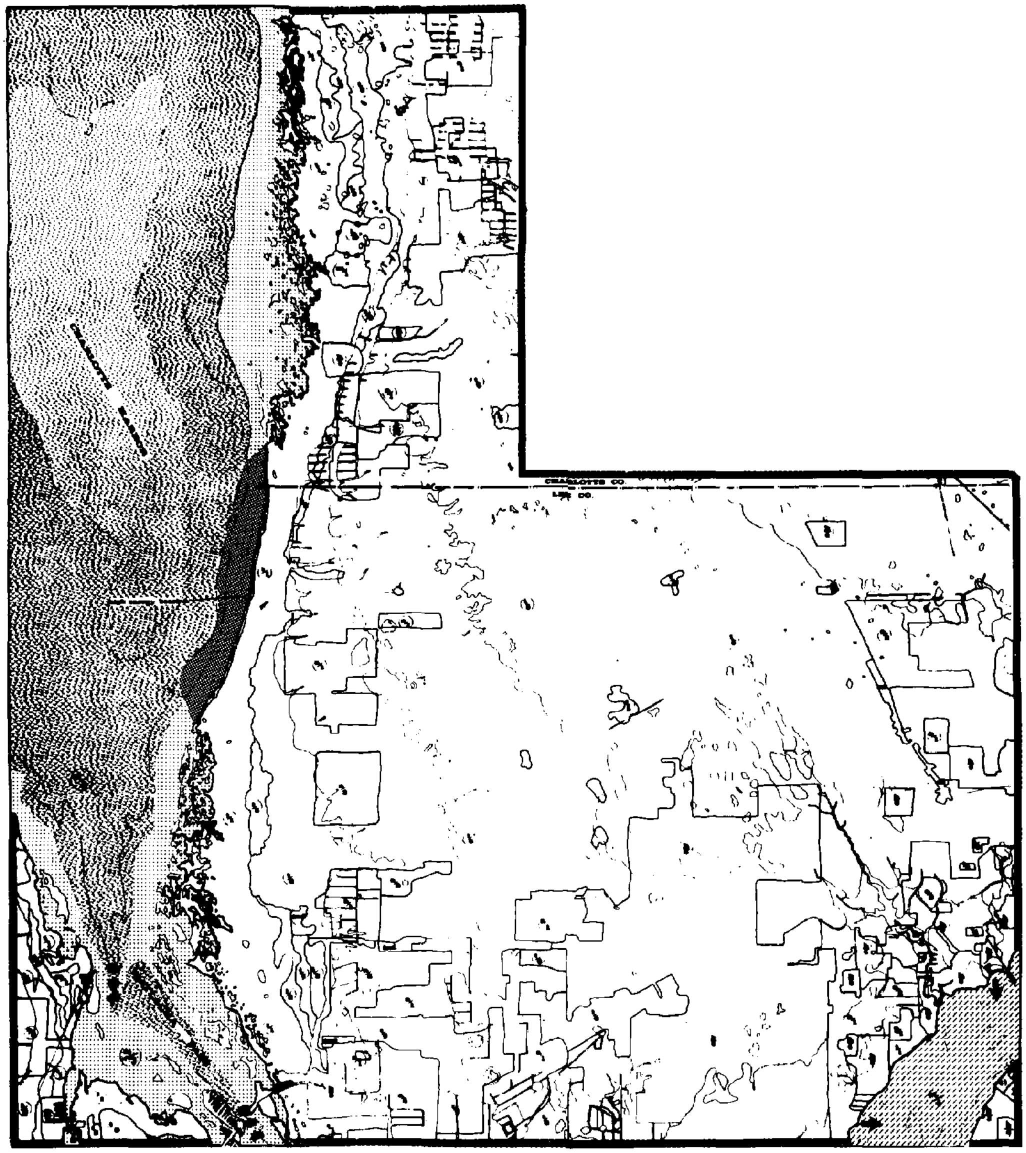
WASTE OUTFALL

NORTH

0 1 2 3

LEGEND

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE — UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

NATURAL TERRESTRIAL

INDUSTRIAL

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

WASTE OUTFALL

0 1 2 3

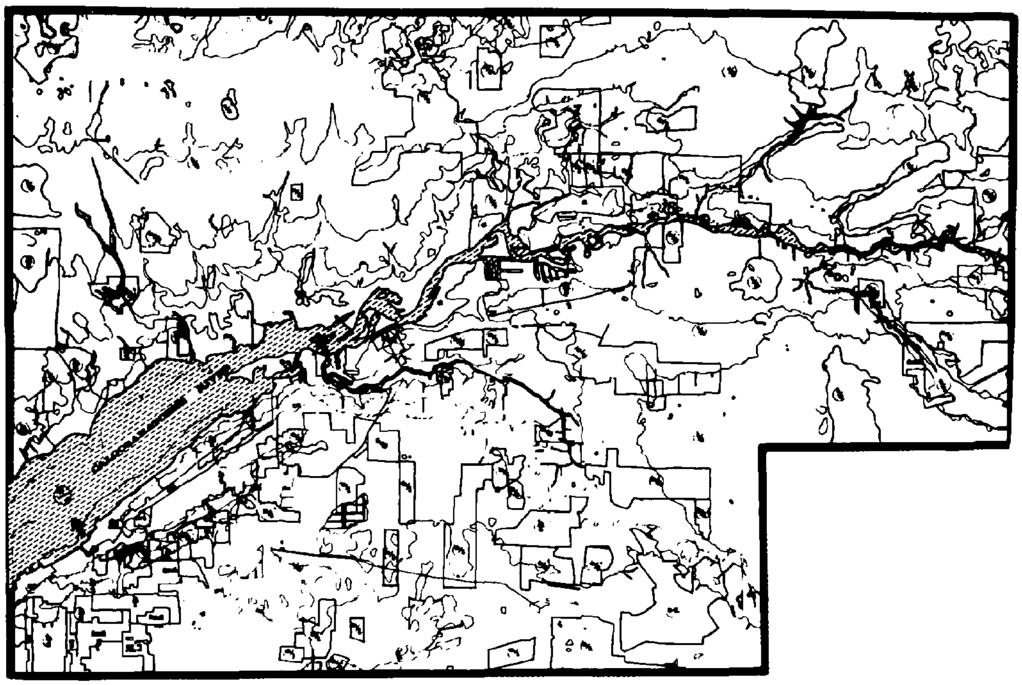
NORTH

LEGEND

MAP NUMBER 6

DECEMBER 31 1971

SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

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SUBSYSTEM CLASSIFICATION

MAP NUMBER 7

NATURAL TERRESTRIAL
INDUSTRIAL
AGRICULTURAL
URBAN

MARINE

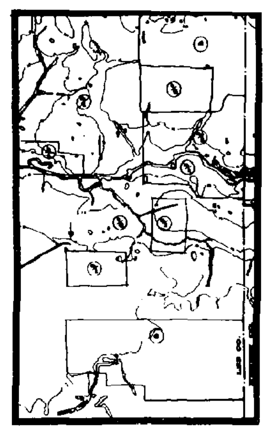
HIGH ENERGY BEACH
HIGH VELOCITY CHANNEL
OYSTER REEFS
WASTE OUTFALL

0 1 2 3

NORTH

LEGEND

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

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SUBSYSTEM CLASSIFICATION

MAP NUMBER 8

LEGEND

NATURAL TERRESTRIAL

INDUSTRIAL

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

WASTE OUTFALL

0 1 2 3

NORTH

DECEMBER 31 1971

SCALE 1 inch : 1 mile

SOUTHWEST FLORIDA PLANNING TEAM
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SUBSYSTEM CLASSIFICATION

MAP NUMBER 9

NATURAL TERRESTRIAL
INDUSTRIAL
ind
AGRICULTURAL
URBAN

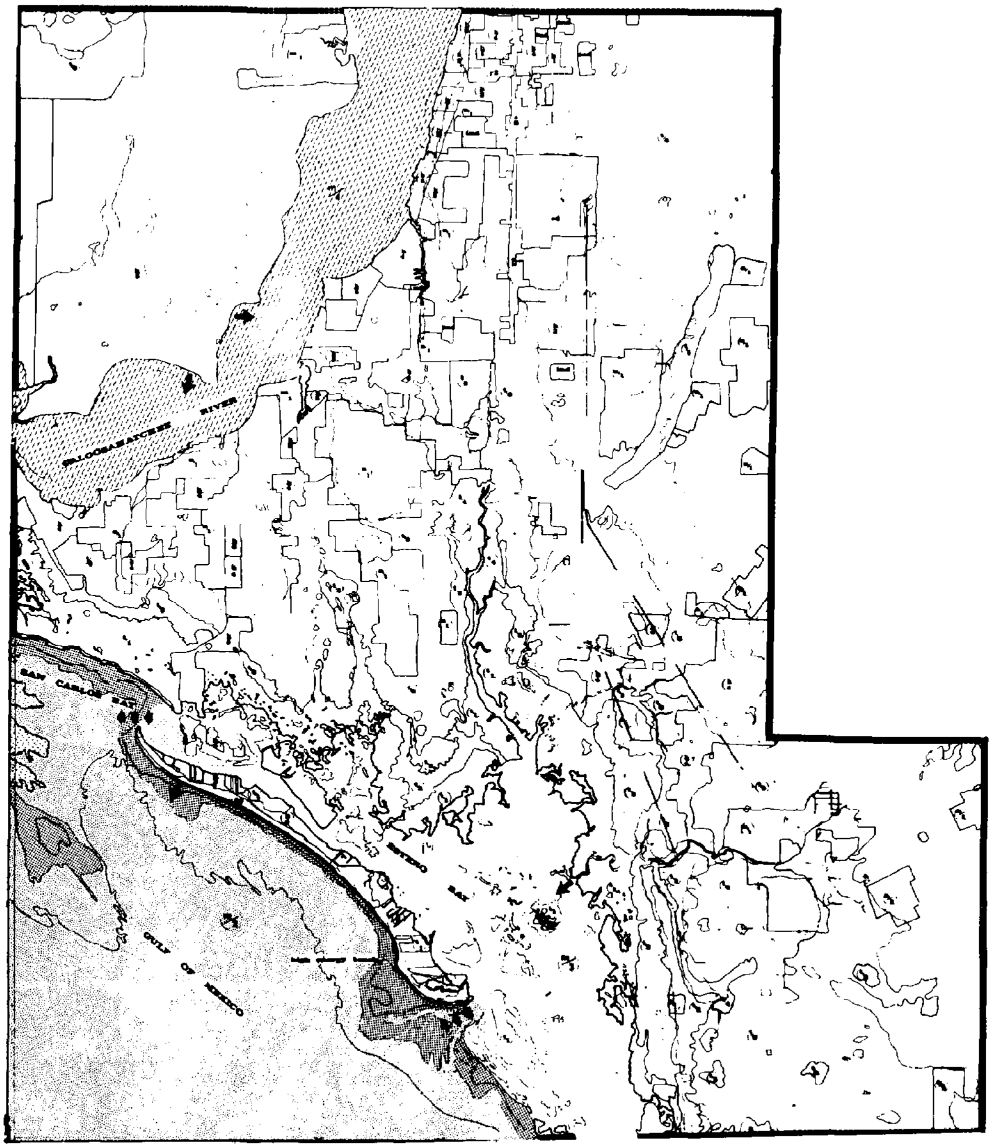
MARINE
HIGH ENERGY BEACH
HIGH VELOCITY CHANNEL
OYSTER REEFS
WASTE OUTFALL

0 1 2 3

NORTH

LEGEND

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

NATURAL TERRESTRIAL

INDUSTRIAL

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

WASTE OUTFALL

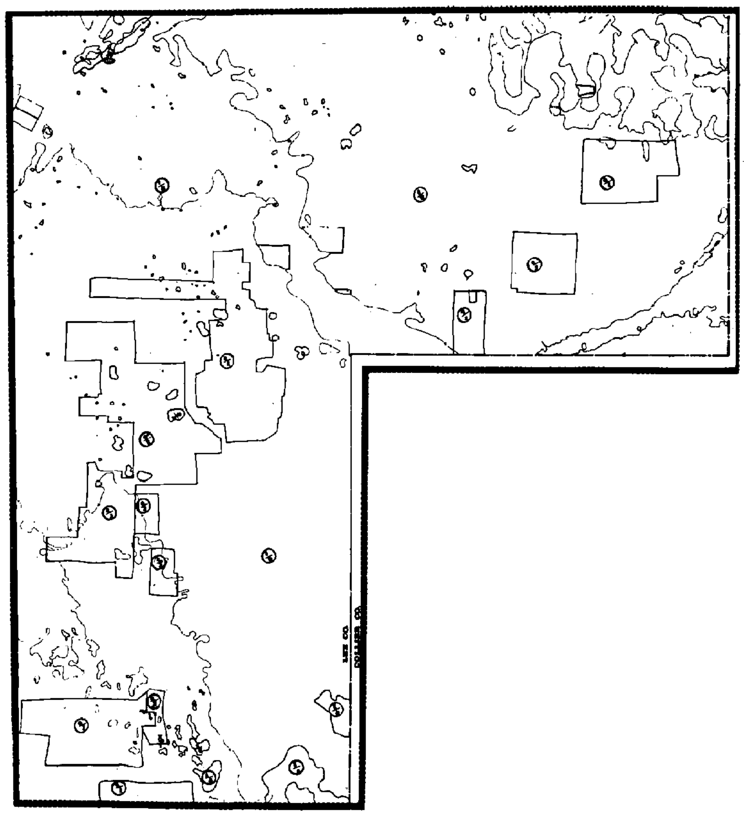
LEGEND

0 1 2 3

NORTH

MAP NUMBER 10

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

NATURAL TERRESTRIAL

INDUSTRIAL

ind

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

WASTE OUTFALL

LEGEND

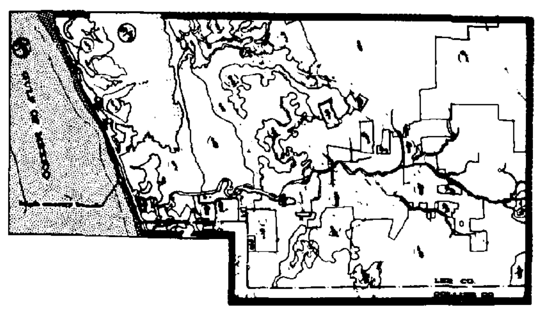
0 1 2 3

NORTH

MAP NUMBER

11

DECEMBER 31 1971
SCALE 1 inch : 1 mile



SOUTHWEST FLORIDA PLANNING TEAM

DEPARTMENT OF ARCHITECTURE — UNIVERSITY OF FLORIDA

SUBSYSTEM CLASSIFICATION

NATURAL TERRESTRIAL

INDUSTRIAL

AGRICULTURAL

URBAN

MARINE

HIGH ENERGY BEACH

HIGH VELOCITY CHANNEL

OYSTER REEFS

WASTE OUTFALL

LEGEND

0 1 2 3

NORTH

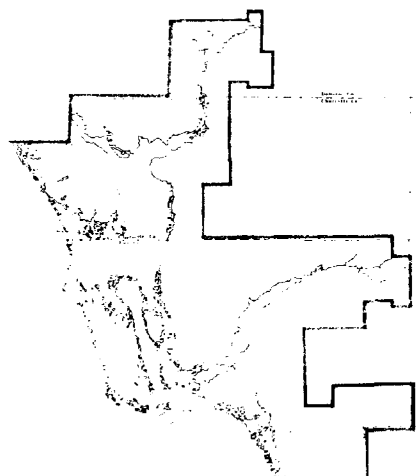
MAP NUMBER 12

DECEMBER 31 1971

SCALE 1 inch : 1 mile

IDENTIFICATION AND EVALUATION OF COASTAL RESOURCE PATTERNS IN FLORIDA

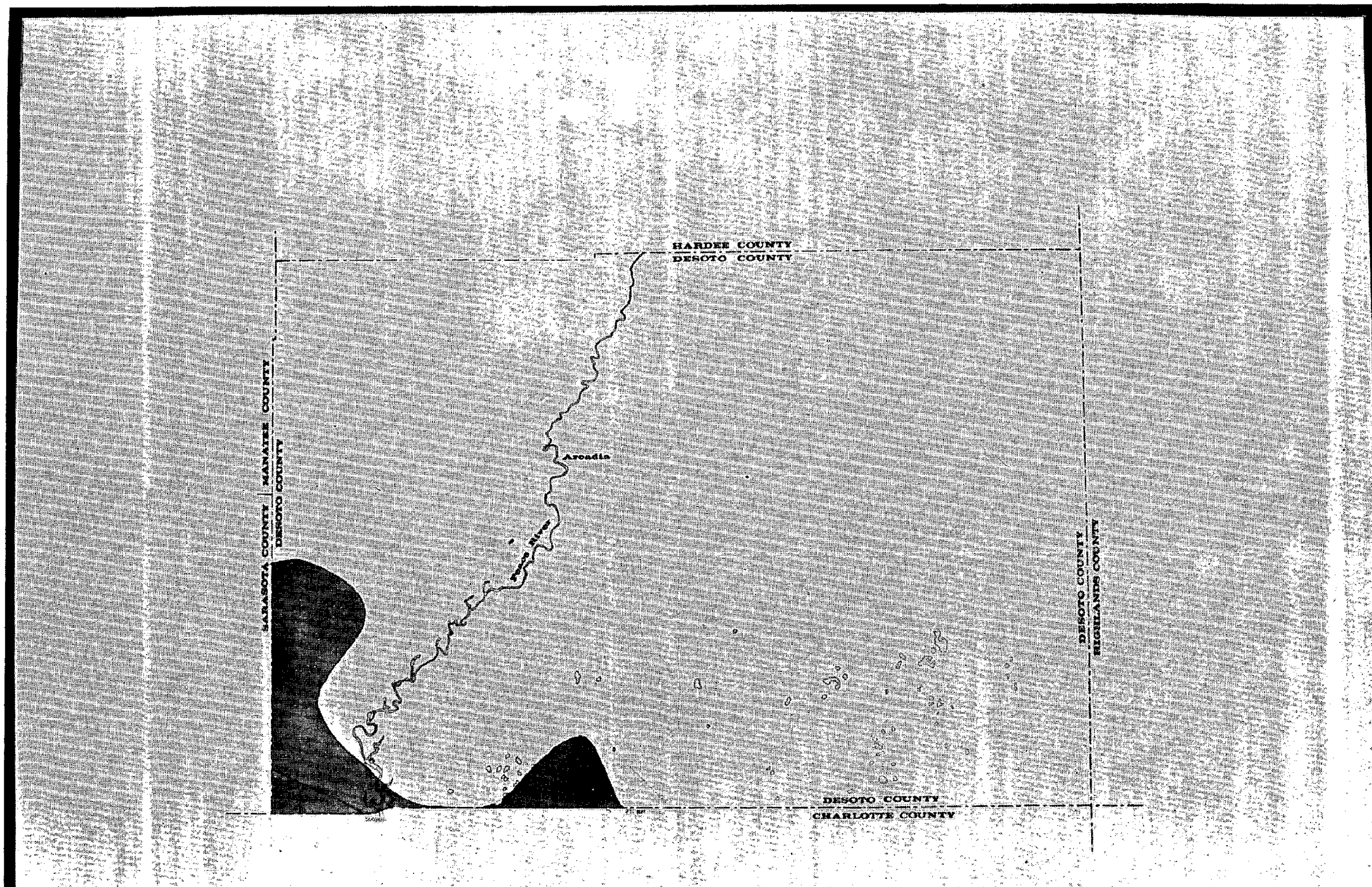
HYDROLOGICAL STUDY MAPS



BOUNDARY OF STUDY AREA

INDEX:

Desoto	D_A	Groundwater Salinity, parts per million
	D_B	Potentiometric Head, feet
	D_{C_1}	Surface Soil Permeability, relative values
	D_{C_2}	Paved Area, greater than 15%
	D_{C_3}	Slope of Terrain, percent
	D_C	Surface Runoff Coefficients
	D_E	Storm Tides, years
	D_F	Composite, overlays
Charlotte	C_A	Groundwater Salinity, parts per million
	C_B	Potentiometric Head, feet
	C_{C_1}	Surface Soil Permeability, relative values
	C_{C_2}	Paved Area, greater than 15%
	C_{C_3}	Slope of Terrain, percent
	C_C	Surface Runoff Coefficient
	C_E	Storm Tides, years
	C_F	Composite, overlays
Lee	L_A	Groundwater Salinity, parts per million
	L_B	Potentiometric Head, feet
	L_{C_1}	Surface Soil Permeability, relative values
	L_{C_2}	Paved Area, greater than 15%
	L_{C_3}	Slope of Terrain, percent
	L_C	Surface Runoff Coefficient
	L_E	Storm Tides, years
	L_F	Composite, overlays



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

GROUND WATER SALINITY

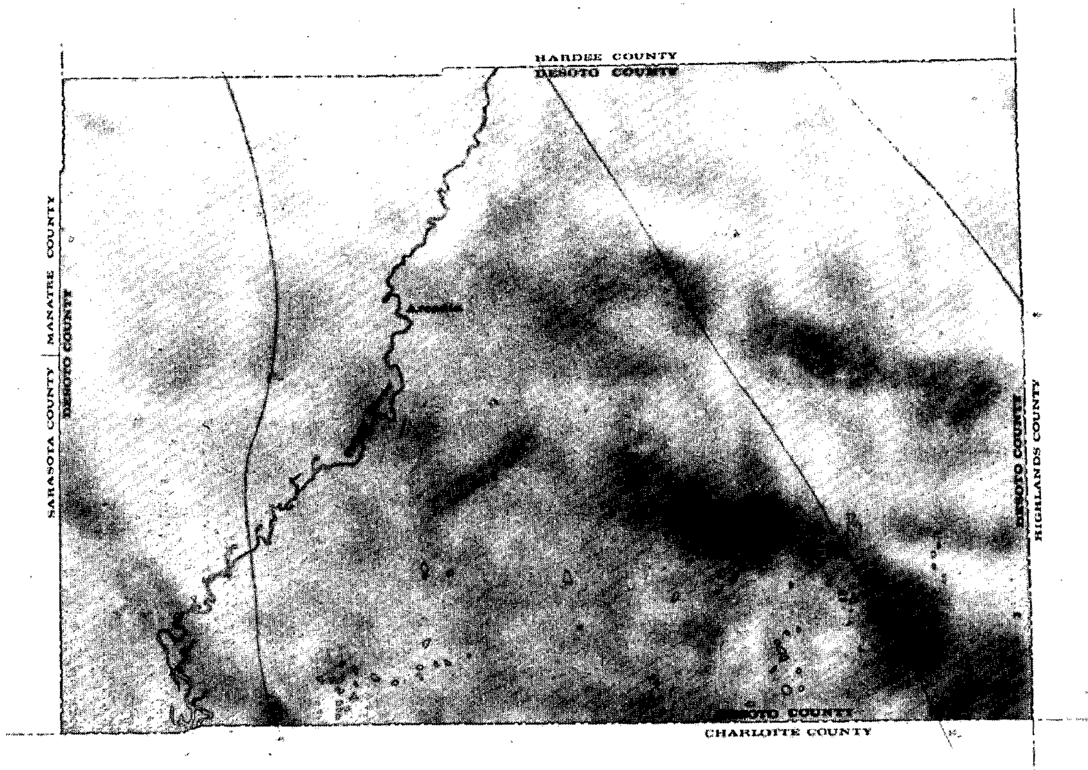
DECEMBER 31, '71

north

SCALE: 1" = 1 mile

MAP NUMBER

DA

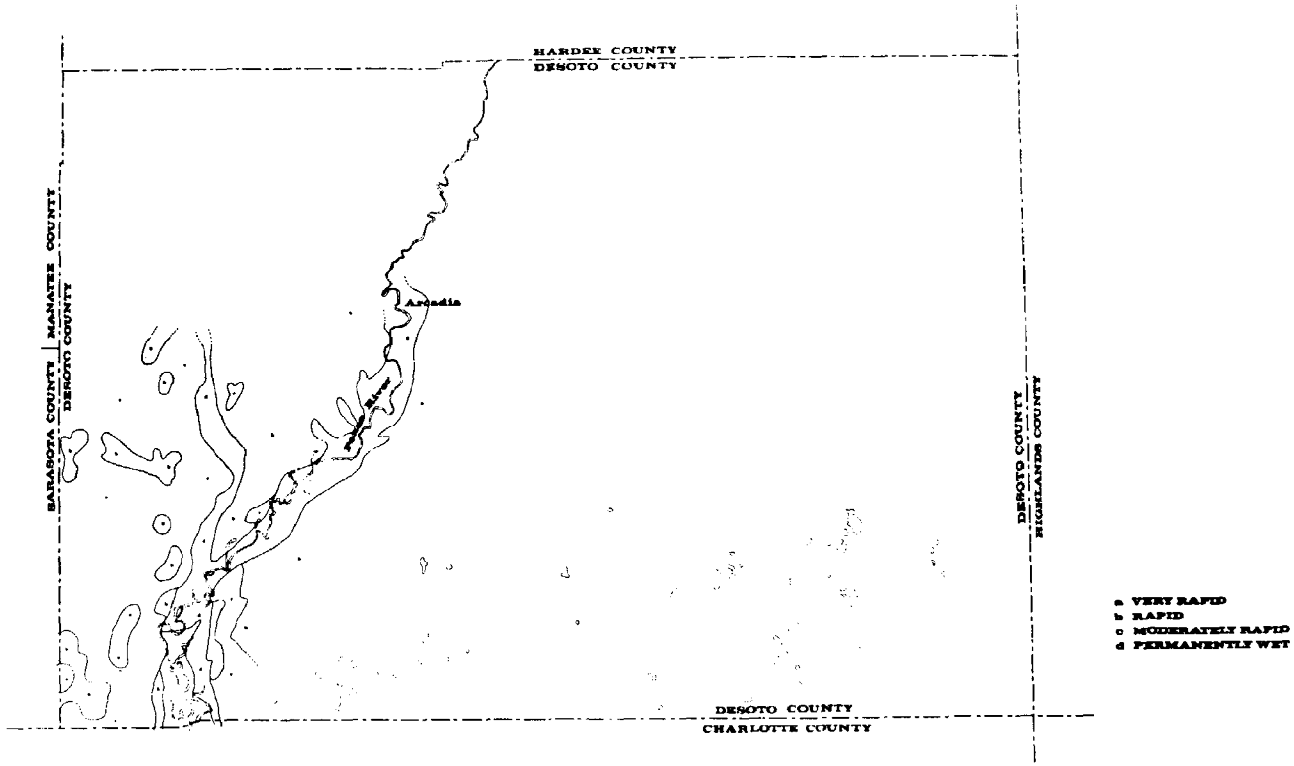


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

POTENTIOMETRIC HEAD

DECEMBER 31, '71
north
SCALE: 1" = 1 mile

MAP NUMBER
DB



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE SOIL PERMEABILITY

DECEMBER 31,'71

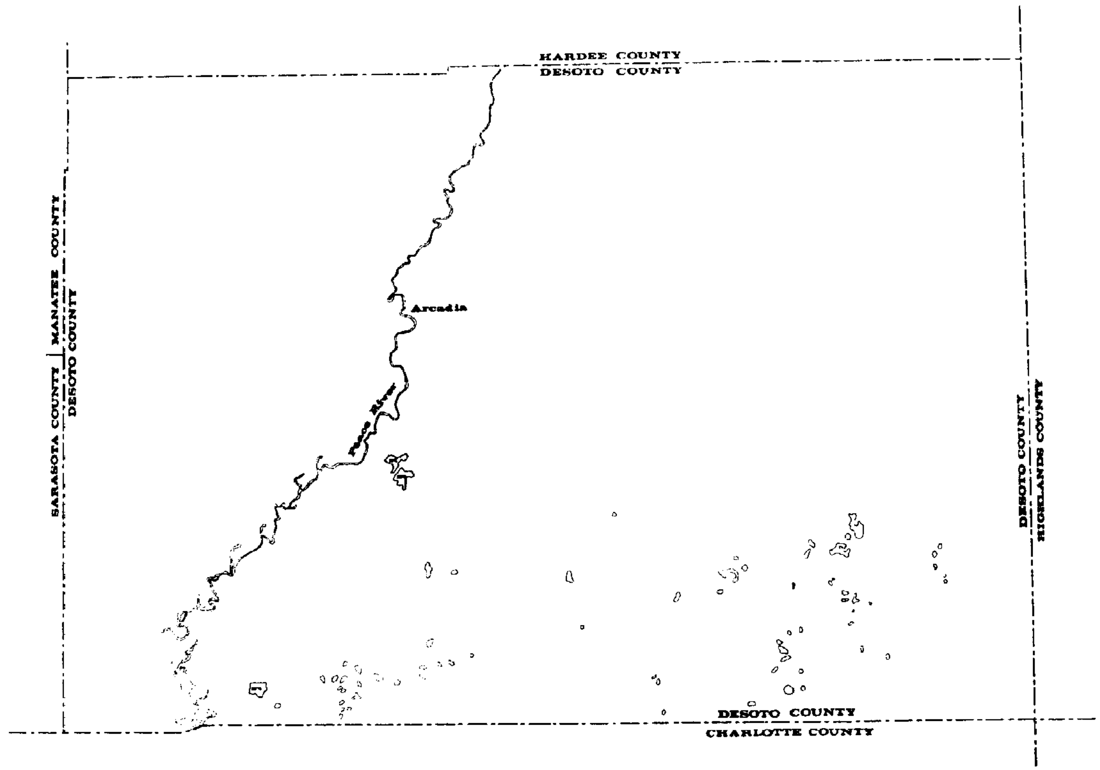
north

0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER

DC1

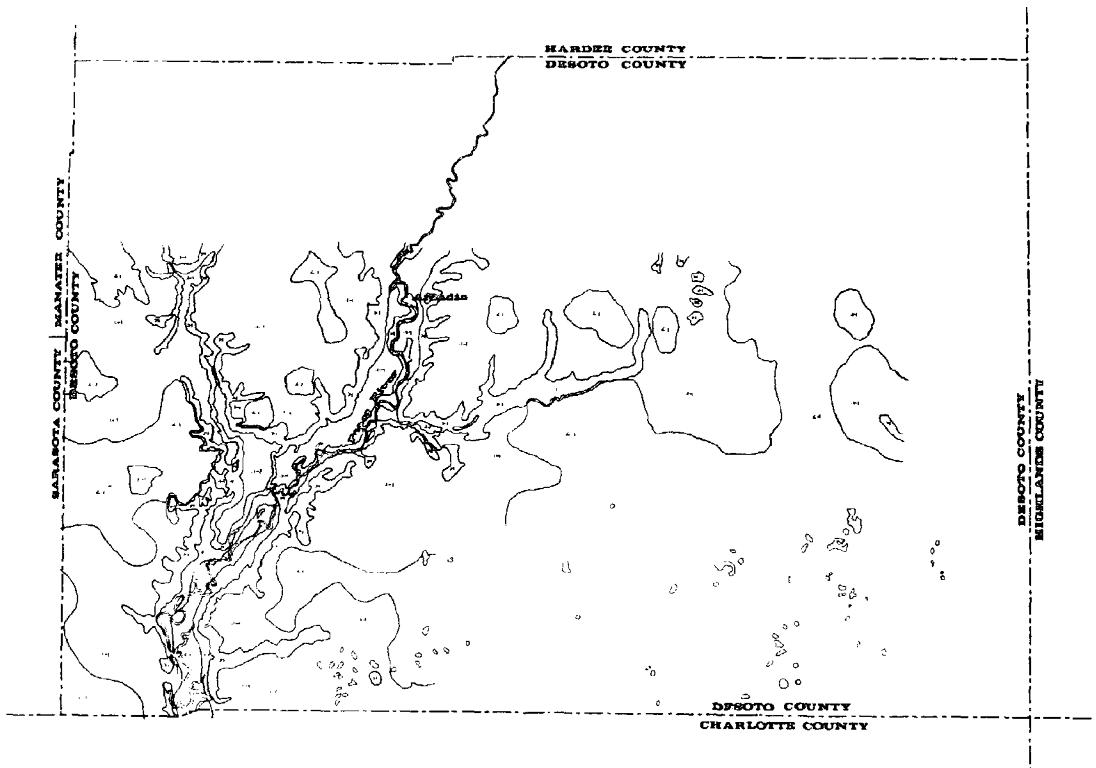


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

PAVED AREA

DECEMBER 31,'71
north
SCALE: 1" = 1 mile

MAP NUMBER
DC2



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

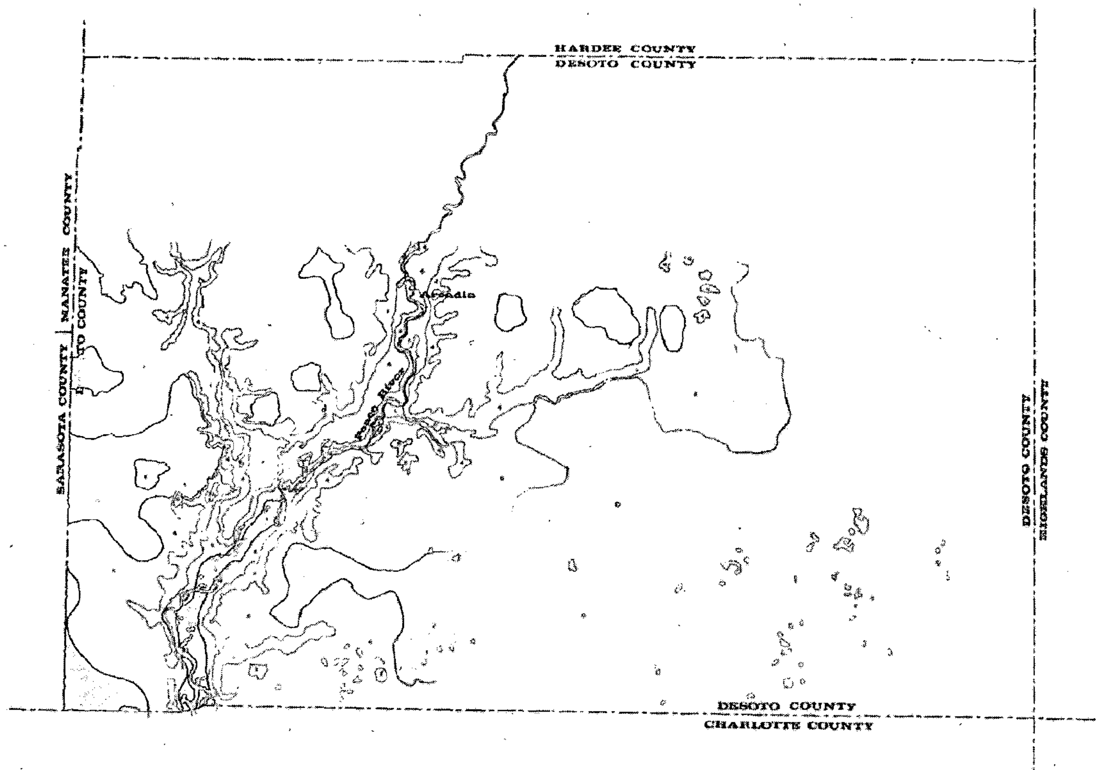
SLOPE OF TERRAIN

DECEMBER 31, '71

north 0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER DC3



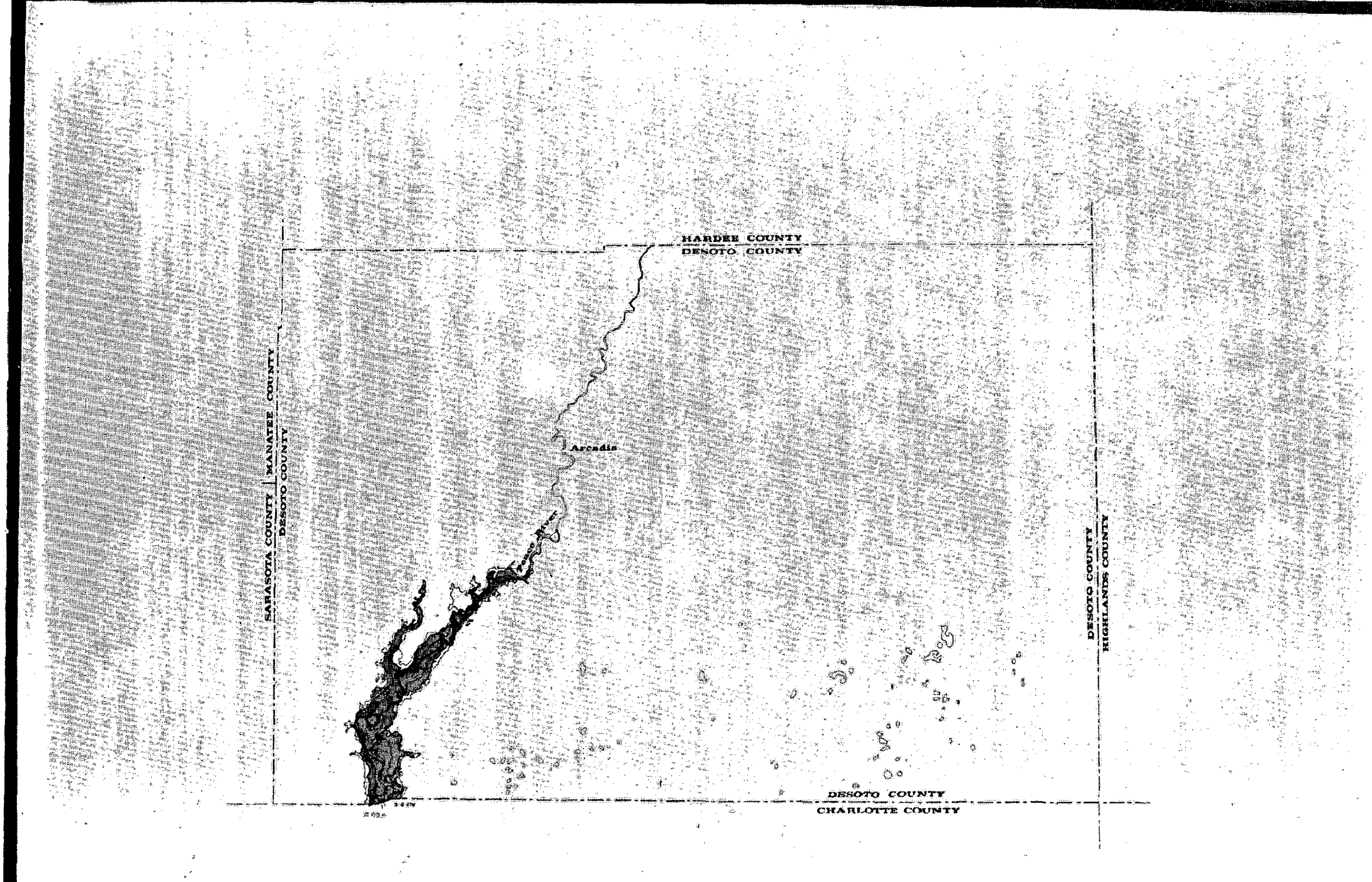
SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE RUNOFF COEFFICIENT

DECEMBER 31, '71

north 0 1 2 3
SCALE: 1" = 1 mile

MAP NUMBER
DC



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

STORM TIDES

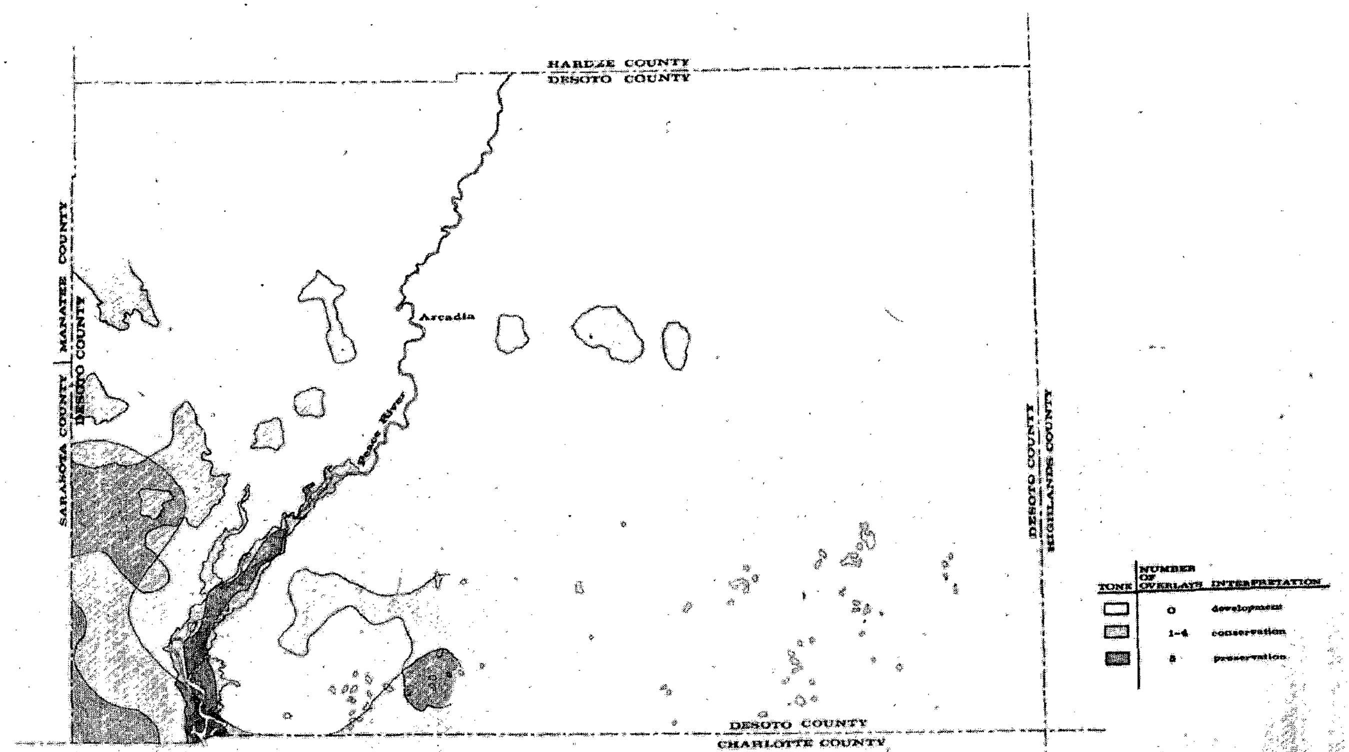
DECEMBER 31,'71

north

SCALE: 1" = 1 mile

MAP NUMBER

DE



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

COMPOSITE

DECEMBER 31, '71

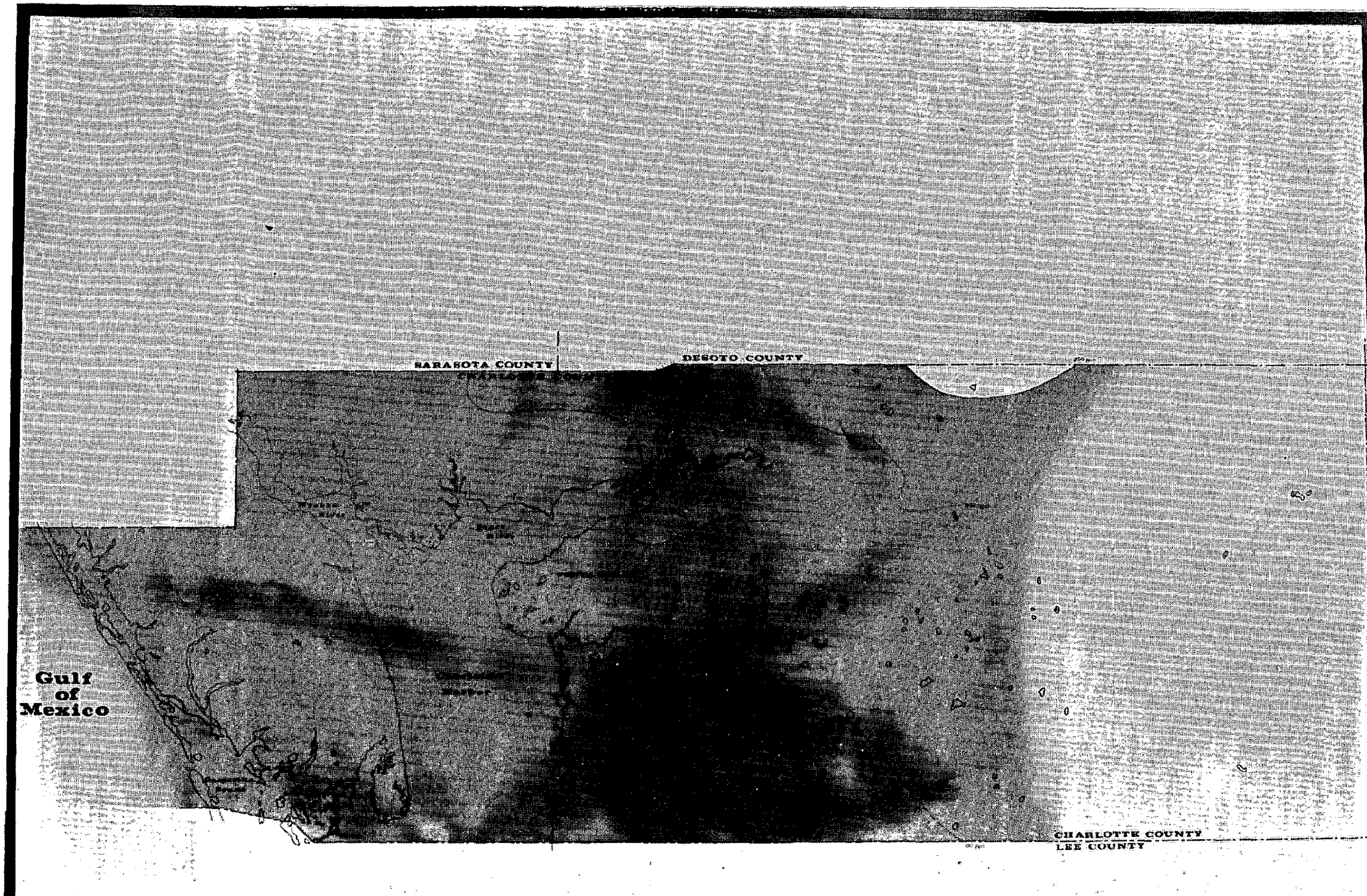
north

0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER

DF



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

GROUND WATER SALINITY

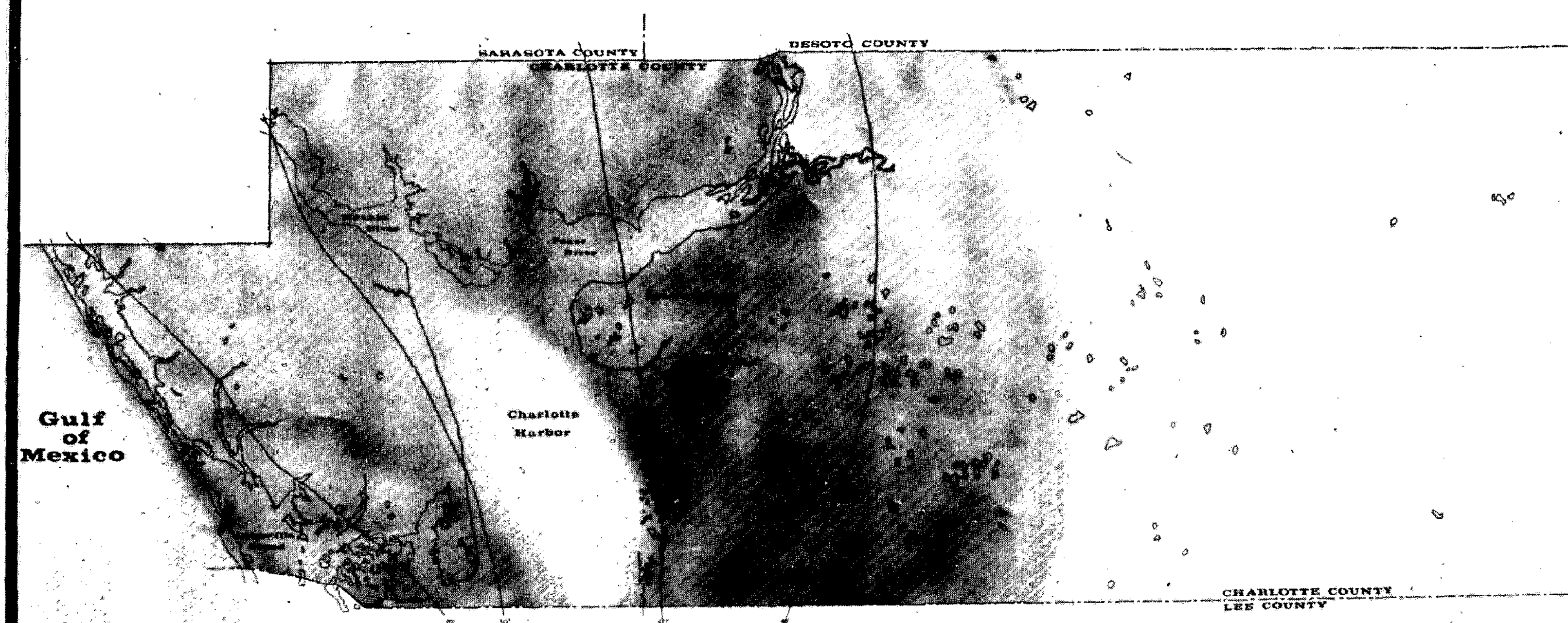
DECEMBER 31, '71

north

SCALE: 1" = 1 mile

MAP NUMBER

CA

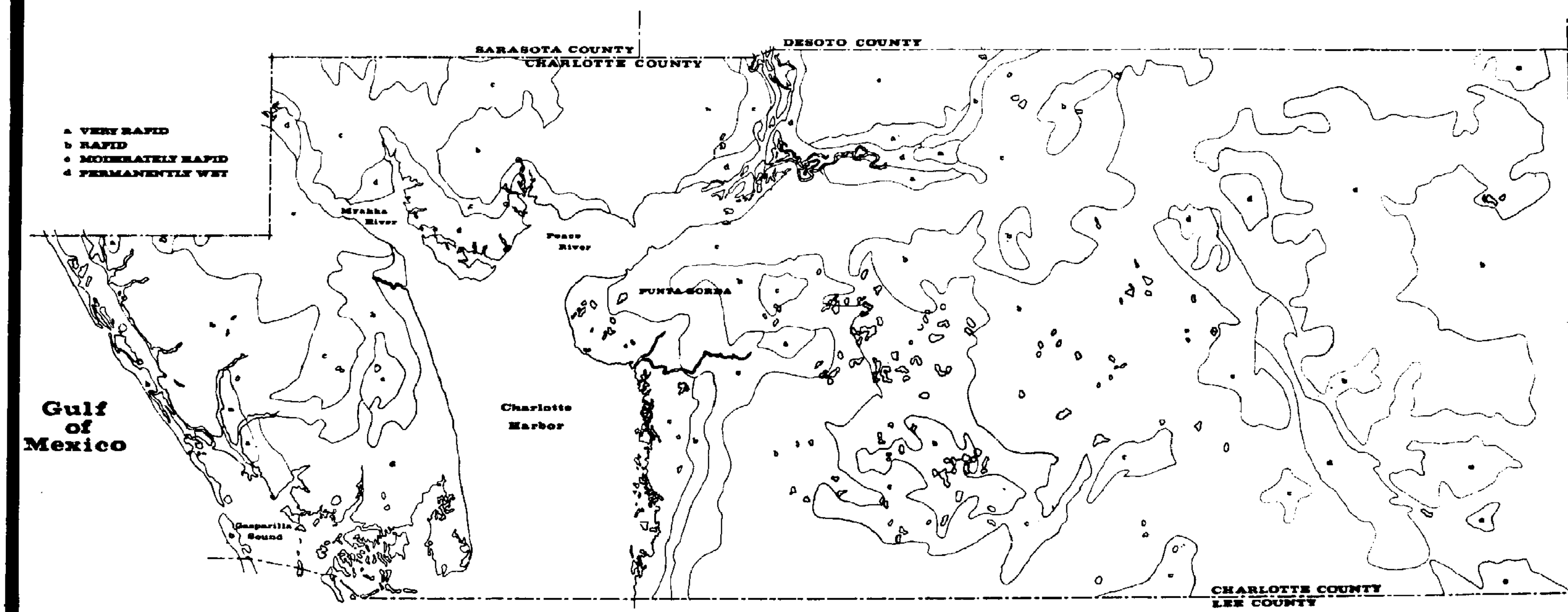


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

POTENTIOMETRIC HEAD

DECEMBER 31,'71
north
SCALE: 1" = 1mile

MAP NUMBER
CB



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE SOIL PERMEABILITY

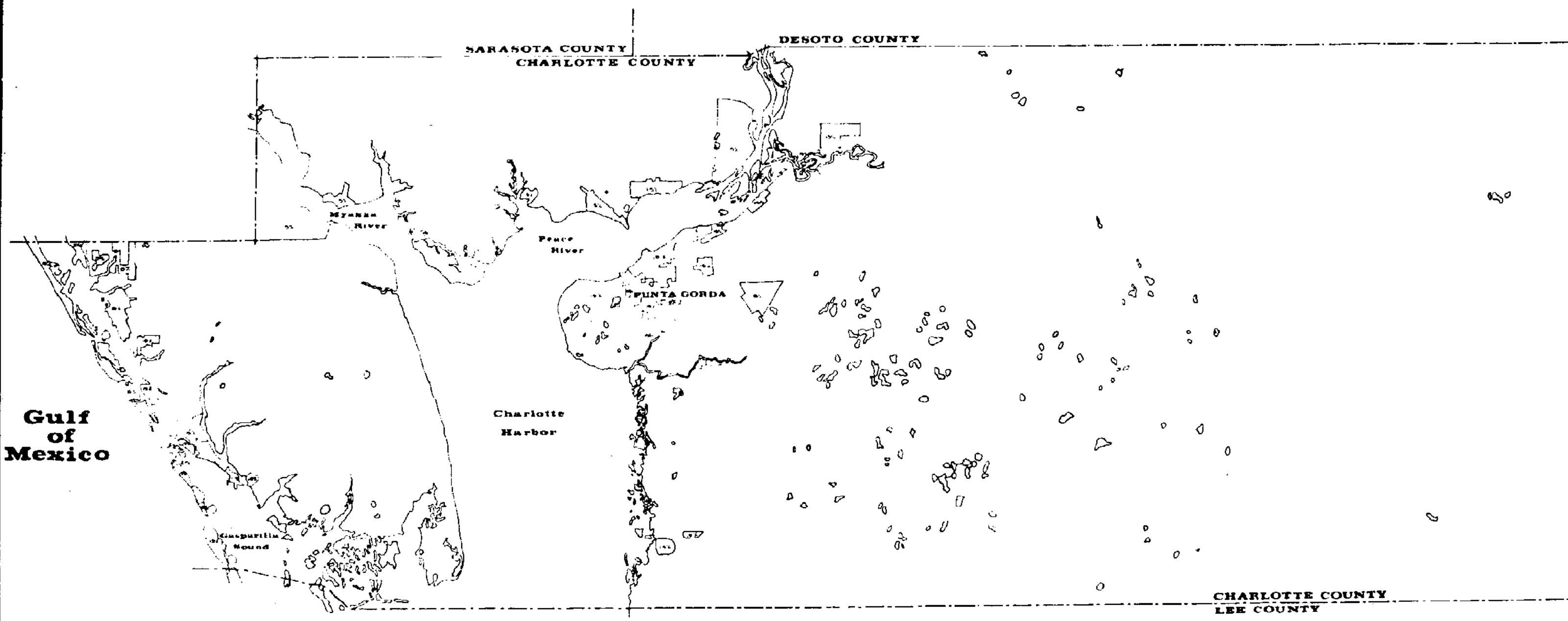
DECEMBER 31, '71

north

SCALE: 1" = 1 mile

MAP NUMBER

CC1

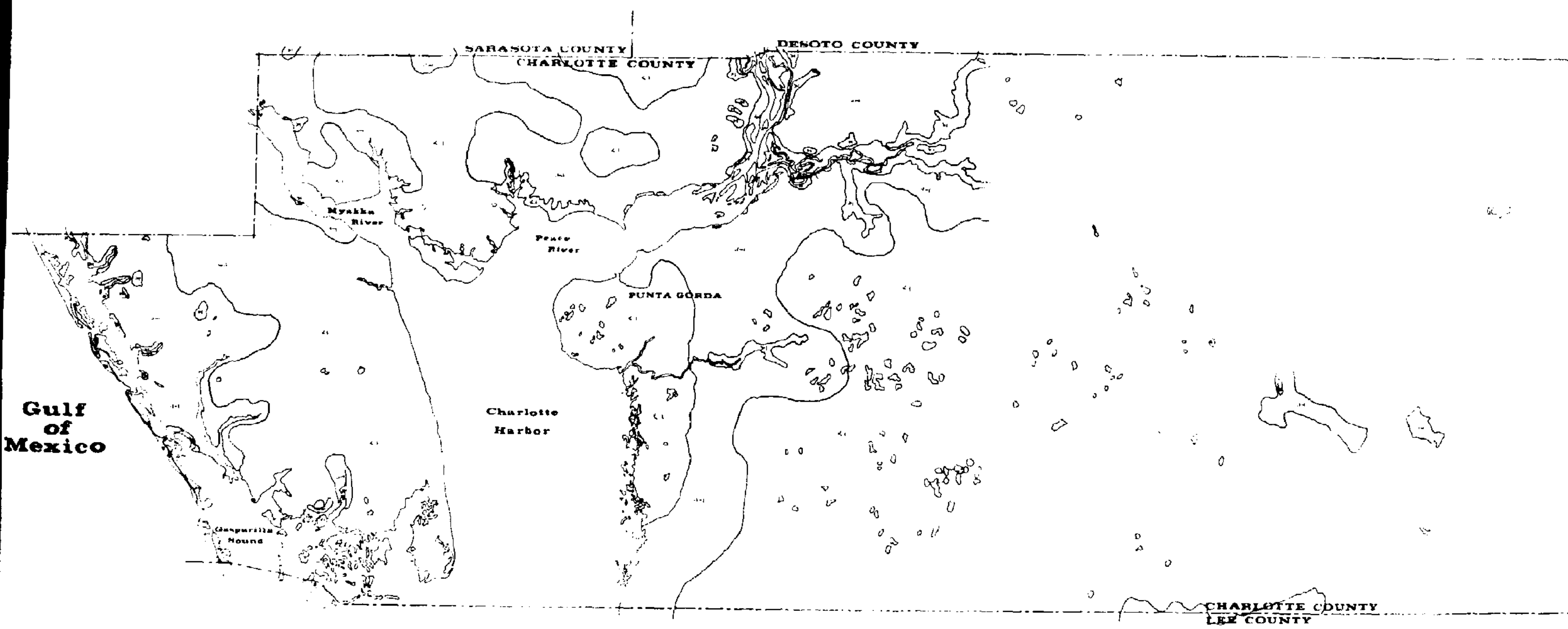


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

PAVED AREA

DECEMBER 31, '71
north
0 1 2 3
SCALE: 1" = 1 mile

MAP NUMBER
CC2

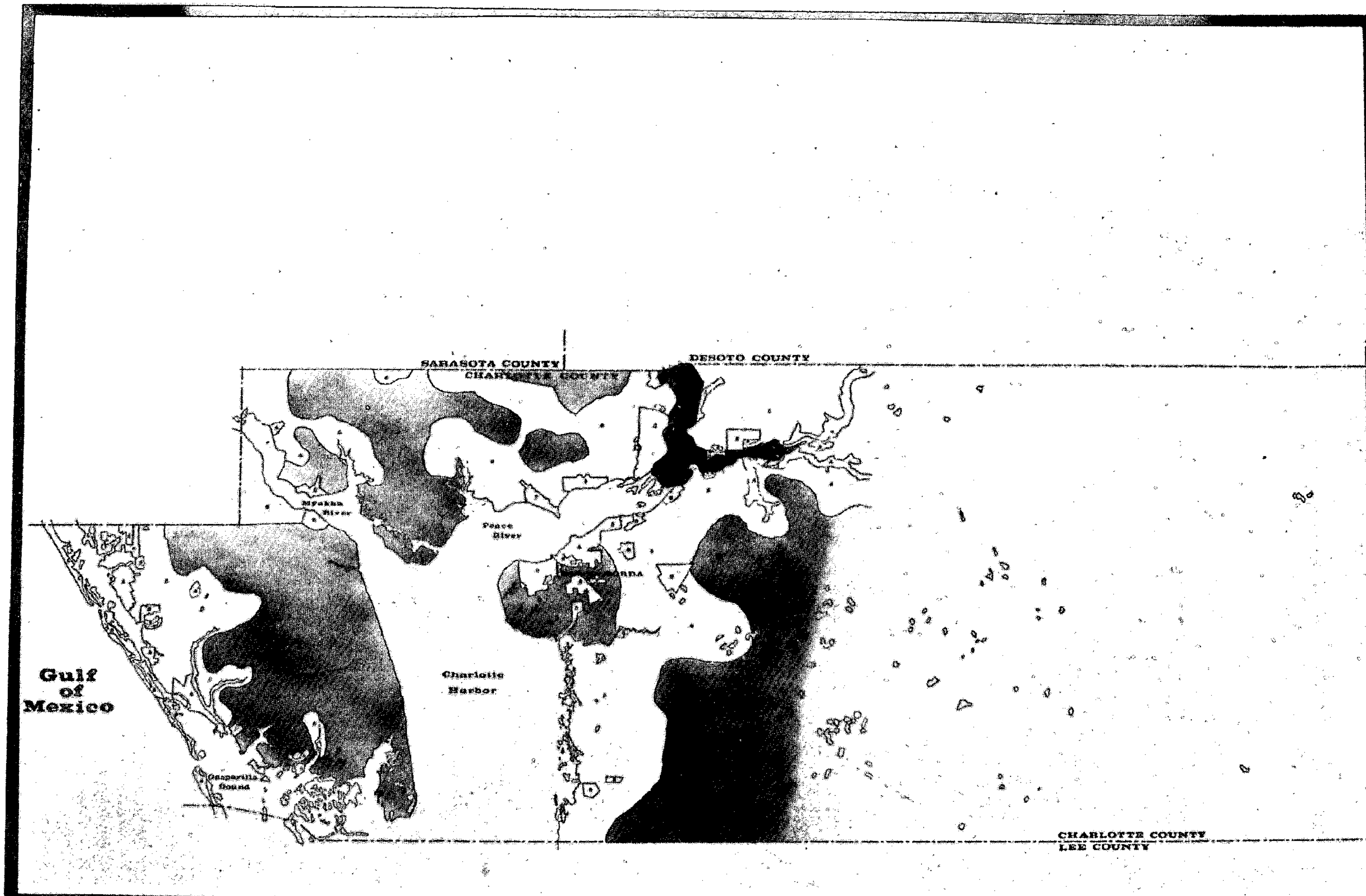


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SLOPE OF TERRAIN

DECEMBER 31,'71
north
SCALE: 1" = 1 mile

MAP NUMBER
CC3

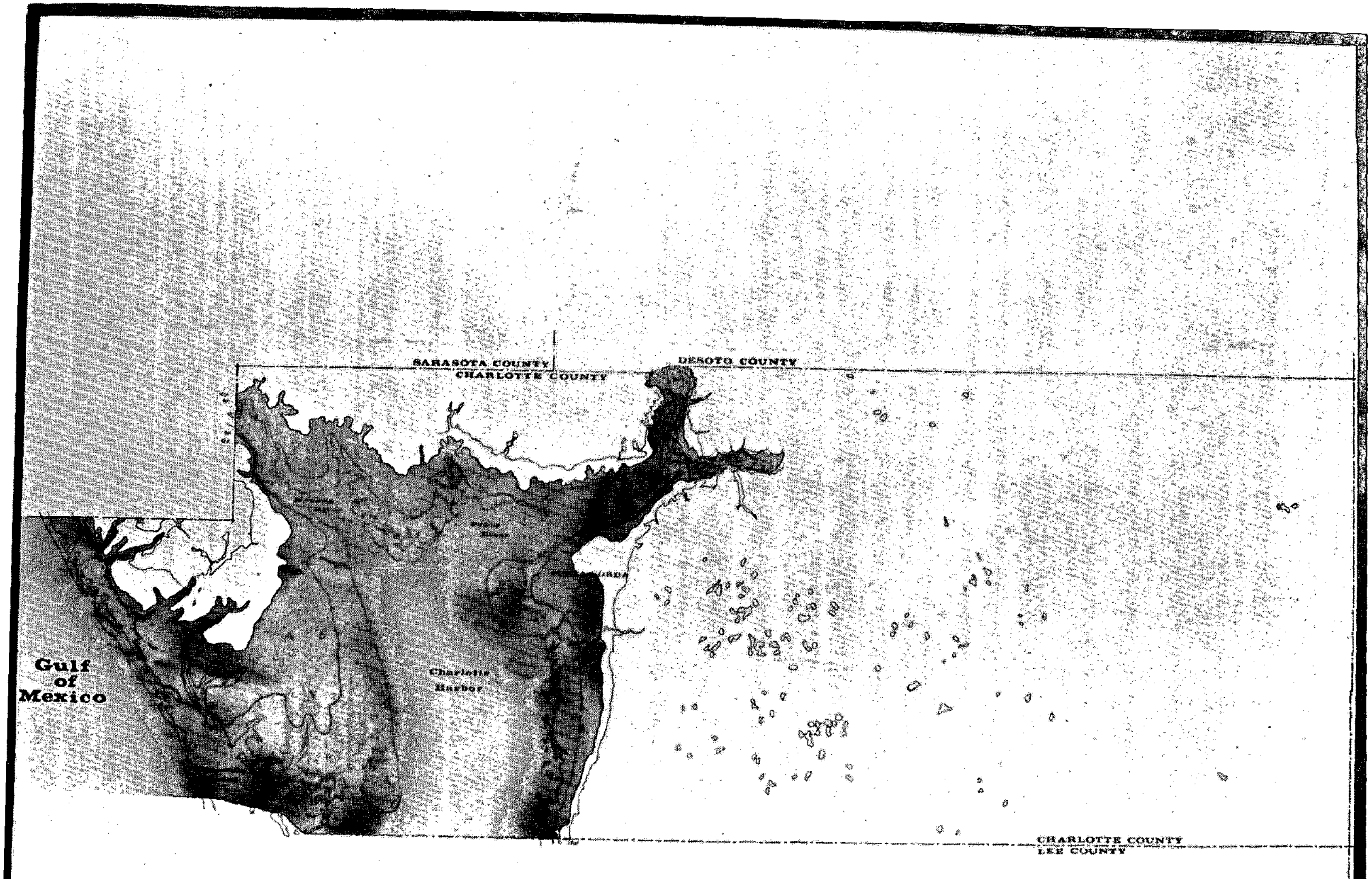


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE RUNOFF COEFFICIENT

DECEMBER 31, '71
north
SCALE: 1" = 1 mile

MAP NUMBER
CC



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

STORM TIDES

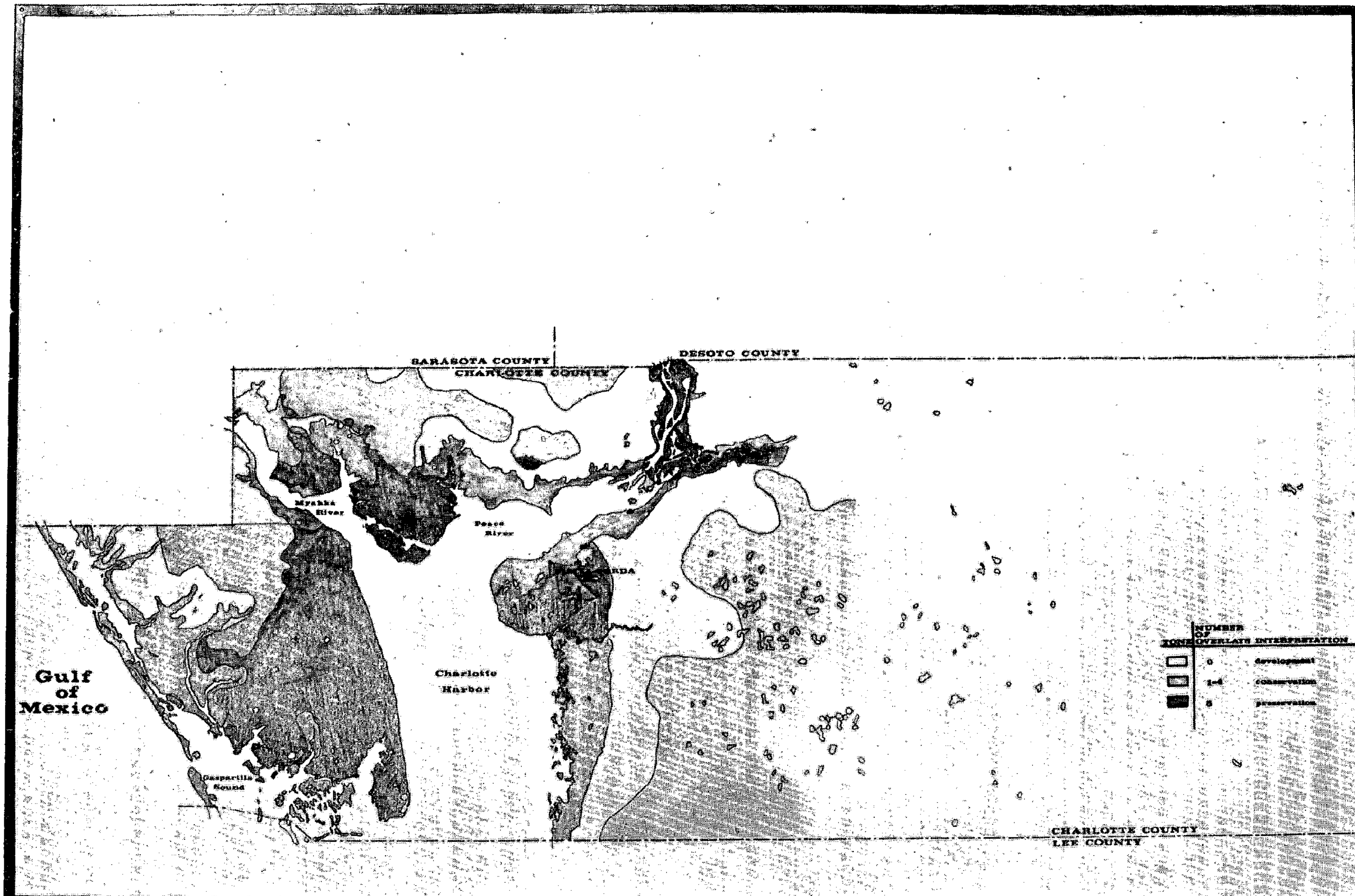
DECEMBER 31, '71

north 0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER

CE



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

COMPOSITE

DECEMBER 31, '71

north

SCALE: 1" = 1 mile

MAP NUMBER

CF

SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

GROUND WATER SALINITY

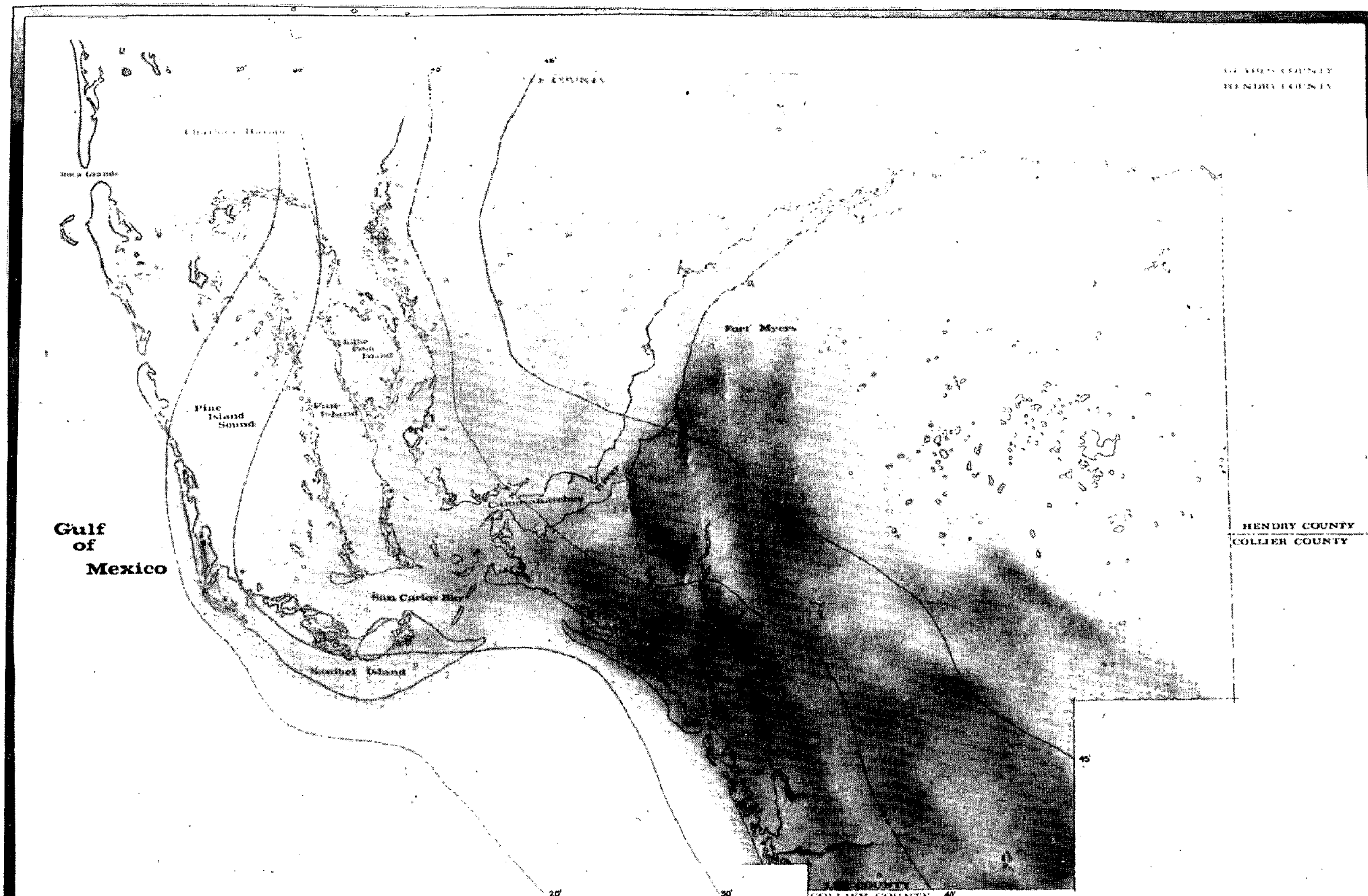
DECEMBER 31,'71

north 0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER

LA

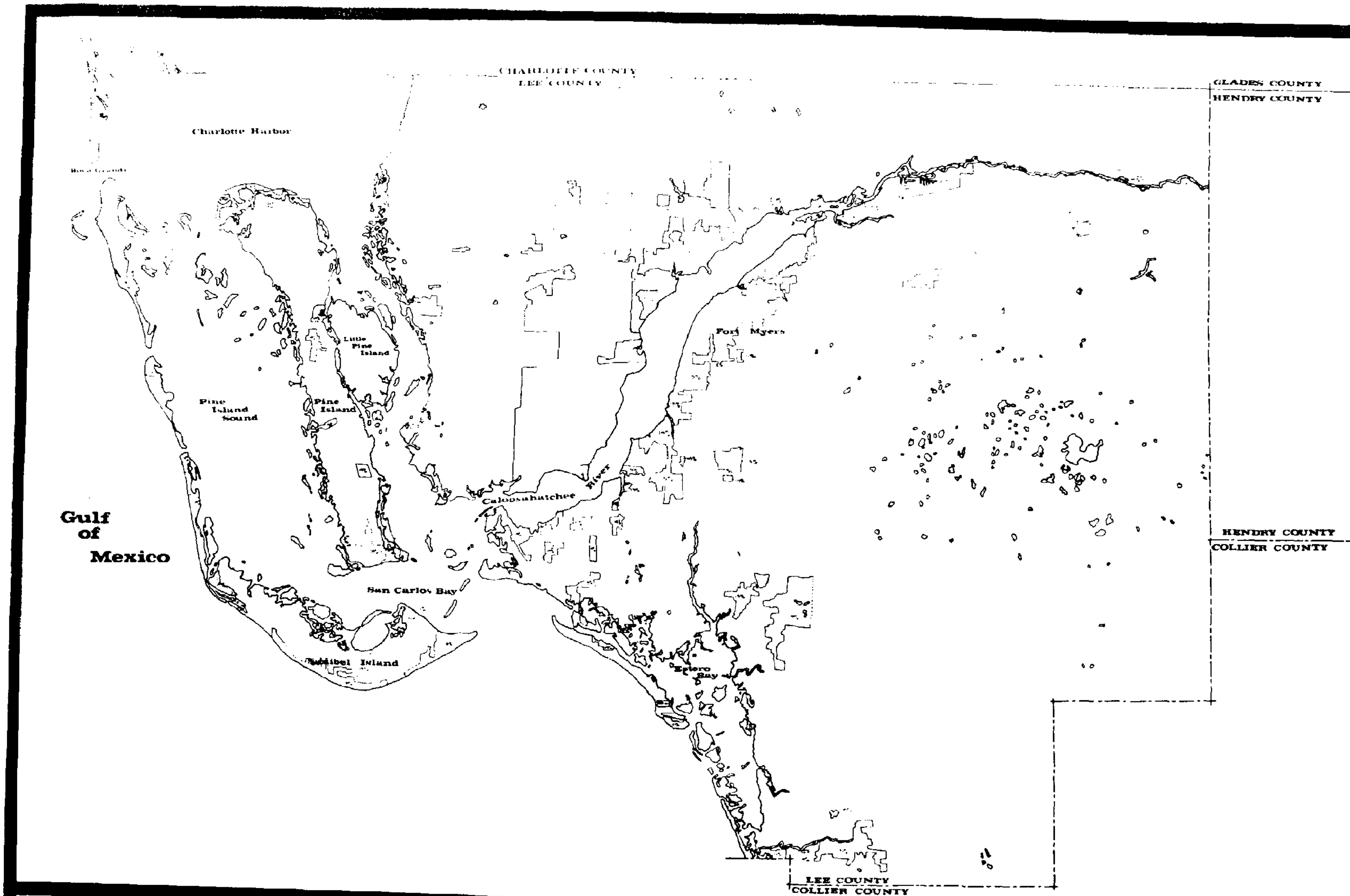


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

POTENTIOMETRIC HEAD

DECEMBER 31,'71
north
SCALE: 1" = 1 mile

MAP NUMBER
L B

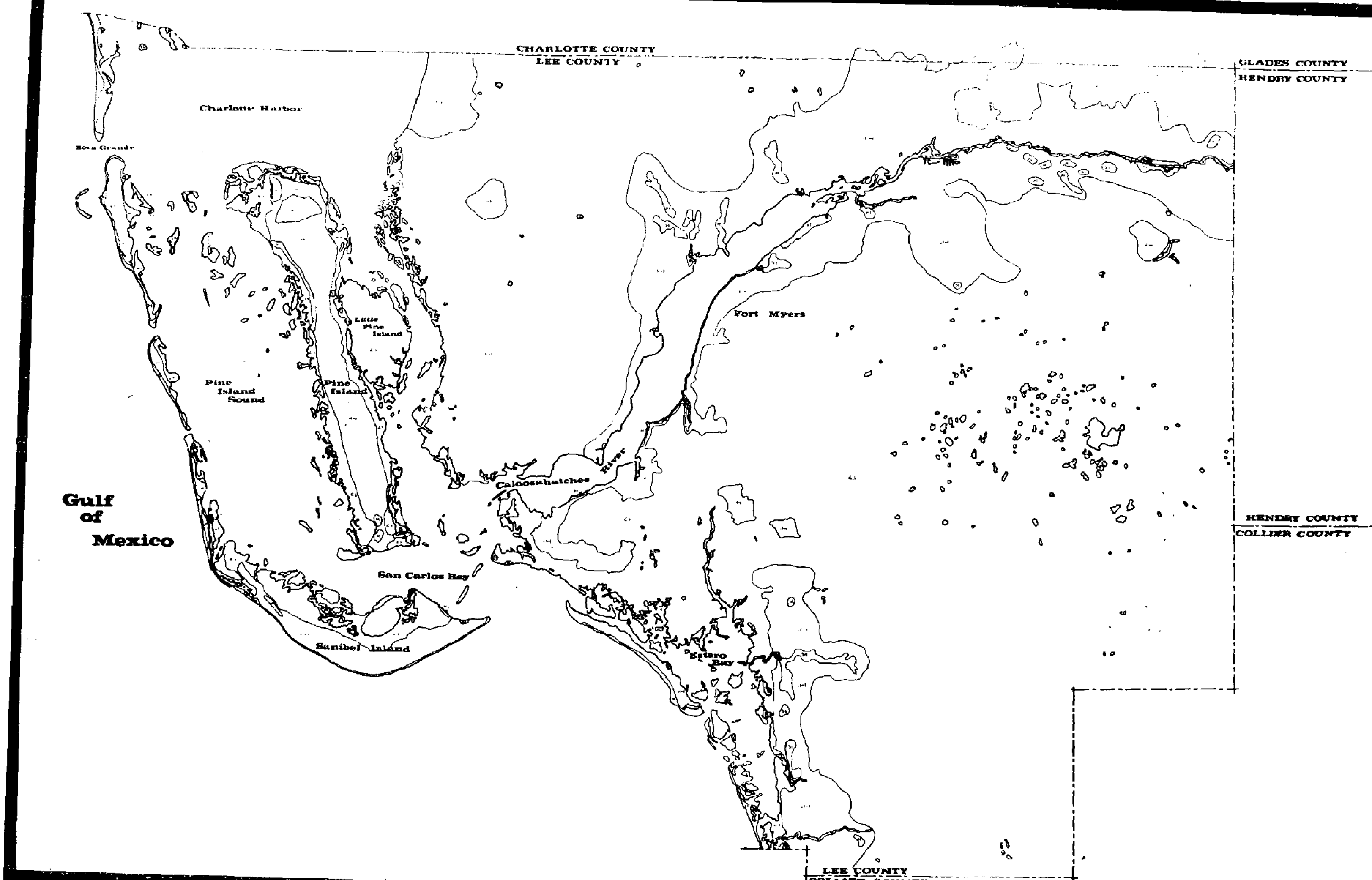


SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

PAVED AREA

DECEMBER 31, '71
north 0 1 2 3
SCALE: 1" = 1 mile

MAP NUMBER
LC2



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SLOPE OF TERRAIN

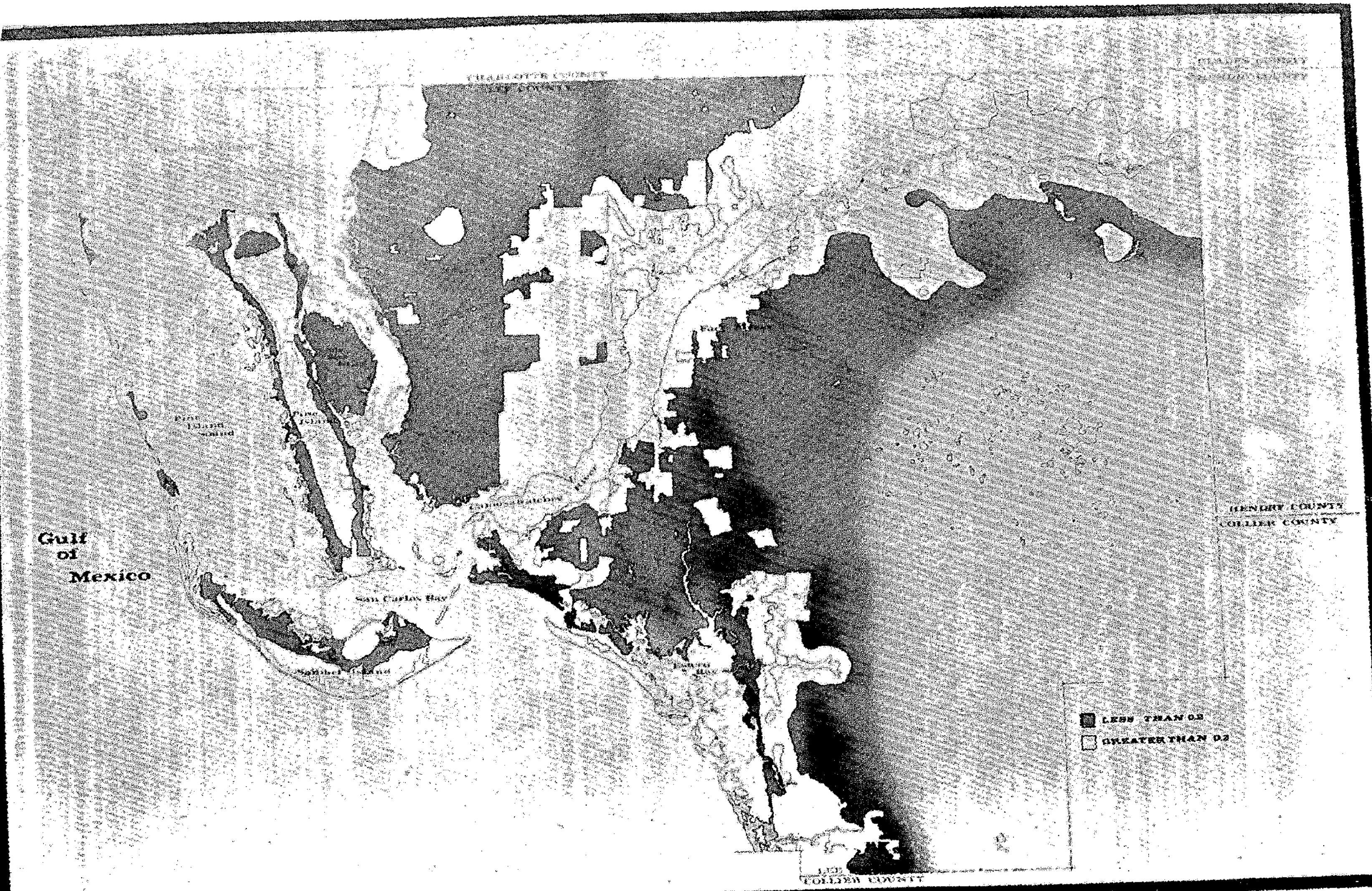
DECEMBER 31, '71

north

SCALE: 1" = 1 mile

AP NUMBER

LC3



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE RUNOFF COEFFICIENT

DECEMBER 31, '71

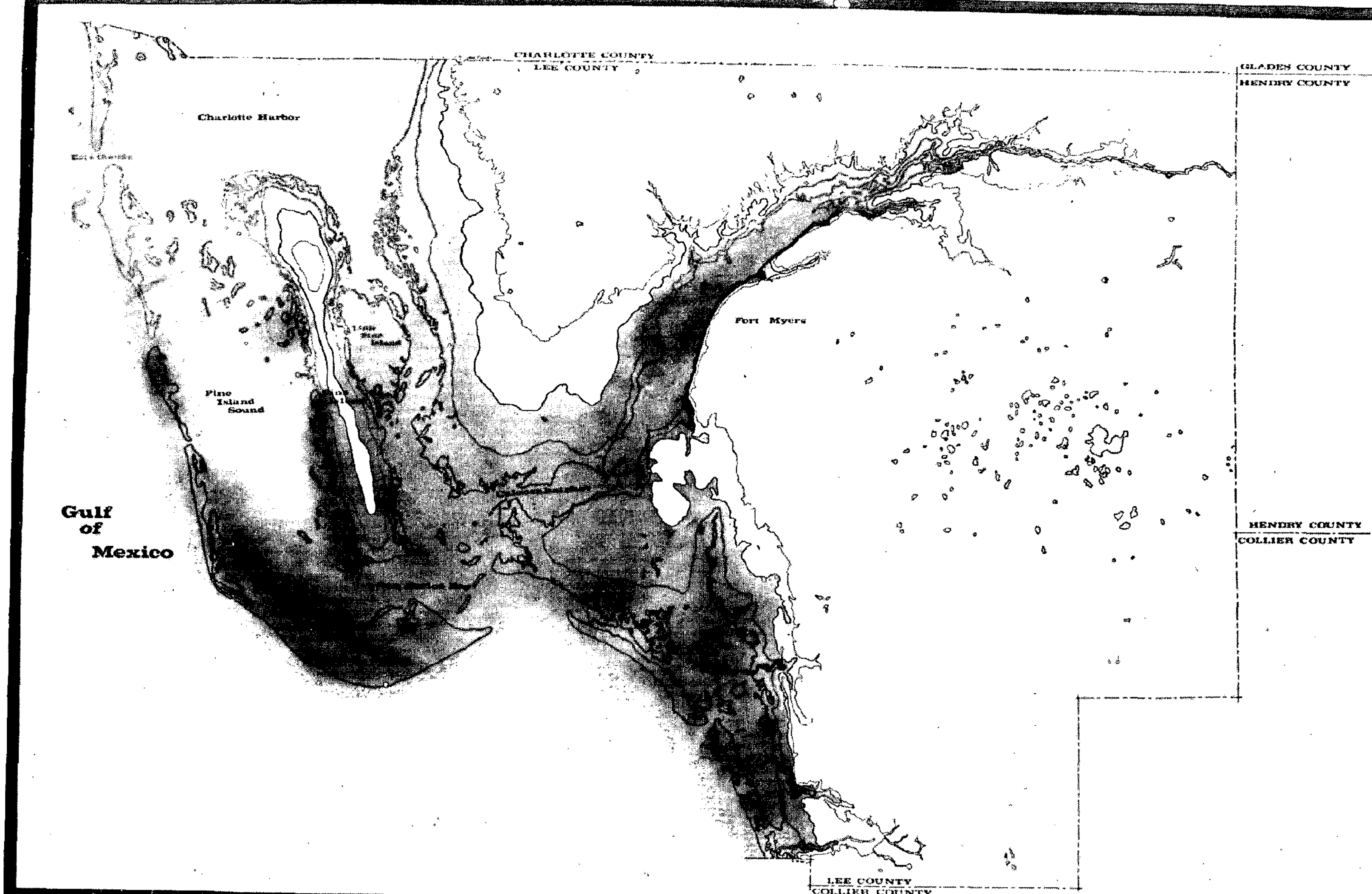
north

0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER

LC



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

STORM TIDES

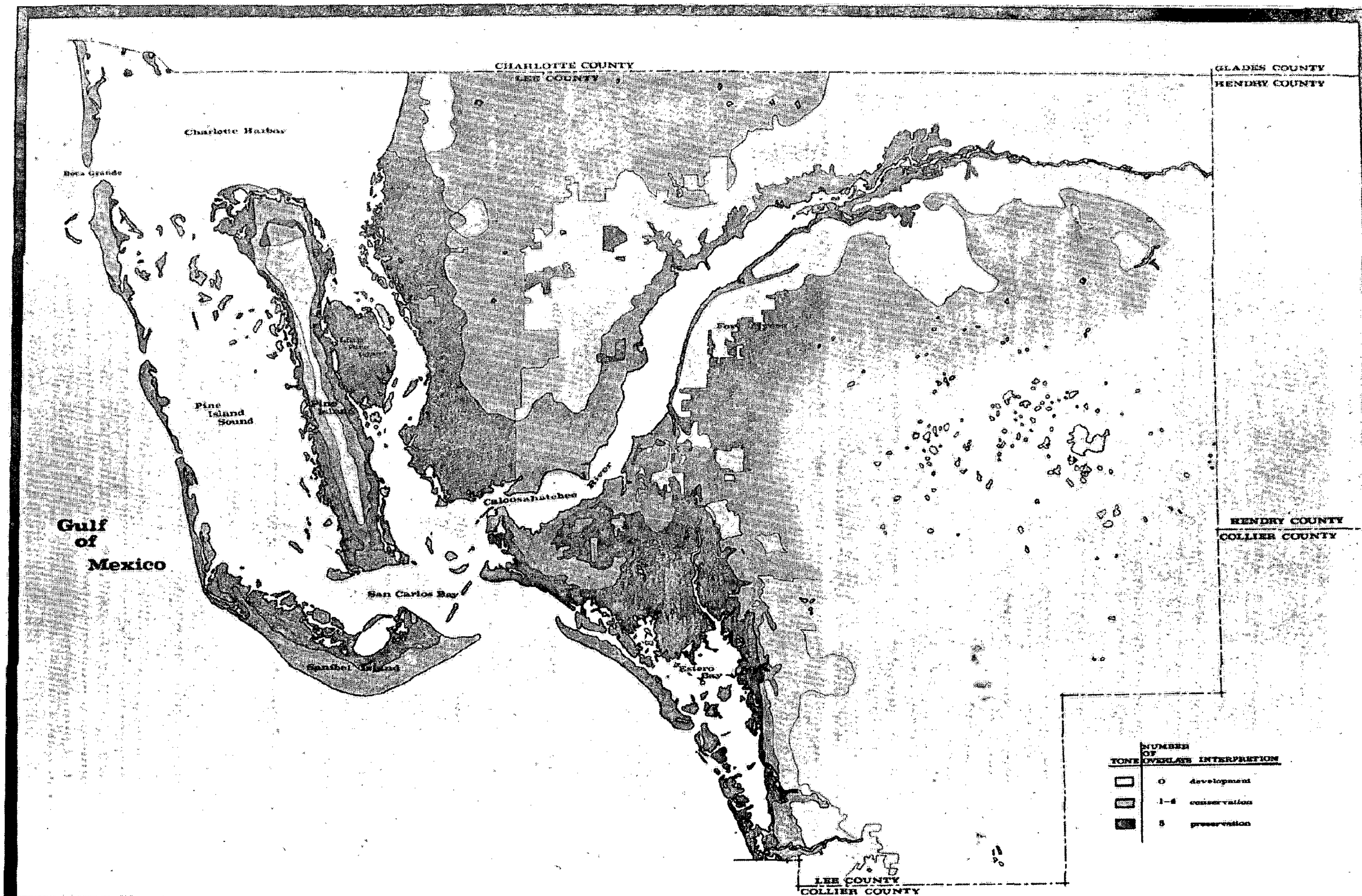
DECEMBER 31,'71

north 0 1 2 3

SCALE: 1" = 1 mile

MAP NUMBER

LE



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

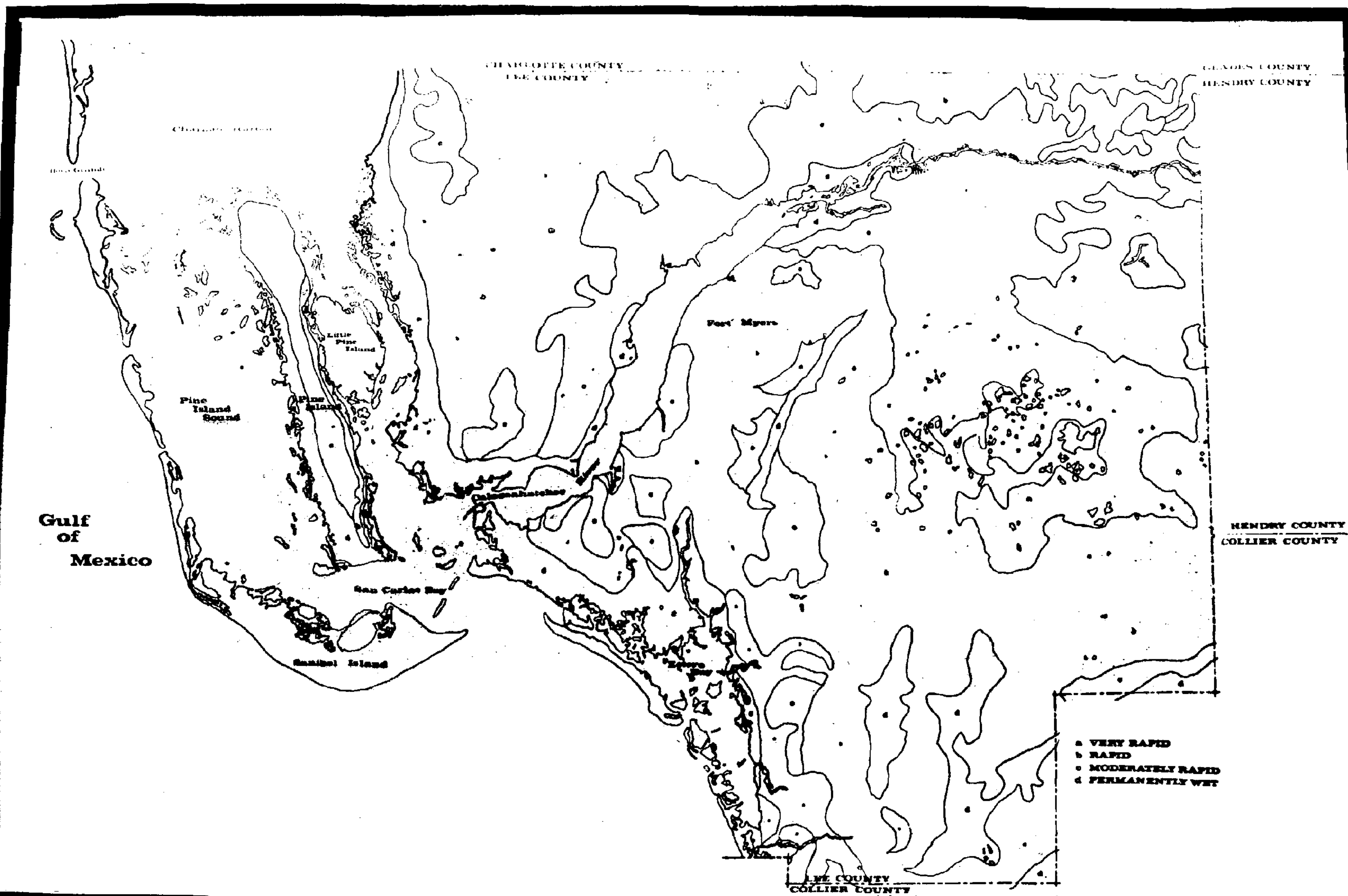
COMPOSITE

DECEMBER 31, '71

north

SCALE: 1" = 1 mile

MAP NUMBER **LF**



SOUTH WEST FLORIDA PLANNING TEAM
DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF FLORIDA

SURFACE SOIL PERMEABILITY

DECEMBER 31,'71

north

SCALE: 1" = 1 mile

MAP NUMBER

LC1