FDER CM-64 (A2) Grant: Final Report

Planning Department

Monroe County

Florida

Funds for this project were provided by the Florida Department of Environmental Regulation, Office of Coastal Management, from a grant from the U.S. Department of Commerce, Office of Ocean and Coastal Resource Management, under the Coastal Zone Management Act of 1972, as amended

The format of this report will follow the Scope of Work for this grant, as amended by the second amendment dated September 28, 1984.

TASK I. Revisions to the Coastal Zone Protection and Conservation Element.

(1) Maps of Endangered Species.

These maps are complete and are being transferred to sepia by the Department's draftsmen so they can be reproduced. They will be sent to DER under separate cover. The following section describes the maps and their use.

The maps are drawn at a scale of 1:24,000 (1" = 2000'), which is the scale the County is using for all its Land Use Plan maps. They are drawn on a copy of the County's "Existing Conditions" Maps, which show all existing development and wetland or upland vegetation.

Of the thirty endangered or threatened animal species in the Keys, there are sufficient data to map 16 species. Of these 16 species, 6 have been mapped by showing generalized ranges. For these species the range boundary is a solid line interrupted by the code number of the species with two stars. The arrows along the line point inward towards the range. The six species mapped in this manner are:

1) American Crocodile (code A204) - Range includes parts of Maps 5, 6 and 7. Within the range, the crocodile may inhabit open water (code 500), or mangroves (code 612, 620).

2) Key Largo Woodrat (code A401) - Range includes Upper Key Largo on Map 7. Within the range, the woodrat inhabits tropical hardwood hammocks (vegetation code 426).

3) Key Deer (code A402) - Two ranges are shown. The total range is delineated as described above, and includes areas on Maps 1, 2, and 3. The smaller range is delineated by a line with two arrows instead of one. Approximately 2/3 of the population is concentrated in this area. Within its range, the Key Deer utilizes all habitats and many developed areas.

4) Key Largo Cotton Mouse (code A404) - Range is same as Key Largo Woodrat, shown on Map 7.

5) West Indian Manatee (code A406) - Range includes bay waters along north and west side of Key Largo, on Maps 6 and 7. Within this range, the manatee inhabits open water, bays, creeks and canals.

6) Schaus Swallowtail Butterfly (code A502) - Range includes Upper Key Largo, shown on Map 7. Within this range, the Schaus Swallowtail inhabits tropical hardwood hammocks (vegetation code 426).

Ten species are mapped by showing the locations of known populations and reported observations. The following species are mapped in this manner:

1) Big Pine Ringneck Snake (code A206)
2) Eastern Indigo Snake (code A208)
3) Key Mud Turtle (code A209)
4) Florida Brown Snake (code A211)
5) Miami Black Headed Snake (code A212)
6) Florida Ribbon Snake (code A213)
7) Eastern Brown Pelican (code A306) (Nesting colonies mapped).
8) Silver Rice Rat (code A403)
9) Key Vaca Raccoon (code A405)
10) Stock Island Tree Snail (code A501).

For each of these species, a star is placed on the map at the center of the general area where it was observed. Please note that in many cases, the actual observation was somewhere within the vegetative community where the star is located, but it may not be directly under the star itself. At each star, there is a notation for the species code number(s), followed by a second number which is the County's number for that observation record. For example, A209-01 is the first observation record for the Key Mud Turtle. Attachment 1, of this report, is a print-out of the computer listing of all observation records, giving a brief synopsis of the source and location.

The final set of data for the endangered and threatened animals is the Table found in Attachment 2. This Table is used with the maps. All 30 species are listed with the County's species codes. As explained in the Table's footnote, an asterisk denotes the ten species for which observations are mapped, and a plus sign denotes the six species for which ranges are mapped. The "habitat" columns show the habitats where the species breeds or nests (B), feeds (F) and rests or roosts (R). The habitat columns are abbreviations of the names of the vegetation types mapped on the "Existing Conditions" maps, and the vegetation codes are also shown. For example, "SLP" stands for slash pinelands, which has the code 411 on the maps.

The final column of this Table shows the geographic range of the species.

TASK II. Interagency Agreements.

Attachment 3 is two letters initiating monthly meetings of County personnel with local representatives of the U.S. Army Corps of Engineers and Florida Department of Environmental Regulation. Other agencies now represented at these meetings include U.S. Fish and Wildlife Service, Florida Department of Natural Resources, and Florida Game and Freshwater Fish Commission.

The County also participates in the Florida Keys Interagency Management Committee, chaired by DCA.

TASK III. Ordinance Development.

(1) Trees and Vegetation.

Attachment 4 is the revision to this ordinance prepared by the Planning Department, along with a letter transmitting it to the County's Land Use Plan consultants. Adoption may occur as part of the new Land Use Plan.

(3) Freshwater Wetlands.

Attachment 5 is the definitions of the vegetation communities mapped on the County's "Existing Conditions" maps. Freshwater wetlands are mapped with code 641, and a definition of this unit is included in Attachment 5.

(4) Mangrove Trimming.

Staff determined that a mangrove trimming ordinance is not required at present. The proposed revision to the Trees and Vegetation ordinance can address this problem, and the State has recently enacted an ordinance regulating mangrove trimming.

TASK IV. Standards for Site Development.

Attachment 6 is narrative descriptions and a sensitivity analysis of the different natural communities of the Keys. This material will be used as the data base for the new Land Use Plan and site development regulations. Please note that the enclosed material, while it is being used for the development of planning scenarios, is still in a draft form. Revisions are anticipated as the program advances to subsequent phases.

TASK V. Coral Reef.

One section of Attachment 5 addresses coral reefs.

TASK VI. Coordinate with DCA Land Use Plan Program.

It should be evident that the entire focus of this grant program has been coordinated with the Land Use Plan effort of the County and DCA.

ATTACHMENT 1

Explanation of Index Entries

Species Code:
Record #:
FNAI Element Occurence Code:
Author/Observer:
Citation:
Location: Township - Range - Section: Key
Vegation Code:
Hammock Atlas Reference:

A207
01
AHRDB11011.002
Jun 10 77
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16a,b,c

A207
02
AHRDB11011.003
May 26 77
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16d,e

A207
03
AHRDB11011.004
1977
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16f

A207
04
AHRDB11011.005
Jun 15 77
Weiner, A.H.
Hammocks Survey
066S-029E: L113
426
L9/17

A207
05
AHRDB11011.006
Jun 21 77
Weiner, A.H.
Hammocks Survey
066S-028E: L113
426
L9/21

A207
06
AHRDB11011.007
Jan 5 77
Weiner, A.H.
Hammocks Survey
066S-028E: L110
426
L9/35

A207
07
AHRDB11011.011
Mar 24 82
Weiner, A.H.
Hammocks Survey
063S-038E: L134
426
L4/1

A207
08
AHRDB11011.012
Dec 7 81
Weiner, A.H.
Hammocks Survey
067S-030E: L116
426
L8/11

A209
01
-
Oct 5 78
Barbour, D. Bruce
Letter to Paul Moler (5/2/79)
066S-028E-29: L110
426, 740.3
L9/35

A209
02
-
Oct 26 78
Barbour, D. Bruce
Letter to Paul Moler (5/2/79)
066S-028E-31, 067S-028E-06: L109
426
L10/6a

A209
03
AHRAE01011.001
May 26 77
Weiner, A.H.
Hammocks Survey
066S-029E-17: L114
426
L9/16d

A209
04
AHRAE01011.001
May 26 77
Weiner, A.H.
Hammocks Survey
066S-029E-17: L114
426
L9/16e

A209
05
-
Nov 16 78
Barbour, D. Bruce
Letter to Paul Moler (5/2/79)
066S-029E-31: L112
640
-

A209
06
-
Oct 26 78
Barbour, D. Bruce
Letter to Paul Moler (5/2/79)
066S-028E-28: L110
426, 640
L9/36

A209
07
AHRAE01011.002
Sep 12 77
Weiner, A.H.
Hammocks Survey
066S-028E-29: L110
426, 740.3
L9/35

A209
08
-
-
Lazelle, Skip
Letter to FWS
067S-030E-06: L116
426
L8/11

A212
01
AHRDB35060.001
May 26 82
Achor, Karen L.
Special Animal Field Report Form, 6/8/82
061S-039E-01,12: L135
640, near 426
L2/8

A212
02
AHRDB35060.006
Sep 76
-
Specimen #JF-39064 SM
060S-040E: L136
prob. 426
-

A212
03
AHRDB35060.007
Jun 78
Porras, L. & L.D. Wilson
New Distributional Records for Tantilla oolitica
065S-034E-19: L148
426
L6/2

A213
01
AHRDB36122.001
May 26 77
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16d,e

A213
02
AHRDB36122.002
1977
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16f

A213
03
AHRDB36122.003
Jan 5 77
Weiner, A.H.
Hammocks Survey
066S-028E: L110
426, 641
L9/35

A213
04
AHRDB36122.004
May 23 70
Christman, S.P.
Specimen #UF-44325 SM
066S-029E: L116
411
-

A213
05
-
May 23 76
Keefer
Specimen #UF-44326 SM
066S-029E: L116
411
-

A213
06
-
-
Porras
Specimen #UF-44327 SM
066S-029E: L116
411
-

A306
01
-
1968-1976
Williams, Lovett E., Jr. (ed.)
Recovery Plan for the Eastern Brown Pelican, p.34
067S-026E-26: L161
?
-

A306
02
ABNDB01022.011
Jun 25 75
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
061S-038E: L149
?
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A306
03
ABNDB01022.012
Apr 19 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
062S-038E: L150
?
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A306
04
ABNDB01022.013
Jul 78
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
061S-034E: L151
?
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A306
05
ABNDB01022.014
May 14 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
066S-030E: L152
612
-

A306
06
ABNDB01022.015
Feb 13 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
063S-035E: L153
?
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A306
07
ABNDB01022.016
May 27 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
? :L154
?
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A306
08
ABNDB01022.017
May 27 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
065S-028E: L155
?
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A306
09
ABNDB01022.018
May 14 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
066S-032E: L156
426, 740.1
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A306
10
ABNDB01022.019
May 27 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
066S-027E-04: L157
?
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A306
11
ABNDB01022.020
Apr 19 76
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
063S-035E: L153
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A306
12
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1975-1976
Osborn, Ronald G. & Thomas W. Custer
Herons & Their Allies: Atlas of Atlantic Coast Colonies, 1975 & 1976
066S-027E-04: L157
?
-

A306
13
-
1976-1978
Nesbitt, Steven A., et al.
Florida Atlas of Breeding Sites for Herons & Their Allies:1976-1978
066S-027E-04: L157
?
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A306
14
-
1968-1976
Williams, Lovett E., Jr. (ed.)
Recovery Plan for the Eastern Brown Pelican, p.34
066S-030E-29: L162
612
-

A306
15
-
1968-1976
Williams, Lovett E., Jr. (ed.)
Recovery Plan for the Eastern Brown Pelican, p.34
066S-031E-21, 22: L163
612,640
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A306
16
-
1968-1976
Williams, Lovett E., Jr. (ed.)
Recovery Plan for the Eastern Brown Pelican, p.34
066S-031E-19: L122
612
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A306
17
-
1968-1976
Williams, Lovett E., Jr. (ed.)
Recovery Plan for the Eastern Brown Pelican, p.34
065S-030E: L164
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A401
01
AMAFF08011.001
79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
059S-040E-13: L136
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L1/5

A401
02
AMAFF08011.002
Sep 20 77
Weiner, A.H.
Hammocks Survey
059S-040E-13,23,24: L136
426
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A401
03
AMAFF03081.004
79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
059S-040E-23: L136
426
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A401
04
AMAFF03081.005
79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
059S-040E-25: L136
426
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A401
05
AMAFF03081.006
79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-10: L136
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A401
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Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-10: L136
426
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A401
07
AMAFF03081.008
79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-16: L135
426
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A401
08
AMAFF03081.009
79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-28: L135
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A401
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Sep 30 78
Weiner, A.H.
Hammocks Survey
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Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
059S-040E-24: L136
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A401
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AMAFF03081.012
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Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-02: L136
426
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A401
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AMAFF03081.016
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Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
059S-040E-35: L136
426
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A401
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AMAFF03081.017
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Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-10: L136
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A401
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Layne, James N.
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A401
16
-
Mar 84
Weiner, A.H.
Hammocks Survey
059S-040E-26,35; 060S-040E-02,03: L136
426
L1/12

A401
17
-
Feb 84
Weiner, A.H.
Hammocks Survey
060S-040E-02: L136
426
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A401
18
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Feb 26 84
Weiner, A.H.
Hammocks Survey
060S-040E-09,15: L136
426
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A401
19
-
Jan 84
Weiner, A.H.
Hammocks Survey
060S-040E-29: L135
426
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A401
20
-
Dec 83
Weiner, A.H.
Hammocks Survey
060S-040E-29,31,32: L135
426
L2/5

A403
01
AMAFF01030.001
Feb 7 73
Spitzer, Numi
Thesis, telephone conservation w/ D. Jackson
066S-028E-29: L110
426, 740.3
L9/35

A403
02
-
Feb 80
Spitzer, Numi
Status Report on Oryzomys argentatus, the Silver Rice Rat p.2 para. 3
065S-028E-29: L159
612
-

A403
03
AMAFF01030.001
Feb 8 73
Spitzer, Numi
Thesis, telephone conservation w/ D. Jackson
066S-028E-29: L110
426, 740.3
L9/35

A403
04
-
Nov 12 81
Spitzer, Numi
Thesis
066S-028E-01: L113
612, 640
-

A403
05
-
Nov 22 81
Spitzer, Numi
Thesis
066S-028E-01: L113
612, 640
-

A403
06
-
Nov 12 81
Spitzer, Numi
Thesis
066S-028E-01: L113
612, 640
-

A403
07
-
Nov 18 81
Spitzer, Numi
Thesis
066S-028E-01: L113
612, 640
-

A403
08
-
Nov 18 81
Spitzer, Numi
Thesis
066S-028E-12: L113
612, 640
-

A403
09
-
Nov 20 81
Spitzer, Numi
Thesis
065S-028E-35: L113
620, 640
-

A403
10
-
Oct 9 81
Spitzer, Numi
Thesis
066S-030E-05: L143
?
-

A403
11
-
Oct 11 81
Spitzer, Numi
Thesis
066S-030E-05: L143
?
-

A403
12
-
Nov 28 81
Spitzer, Numi
Thesis
066S-029E-19: L114
620, 640
-

A403
13
-
Jan 19 81
Spitzer, Numi
Thesis
065S-028E-29,32: L159
612, 640
-

A403
14
-
Jan 20 81
Spitzer, Numi
Thesis
065S-028E-29,32: L159
612, 640
-

A403
15
-
1976
Spitzer, Numi
Thesis
065S-028E-29,32: L159
612, 640
-

A403
16
-
1980
Spitzer, Numi
Thesis
065S-028E-29,32: L159
612, 640
-

A403
17
-
Oct 5 81
Spitzer, Numi
Thesis
067S-027E-07,08: L107
612, 620, 640
-

A403
18
-
Nov 2 81
Spitzer, Numi
Thesis
066S-028E-26: L111
620, 640
-

A403
19
-
Nov 4 81
Spitzer, Numi
Thesis
066S-028E-23: L111
620, 640
-

A403
20
-
Dec 1 81
Spitzer, Numi
Thesis
066S-028E-23: L111
620, 640
-

A403
21
-
Dec 6 81
Spitzer, Numi
Thesis
066S-028E-23: L111
620, 640
-

A403
22
-
Nov 8 81
Spitzer, Numi
Thesis
066S-028E-26: L111
620, 640
-

A403
23
-
Dec 6 81
Spitzer, Numi
Thesis
066S-028E-26: L111
620, 640
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A403
24
-
Jan 2 81
Spitzer, Numi
Thesis
065S-028E-26: L160
?
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A403
25
-
Jan 9 81
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Thesis
065S-028E-26: L160
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A403
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-
Jan 19 81
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Thesis
065S-028E-26: L160
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A403
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1984
Spitzer, Numi
Personal communication
066S-027E-08,09: L158
?
-

A404
01
AMAFF03081.001
Aug 79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
060S-040E-16: L135
426
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A404
02
AMAFF03081.002
Jun 79
Humphrey, S.R. & D.B. Barbour
Status & Habitats of 8 Endangered & Threatened Rodents in Fla.
059S-040E-26: L136
426
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A404
03
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78
Layne, James N.
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064S-036E-02,03: L139
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A405
01
AMAJE02011.006
Jun 10 77
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16a,b,c

A405
02
AMAJE02011.007
May 26 77
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16d,e

A405
03
AMAJE02011.008
1977
Weiner, A.H.
Hammocks Survey
066S-029E: L114
426
L9/16f

A405
04
AMAJE02011.009
Jun 21 77
Weiner, A.H.
Hammocks Survey
066S-028E: L113
426
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A405
05
AMAJE02011.010
May 16 78
Weiner, A.H.
Hammocks Survey
066S-028E: Little Knockemdown
426
L9/32

A405
06
AMAJE02011.012
Feb 11 82
Weiner, A.H.
Hammocks Survey
066S-028E: L110
426
L9/38a,b

A405
07
AMAJE02011.011
Feb 16 82
Weiner, A.H.
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066S-030E: L117
426
L8/7

A405
08
AMAJE02011.005
Aug 15 77
Weiner, A.H.
Hammocks Survey
066S-030E: L117
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A405
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AMAJE02011.004
Aug 1 77
Weiner, A.H.
Hammocks Survey
066S-030E: L117
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A405
10
AMAJE02011.003
Aug 16 77
Weiner, A.H.
Hammocks Survey
066S-030E: L117
426
L8/8

A405
11
AMAJE02011.002
Aug 6 77
Weiner, A.H.
Hammocks Survey
066S-030E: L117
426
L8/6

A405
12
AMAJE02011.001
Jul 30 77
Weiner, A.H.
Hammocks Survey
066S-030E: L117
426
L8/5

A501
01
ASGAS45011.001
80
Thompson, F.G.
Final Report to USFWS on Stock Island Tree Snail, Orthalicus r. reses
067S-025E-27: L102
426, 740.1
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ATTACHMENT 2

FISHES

SPECIES NAME LATIN NAME (COMMON NAME) CODE	HABITAT SLP 411	 THH 426	 OPW 500	 FRM 612	 SCM 620	 SMB 640	 FWW 641	 SGB 645	 B/B 710	 COR 801	RANGE
Menidia conchorum (Key Silverside) A101			F R					B F R			Big Pine, Cudjoe, Key West

SLP:Slash pineland THH:Tropical hardwood hammock OPW:Open water FRM:Fringing mangrove
SCM:Scrub mangrove SMB:Salt marsh-buttonwood association FWW:Freshwater wetland
SGB:Seagrass bed B/B:Beach w/associated berm COR:Coral reef B:Breeding F:Feeding
R:Resting *:Observations mapped +:Range mapped

PRELIMINARY

MONROE COUNTY PLANNING DEPARTMENT

REPTILES

SPECIES NAME LATIN NAME (COMMON NAME) CODE	HABITAT SLP 411	 THH 426	 OPW 500	 FRM 612	 SCM 620	 SMB 640	 FWW 641	 SGB 645	 B/B 710	 COR 801	RANGE
Alligator mississippiensis (American Alligator) A201		B	F	F	F		B F				Little Pine to Cudjoe (inclusive)
Caretta caretta caretta (Atlantic Loggerhead Turtle) A202			F R					F	B	F	Upper Matecumbe (nesting), Lower Matecumbe (nesting), all marine waters
Chelonia mydas mydas (Atlantic Green Turtle) A203			F R					F	B		All marine waters
Crocodylus acutus (American Crocodile) A204 +		B	F R	F	F				B R		Key Largo, Plantation, Florida Bay, Little Pine to Big Pine (inclusive), Johnston, Sugarloaf
Dermochelys coriacea (Leatherback Turtle) A205			F R								All marine waters
Diadophis punctatus acricus (Big Pine Ringneck Snake) A206 *	B F R	? ? ?									No Name to Sugarloaf (inclusive)
Drymarchon corais couperi (Eastern Indigo Snake) A207 *	B F1 R1	B F1 R1		F2	F2	F2	F2				Key Largo, Plantation, No Name to Sugarloaf (inclusive) [pan-Keys?]
Eretmochelys imbricata imbricata (Atlantic Hawksbill Turtle) A208			F R					F	B	F	All marine waters

Kinosteron bauri bauri (Key Mud Turtle) A209 *	F2 R2	F2 R2					B F1 R1				Big Pine to Stock Island (inclusive)
Lepidochelys kempi (Atlantic Ridley Turtle) A210			R					F R			All marine waters
Storeria dekayi victa (Florida Brown Snake) Lower Keys population A211 *	B F R						B F R				Big Pine, No Name, Sugarloaf
Tantilla oolitica (Miami Black-headed Snake) A212 *	B F1 R1	B F1 R1			F2 R2	F2 R2	F2 R2				Key Largo to Grassy Key (inclusive)
Thamnophis sauritus (Florida Ribbon Snake) Lower Keys population A213 *				B F R	B F R	B F R	B F R				No Name to Cudjoe (inclusive)

SLP:Slash pineland THH:Tropical hardwood hammock OPW:Open water FRM:Fringing mangrove
SCM:Scrub mangrove SMB:Salt marsh-buttonwood association FWW:Freshwater wetland
SGB:Seagrass bed B/B:Beach w/associated berm COR:Coral reef B:Breeding F:Feeding
R:Resting *:Observations mapped +:Range mapped

BIRDS

SPECIES NAME LATIN NAME (COMMON NAME) CODE	HABITAT SLP 411	 THH 426	 OPW 500	 FRM 612	 SCM 620	 SMB 640	 FWW 641	 SGB 645	 B/B 710	 COR 801	RANGE
Charadrius alexadrinus tenuirostris (Southeastern Snowy Plover) A301									B F R		Middle Keys, Big Pine, Florida Bay
Columba leucocephala (White-crowned Pigeon) A302	F R	F R		B R							Pan-keys
Falco peregrinus (Peregrine Falcon) A303		F R		F R	F R				F		Pan-keys
Haliaeetus leucocephalus (Bald Eagle) A304	B F2 R2	B F2 R1	F1	B F2 R2	B F2 R2	F2	F2		F2		Little Pine to Key West Florida Bay
Mycteria americana (Wood Stork) A305			F	F R	F	F	F	F			Key Largo, Florida Bay
Pelecanus occidentalis carolinensis (Eastern Brown Pelican) A306 *		B2 R1	F	B1 R1	R1			F	R2		Pan-keys, Florida Bay, Marquesas, Dry Tortugas
Sterna albifrons antillarium (Least Tern) A307			F						B R		Pan-keys

Sterna dougallii dougallii (Roseate Tern) A308			F						B R		Crawl Key, Cocoplum Beach, islands off Seven-Mile Bridge, Key West Harbor, Dry Rocks, Dry Tortugas

SLP:Slash pineland   THH:Tropical hardwood hammock   OPW:Open water   FRM:Fringing mangrove
SCM:Scrub mangrove   SMB:Salt marsh-buttonwood association   FWW:Freshwater wetland
SGB:Seagrass bed   B/B:Beach w/associated berm   COR:Coral reef   B:Breeding   F:Feeding
R:Resting   *:Observations mapped   +:Range mapped

MAMMALS

SPECIES NAME LATIN NAME (COMMON NAME) CODE	HABITAT SLP 411	 THH 426	 OPW 500	 FRM 612	 SCM 620	 SMB 640	 FWW 641	 SGB 645	 B/B 710	 COR 801	RANGE
Neotoma floridana smalli (Key Largo Woodrat) A401 +		B F R									Upper Key Largo, Lignum Vitae (introduced)
Odocoileus virginianus clavium (Key Deer) A402 +	F R	B F R		F R	F R	F	F				Little Pine to Sugarloaf (inclusive)
Oryzymus argentatus (Silver Rice Rat) A403 *				B F R	B F R	B F R	B F R				Little Pine to Sugarloaf (inclusive)
Peromyscus gossyupinus allipaticola (Key Largo Cotton Mouse) A404 +		B F R									Upper Key Largo
Procyon lotor auspicatus (Key Vaca Raccoon) A405 *	B F R	B F R		F R	F R	F R	F R		F R		Grassy Key to Cudjoe (inclusive)
Trichechus manatus latirostris (West Indian Manatee) A406 +			B F R					B F R			Upper Keys, Florida Bay

SLP:Slash pineland THH:Tropical hardwood hammock OPW:Open water FRM:Fringing mangrove SCM:Scrub mangrove SMB:Salt marsh-buttonwood association FWW:Freshwater wetland SGB:Seagrass bed B/B:Beach w/associated berm COR:Coral reef B:Breeding F:Feeding R:Resting *:Observations mapped +:Range mapped

INVERTEBRATES

SPECIES NAME LATIN NAME (COMMON NAME) CODE	HABITAT SLP 411	 THH 426	 OPW 500	 FRM 612	 SCM 620	 SMB 640	 FWW 641	 SGB 645	 B/B 710	 COR 801	RANGE
Heraclides aristodemus ponceanus (Schaus' Swallowtail) A502 +		B F R									Upper Key Largo
Orthalicus reses reses (Stock Island Tree Snail) A501 *		B F R									Stock Island

SLP:Slash pineland THH:Tropical hardwood hammock OPW:Open water FRM:Fringing mangrove SCM:Scrub mangrove SMB:Salt marsh-buttonwood association FWW:Freshwater wetland SGB:Seagrass bed B/B:Beach w/associated berm COR:Coral reef B:Breeding F:Feeding R:Resting *:Observations mapped +:Range mapped

ATTACHMENT 3

8/25/83 mcR

COUNTY of MONROE
KEY WEST, FLORIDA 33040
(305) 294-4641 Ext. 130
Planning Department
5825 Jr. College Rd. West
Key West, Fla. 33040

August 25, 1983

Mr. Gary Shaffer,
Branch Office Manager
Fla. Dept. of Environmental Regulation
11400 Overseas Highway, Suite 219
Marathon, Fla. 33050

Dear Mr. Shaffer:

As you are aware, several government agencies have regulatory jurisdiction over various aspects of dredging, filling and structural activities in the waters and wetlands of Monroe County. It is the feeling of this Department that the public and all the agencies could benefit from greater communication and coordination. To this end, we would like to propose a first step towards greater coordination: specifically, that the local personnel of the agencies who are involved in the processing of permit applications meet on a regular basis. We think that one meeting a month would be a good start. We propose that a meeting be set up for the week of September 19-23 in order to discuss a schedule and format for future meetings. Please contact the biologist in our Key West office, Mark Robertson (ext. 171), in order to arrange a meeting date convenient for your staff.

I hope that our proposal will benefit everyone involved. I look forward to your response.

Sincerely,

Jeffrey M. Doyle

Jeffrey M. Doyle, Ph.D.
Director

JD:cm

cc: Mr. John Adams, U.S. Army Corps of Engineers
Mr. Michael Slayton, U.S. Army Corps of Engineers
Mr. Curtis Kruer, U.S. Army Corps of Engineers

COUNTY of MONROE
KEY WEST, FLORIDA 33040
(305) 294-4641 Ext. 130
Planning, Bldg. & Zoning
5825 Jr. College Rd. West
Key West, Fla. 33040

August 25, 1983

Mr. John Adams,
Chief, Regulatory Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Fla. 32232

Dear Mr. Adams:

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Sincerely,

Jeffrey M. Doyle

Jeffrey M. Doyle, Ph.D.
Director

JD:cm

cc: Mr. Gary Shaffer, Fla. Dept. of Environmental Regulation
Mr. Michael Slayton
Mr. Curtis Kruer

ATTACHMENT 4

COUNTY of MONROE
KEY WEST, FLORIDA 33040
(305) 294 4641

July 7, 1984

Ms. Wendy U. Larsen
Siemon, Larsen & Purdy
200 South Wacker Drive
Suite 2110
Chicago, Illinois 60606

RE: Draft revisions to Chapter 18 of Monroe County Code, "Trees and Vegetation."

Dear Wendy:

I am enclosing a copy of the proposed revisions to this ordinance that we discussed last week.

For background, these revisions were prepared by Andy Hooten and myself as part of the County's FDER grant. We started with a revision from the Florida Keys Resource Planning and Management Committee, and then made further changes. We sent that draft to seventy individuals and organizations state-wide for review and comment. The reviewers represented a broad spectrum, including environmental advocacy groups, citizens' associations, attorneys representing primarily developers, and consulting firms. We received thirteen replies. These comments were incorporated into this final draft.

Two points deserve special mention. First, we have had an ongoing debate about the advisability of a mangrove trimming ordinance. The County has received a number of applications to "trim" mangroves in order to provide a view of the water or increase breezes (cutting of wetland vegetation does not require ACOE or FDER permits). At present, the County's policy does not permit trimmming mangroves along natural shorelines, except for that which is required for water access (ie, around a dock). The logic behind this policy is that Chapter 4 of the Code specifies full protection for shoreline mangroves, and trimming would eliminate many of the functions that Chapter 4 is intended to protect (the "Coastal Zone Element" of the Comprehensive Plan also specifies a high degree of protection for shoreline mangroves). In addition, the County's new (1984) flood regulations specify no removal of mangroves that would increase the probability of flood damage. Finally, we envisioned a large enforcement problem associated with mangrove "trimming" permits. Our conclusion was that a separate ordinance for mangrove trimming was not appropriate. We felt that the enclosed revisions to Chapter 18 would give the County sufficient criteria and guidelines to address applications for mangrove trimming; we have not explicity stated whether or not it is a "permittable" activity.

Second, I would like to mention that we prepared this revision prior to the County's current program to totally revise all land use regulations. However, I think that there are a number of sections that are valuable in that they reflect our experience in the current permitting arena, and the input of a number of individuals.

Please do not hesitate to call me if you have any questions or commments.

Sincerely yours,

Mark L. Robertson

Mark L. Robertson,
Biologist

cc: Mr. Jerry Annas
Mr. Charles Pattison, DCA

FORMAT

PROPOSED DELETIONS: [<u>Words in brackets and underlined</u>].

PROPOSED ADDITIONS: **Words in boldface type.**

Chapter 18

TREES AND VEGETATION

ARTICLE I. IN GENERAL

Secs. 18-1 - 18-15. Reserved.

ARTICLE II. LAND CLEARING

Sec. 18-16. Definitions.

As used in this article, the following terms shall have the meanings indicated in this section:

COUNTY BIOLOGIST: A person employed by the Monroe County Building, Planning and Zoning Department in the capacity of "Biologist", as set forth in the job description of the County Personnel Section. For the purpose of enforcing this ordinance the county biologist shall be a code inspector as defined in Section 6-285 of this code of ordinances.

DESTRUCTION OF VEGETATION means the removal of all or parts of vegetation by any means; specific actions which cause vegetation to die, including but not limited to damage inflicted upon the root system by heavy machinery or lethal substances; changing the natural grade above the root systems or around the trunks (specifically trees), damage inflicted on the vegetation permitting infection or pest infestation, application of herbicidal or other lethal chemicals, paving over the root system, or arson.

DEVELOPMENT means the carrying out of any building operation or the making of any material change in the use or appearance of any structure, and for the purpose of this article, shall include:

(1) The placement or construction of any structure on land;
(2) The reconstruction, alteration of the size, or material change in the external appearance, of a structure on the land;
(3) Alteration of a shore or bank of a seacoast, including any coastal construction as defined in section 161.021, Florida statutes, 1975;

(4) Demolition of a structure;
(5) [Clearing of land or removal of any vegetation] **Destruction of vegetation, as defined in this ordinance, or;**
(6) Deposit of refuse, solid or liquid waste, or fill on a parcel of land.

LAND CLEARING PERMIT means a permit issued by Monroe County authorizing the destruction of vegetation, as defined in this ordinance.

NO DESTRUCTION OF VEGETATION STATEMENT means a notarized statement signed by the property owner or his authorized agent stating that destruction of vegetation, as defined in this ordinance, shall not occur as a consequence of proposed development on the property.

TROPICAL HARDWOOD HAMMOCK means a [characteristic combination] **community** of plant species repeated in numerous stands, which contain, [predominantly] **but are not limited** to, the following tree species:

Pigeon Plum (Coccoloba diversifolia)
Strangler Fig (Ficus aurea)
Shortleaf Fig (Ficus citrifolia)
Torchwood (Amyris elemifera)
Wild Tamarind (Lysiloma latisiliqum)
Jamaica Dogwood (Piscodia piscipula)
Willow Bustic (Bumelia salicifolia)
Black Ironwood (Krugiodendron ferreum)
Lancewood (Nectandra coriacea)
Gumbo Limbo (Bursea simaruba)
Crabwood (Ateramnus lucidus)
Poisonwood (Metopium toxiferum)
Spanish stopper (Eugenia foetida)
Wild Lime (Zanthoxylum fagara)
Blolly (Guapira discolor)
West Indian Mahogany (Swietenia mahagoni)
Wild Dilly (Manilkara bahamensis)

VEGETATION, for the purposes of this ordinance, means the following plants:

(1) All plants with woody stems;
(2) All shrubs, bushes, grasses and vines greater than 3 feet in height; or

(3) All plants, no matter what size, that are listed as Endangered or Threatened under state or Federal laws; or are listed as Endangered or Threatened for Monroe County by the Florida Committee on Rare and Endangered Plants and Animals, as found in the most recent edition of "Rare and Endangered Biota of Florida, Volume Five, Plants".

MINOR LANDSCAPING MAINTENANCE means the care and trimming of:

(1) Vegetation planted or propogated for landscaping purposes; or
(2) Naturally occurring, individual plants and trees, or small isolated groups of vegetation maintained as landscaping on properties developed in conformance with Monroe County ordinances.

Sec. 18-17. Purposes.

The purposes of this article are to:

(1) To promote and encourage the protection of unique and biologically important natural resources, prevent the adverse effects to adjacent properties caused by the indiscriminate [clearing of land] **destruction of vegetation**, aid in the implementation of other requirements for shoreline and [tree] **plant** protection, and minimize potential adverse impacts upon water quality.

(2) To promote and encourage the protection and conservation of biologically unique vegetation [associations] **communities** known as tropical hardwood hammocks, protect certain rare or aesthetically desirable [tree] **plant** species found within these hammocks, provide performance oriented criteria for the protection of these tropical hammocks and specific [trees] **plants** in recognition of their importance and contributions to the promotion of the health, safety and welfare of the community through carbon dioxide absorption, oxygen release, protection from storm winds, microclimate modification, wind and surface drainage improvement and stabilization.

(3) To protect the vegetation comprising the habitats of the native fauna of Monroe County, particularly those species listed as Endangered or Threatened by State or Federal agencies.

Sec. 18-17.5. Admininstration.

The Zoning Official, as defined in this code of ordinances, shall be responsible for the administration of this chapter.

Sec. 18-18. Land clearing permit - required, [exceptions].

(a) It shall be unlawful and an offense against the county for any person, either individually or through agents, employees or independent contractors, to [clear, by mechanical or any other means], **cause the destruction of vegetation on** any land **or wetlands** located within the unincorporated areas of the county without having first applied for and obtained a land clearing permit from the building department of the county, **subject to specific exemptions to this requirement.**

[(b) A land clearing permit shall be required for the removal of all or parts of naturally occurring vegetation in the county.]

[(c) Review and approval of development site plans which results in the issuance of a development order shall constitute compliance with the requirements of this section. In such cases the land clearing permit will be issued in conjuction with the building permit.]

[(d) THIS SECTION SUBSTANTIALLY REVISED AND MOVED TO SECTION 18-19.]

[Sec. 18-19. Same - Application; field check, verification, prerequisite to issuance.]

[THIS SECTION DELETED AS CURRENTLY WRITTEN.]

Sec. 18-19. Exemptions and undesirable plant species.

(a) A land clearing permit shall not be required for:

(1) Minor landscaping maintenance, as defined in this ordinance;

(2) Minimal clearing of lines less than four (4) feet wide and not lower than one (1) foot above existing ground level for surveying conducted by a registered, professional land surveyor;

(3) Removal of trees or parts thereof which threaten to cause disruption of public or private utility services or threaten to pose a hazard in an emergency condition.

(b) The following plant species are hereby declared to be undesirable plant species:

Asiatic Colubrina (Colubrina asiatica)
Australian pine (Casuarina equisitifolia, Casuarina lepidopholia),
Brazilian pepper (Schinus terebinthifolius),
Paper tree (Melaleuca quinquinervia).

(1) The Building, Planning and Zoning Department shall waive the requirements and fees of this ordinance for the removal of these species, after the property owner has filed an application for a land clearing permit and the county biologist has made a written finding that the proposed destruction of vegetation will not significantly affect plant species other than the above-named undesirable plant species.
(2) No person shall plant, propogate or sell these undesirable species in Monroe County.

Sec. 18-20.

An application for a land clearing permit filed with the building department shall be accompanied by a fee [of ten dollars ($10.00) for each individual site under one acre and twenty dollars ($20.00) for each individual site over one acre proposed for clearing] **established by the Board of County Commissioners.** Such fees are hereby declared to be necessary for the purpose of processing the application and making the necessary inspections for the administration and enforcement of this section.

[Sec. 18-21. Same - Approval.]

[THIS SECTION COMPLETELY DELETED AS CURRENTLY WRITTEN.]

Sec. 18-21.1. Land clearing permit; procedures.

(a) As a precondition to the application for or receiving of a building permit from the Building Department, the owner of a property shall apply to the Building Department for a land clearing permit, or shall file a "No Destruction of Vegetation Statement" with the Building Department.

(THIS ENTIRE PAGE IS A PROPOSED ADDITION)

(b) A land clearing permit or "No Destruction of Vegetation Statement" shall not be required when applications for the following building permits are filed:

(1) Additions, renovations, improvements or alterations to existing single family residences, duplexes, mobile homes, and travel trailers.

(c) The request for a land clearing permit shall be filed on an application form provided by the building department and shall include the following information:

(1) The name and address of the owner of the land for which the land clearing permit is requested;

(2) The name and address of the person that will physically clear the land;

(3) A statement of the purpose(s) for which the land clearing permit is requested;

(4) The legal description and street address, if any, of the land for which the permit is requested;

(5) A map, drawn to scale, of the vegetative communities found on and adjacent to the site. The vegetation map shall identify the different vegetative communities, such as tropical hardwood hammock, mangroves, buttonwood, salt marsh, pinelands, freshwater wetlands. The map shall be accompanied by a descriptive narrative that lists the species of plants that are present in each vegetative community, by scientific names and common names, and specifically identifies any unusual or outstanding natural features of the site. On properties that are one-quarter (1/4) acre or more in size, the vegetation map and accompanying narrative shall be prepared by a qualified person with a working knowledge of the flora and fauna of the Florida Keys. A natural vegetation list and names and addresses of individuals qualified to identify the native flora and fauna may be obtained from the the Monroe County Planning and Zoning Department.

(THIS ENTIRE PAGE IS A PROPOSED ADDITION)

(6) An overall site plan, drawn to scale, of the land for which the land clearing permit is requested, showing the areas to be cleared, the areas to be left uncleared, and any proposed structures or improvements.

(d) The County Biologist shall conduct a site survey to verify the accuracy and completeness of the information supplied with the land clearing permit application. If the County Biologist determines that the application for a land clearing permit does not include the information required by this ordinance, the applicant shall be notified in writing of the deficiencies and there shall be no further review or processing of the application until the deficiencies have been corrected by the applicant.

(e)

(1) The Zoning Official shall review all land clearing permit applications using the standards and criteria set forth in this ordinance. A written report or written recommendation by the County Biologist shall be part of the review by the Zoning Official.

(2) The Zoning Official shall not issue any land clearing permits that are not consistent with the purposes, standards and criteria of this ordinance. The Zoning Official is empowered to require modifications to a land clearing permit application, including but not limited to relocation or restoration of vegetation, in order to insure compliance with the purposes, standards and criteria of this ordinance.

(f)

(1) The decision to issue or deny a land clearing permit application shall be made by the Zoning Official within thirty (30) days of the date of receipt of said application, unless the application is deemed to be incomplete by the County Biologist. In that case, the decision by the Zoning Official shall be made within thirty (30) days of the date when the deficiencies are corrected.

(THIS ENTIRE PAGE IS A PROPOSED ADDITION)

(2) The Zoning Official's decision shall take one of three forms: land clearing permit is approved; land clearing permit is approved subject to specific modifications or conditions; or land clearing permit is denied. In the case of a denial, the applicant shall be notified in writing of the reason(s) for the denial.

(g) On sites where the proposed land clearing is for development that requires building permits, the land clearing permit shall be issued only in conjunction with the appropriate building permit.

Sec. 18-21.5. Same; standards and criteria.

(a) Criteria. The Zoning Official shall authorize the issuance of a land clearing permit if one or more of the following conditions exists:

(1) The vegetation is located in an area where a structure or improvements may be placed according to a plan that otherwise meets the standards and purposes of this ordinance, and other provisions of the County Code; and the vegetation cannot be relocated on or off the property because of age, species or size.

(2) The vegetation is diseased, injured, in danger of falling, too close to existing or porposed structures, or creates unsafe vision clearance for vehicular traffic.

(3) It is in the welfare of the general public that the vegetation be removed for reason(s) other than set forth above.

(b) Standards. The Zoning Official shall consider significant adverse impacts in the following areas on the urban and natural environments, in reviewng a land clearing permit application:

(1) Ground stabilization. Whether the proposed destruction of vegetation will substantially impact the ability of the vegetation to stabilize soils and control erosion.

(THIS ENTIRE PAGE IS A PROPOSED ADDITION)

(2) Water quality and/or aquifer recharge. Whether the proposed destruction of vegetation will substantially lessen the natural assimilation of nutrients, chemical pollutants, heavy metals, silt and other noxious substances from ground and surface waters.

(3) Ecological impacts. Whether the proposed destruction of vegetation will substantially lessen the balance and viability of surrounding biological communities through impacts upon functions such as microclimate modification, food chains or the ability to withstand natural or man-made stresses (eg, hurricances, fires, disease, salt spray, etc.).

(4) Noise pollution. Whether the proposed destruction of vegetation will significantly increase ambient noise levels to the degree that a nuisance is anticipated to occur.

(5) Storm protection. Whether the proposed destruction of vegetation will significantly lessen the ability of the vegetation to decrease property damage or loss of life from tropical storms and hurricanes.

(6) Air Quality. Whether the proposed destruction of vegetation will significantly lessen the natural cleansing of the atmosphere by vegetation through particulate matter interception, and the production of oxygen as a by-product of photosynthesis.

(7) Wildlife habitat. Whether the proposed destruction of vegetation will significantly reduce available habitat for wildlife existence and reproduction, or result in the emigration of wildlife from adjacent or associated ecosystems.

(8) Aesthetic degradation. Whether the proposed destruction of vegetation will have an adverse affect on the public interest in maintaining an aesthetically pleasing environment.

(THIS ENTIRE PAGE IS A PROPOSED ADDITION)

(c) Standards for tropical hardwood hammocks. In all cases where an application is made for a land clearing permit on a site vegetated by tropical hardwood hammock, as defined in this ordinance, the proposed plan or development shall incorporate the maximum possible protection of the tropical hardwood hammock. Protection of such tropical hardwood hammocks as intact areas shall be required in all development, as oppossed to the selective removal of individual plants, or destruction of understory vegetation, or removal of soil and roots. The spatial arrangement of proposed structures and other impervious surfaces shall reflect design considerations which provide maxiumum protection of tropical hardwood hammock communities.

The Zoning Official shall not approve any land clearing permits on sites vegetated by tropical hardwood hammock, unless the proposed land clearing incorporates the maximum possible protection for such tropical hardwood hammock communities.

Sec. 18-21.2. Same - expiration.

(a) A land clearing permit shall expire and become null and void if work authorized by such permit is not commenced within thirty (30) days from the date of the permit issuance or if such work, when commenced, is suspended or abandoned at any time for a period of ninety (90) days.

(b) If the work covered by the land clearing permit has not commenced or has been commenced and been suspended or abandoned, the Zoning Official may extend such permit for a single period of sixty (60) days from the date of expiration of the initial permit, if the request for extension is made prior to the expiration date of the initial permit.

(c) If the work covered by the permit has commenced, is in progress, has not been completed and is being carried on progressively in a substantial manner, the permit shall be in effect until completion of the job.

(d) If work has commenced and the permit becomes null and void or expires because of lack of progress or abandonment, a new permit covering the proposed destruction of vegetation shall be applied for and obtained before proceeding with the work.

Sec. 18-22. Notification of completion of clearing; certificate of completion.

(a) Within [forty-eight (48) hours] **two (2) working days** after the work [contemplated under] **authorized by** the land clearing permit [required by section 18-18] has been completed, the holder of the permit shall notify the building department of such completion, after which the county biologist shall [again field check] conduct a survey of the clearing site. If no violations **of the land clearing permit** have occurred, the [Building Department] **Zoning Official** shall issue a certificate of completion to the holder of the permit. If violations of the permit have occurred, a certificate of completion [will] **shall** not be issued until the site has been restored with native Keys flora [or other appropriate vegetation] as outlined in a restoration plan approved by the [Building, Planning and Zoning Department] **Zoning Official.** No further activity of any nature shall commence on the land that is the subject matter of the land clearing permit until such certificate has been issued.

(b) A certificate of occupancy, as described in Section 6-38 of this code of ordinances, shall not be issued for any building on a site which is subject to a land clearing permit, until a certificate of completion has been issued by the Zoning Official.

[Sec. 18-23. Tree protection.]

[THIS SECTION COMPLETELY DELETED AND REPLACED AS FOLLOWS.]

Sec. 18-23. Plant protection.

To the maximum extent, individuals of species listed as Endangered or Threatened by State or Federal agencies, or by the Florida Committee on Rare and Endangered Plants and Animals as found in the most recent edition of "Rare and Endangered Biota of Florida, Volume Five, Plants", shall be protected, whether they occur naturally or have been planted.

Dimensional variances from lot setback lines may be granted by the board of adjustment to protect threatened or endangered plants, and to otherwise enhance the purposes and intent of this article.

Sec. 18-24. Scope of this article.

This article shall not apply to any municipality located in the county.

[Sec. 18-25. Penalties.]

[THIS SECTION DELETED AND REPLACED AS FOLLOWS.]

Sec. 18-25. Penalties.

Upon conviction in court, a violator of any provision hereof shall be subject to a fine not to exceed five hundred dollars ($500.00) or imprisonment in the county jail for a period not to exceed sixty (60) days, or by both such fine and imprisonment, in the discretion of the court; and each plant, bush and tree cut down, destroyed, removed or moved shall constitute a separate offence. In addition to the fine, the violator shall be required to restore the site with native Keys vegetation as outlined in a restoration plan approved by the Zoning Official.

Sec. 18-26. Civil remedies.

In addition to any other remedies provided by this article the county shall have the following judicial remedies available for violations of this article or any permit issued under this article.

(a) The county may institute a civil action in a court of competent jurisdiction to establish liability and to recover damages for any injury caused by the destruction of vegetation in contravention of the terms of this article.

(b) The county may institute a civil action in a court of competent jurisdiction to impose and recover a civil penalty for each violation in an amount of not more than five thousand dollars ($5,000.00) per offense. However, the court may receive evidence in mitigation. Each tree, bush or other plant unlawfully removed or destroyed under the provisions of this article shall constitute a separate offense hereunder.

(c) The county may institute a civil action in a court of competent jurisdiction to enforce compliance with this article, to enjoin any violation hereof, and to seek injunctive relief to prevent irreparable injury to vegetation or properties encompassed by the terms of this article.

ATTACHMENT 5

VEGETATION AND NATURAL FEATURES:

DEFINITIONS AND BACKGROUND

MONROE COUNTY PLANNING DEPARTMENT

The following vegetation types and natural features have been mapped:

CODE	NAME
411	Slash Pineland
426	Tropical Hardwood Hammock
500	Open Water
612	Fringing Mangroves
620	Scrub Mangroves
640	Salt Marsh and Buttonwood Associations
641	Freshwater Wetlands
710	Beach with Associated Berm
740.0	Disturbed (Bare/Vegetation Unknown)
740.1	Disturbed with Hammock
740.2	Disturbed with Mangrove
740.3	Disturbed with Salt Marsh and Buttonwood
740.4	Disturbed Beach/Berm
740.5	Disturbed with Exotics
740.6	Disturbed with Slash Pine

The definitions of these mapping units follow.

Slash Pineland (411). This is an upland forest community with an open canopy dominated by the native slash pine, *Pinus elliottii* var. *densa*. Plant species that are commonly present include (but are not limited to):

Byrsonima cuneata	Locust Berry
Cassytha filiformis	Love vine
Coccothrinax argentata	Silver Palm
Crossopetalum ilicifolium	Christmas Berry
Croton linearis	Pineland Croton
Morinda royoc	Yellow Root
Pinus elliottii	Slash Pine
Randia aculeata	White Indigo Berry
Thrinax morrissii	Keys Thatch Palm
Sorghastrum secundum	Indian grass.

Slash pinelands are a fire climax community; that is, in the absence of fires they will be replaced by tropical hardwood hammock (map code 426). This is a gradual process that can complicate the distinction between slash pinelands and tropical hoardwood hammock. The separation of these two communities should be made on the basis of dominance by plants that are characteristic of one or the other community.

Slash pinelands occur only in the Lower Keys.

Tropical Hardwood Hammock (426). This is an upland, hardwood forest community that is characterized by a number of West Indian tree species. This community may contain (but is not limited to) the following species:

Amyris elemifera	Torchwood
Ateramnus lucidus	Crabwood
Bumelia salicifolia	Willow Bustic
Bursera simaruba	Gumbo Limbo
Coccoloba diversifolia	Pigeon Plum
Eugenia foetida	Spanish Stopper
Ficus aurea	Strangler Fig
Ficus citrifolia	Shortleaf Fig
Guapira discolor	Blolly
Krugiodendron ferreum	Black Ironwood
Lysiloma latisiliquum	Wild Tamarind
Metopium toxiferum	Poisonwood
Nectandra coriacea	Lancewood
Piscidia piscipula	Jamaica Dogwood
Swietenia mahagoni	West Indian Mahohany
Zanthoxylum fagara	Wild Lime.

Tropical hardwood hammocks are found throughout the Florida Keys. The appearance and species mix varies widely among the hammocks of the Keys.

Open Water (500). These are areas of open water with no discernible emergent vegetation. This category includes "salt ponds", which are shallow, enclosed basins with very restricted tidal influence and generally having extremely variable salinity and temperature regimes (Coastal Coordinating Council, 1974).

The maps show two types of mangrove communities: fringing mangroves (map code 612) and scrub mangroves (map code 620). The definitions of these communities follow.

Fringing Mangroves (612). These are wetland communities subject to tidal influence, where the vegetation is dominated by three species of mangroves, specifically:

Avicennia germinans	Black mangrove
Laguncularia racemosa	White mangrove
Rhizophora mangle	Red mangrove.

Other vascular plant species that may be present include (but are not limited to):

Batis maritima	Saltwort
Lycium carolinianum	Christmas Berry
Monanthochloe littoralis	Key grass
Salicornia spp.	Glasswort
Sesuvium portulacastrum	Sea Purslane
Sporobolus virginicus	Dropseed
Suaeda linearis	Sea Blite.

In general, the trees in fringing mangrove communities have crowns that are sufficiently dense and close-spaced so as to present a closed canopy. In addition, the trees are generally greater than 1.5 meters (4.9 feet) in height (Lugo and Snedaker, 1974).

Scrub Mangroves (620). These are wetland communities subject to tidal influence, where the vegetation is dominated by the same three species of mangroves found in fringing mangrove communities. Other vascular plants, such as those listed for fringing mangrove communities, may also be present in scrub mangrove communities.

Scrub mangroves are distinguished from fringing mangroves by two characters. First, scrub mangroves are generally smaller; on the average they are less than 1.5 meters (4.9 feet) in height (Lugo and Snedaker, 1974). Second, scrub mangroves do not, on the average, have dense, closely spaced crowns that result in a closed canopy.

In some scrub mangrove areas there may be isolated clumps of mangroves more properly classified as fringing mangroves, which probably occur as a result of edaphic (i.e., soil) conditions. These clumps are, in many cases, mapped as part of the surrounding scrub mangrove zone due to the overall character of the area and their small area relative to the scale of the maps.

The most widely used classification system for mangroves is that developed by Lugo and Snedaker (1975), and further described by Odum et al. (1982). The two types of mangrove communities mapped by Monroe County correspond, in general, to Lugo and Snedaker's classifications as follows.

Lugo & Snedaker (1974)	Monroe County Maps
Fringe Forest	Fringing Mangroves (612)
Riverine Forest	" " "
Overwash Forest	" " "
Basin Forest*	" " "
Dwarf Forest	Scrub Mangroves (620)

* - Not well represented in the Florida Keys.

In both types of mangrove communities there may be areas of open water that have been mapped as part of the mangroves. This is due to either the small size of the water body, or that the overall coverage of mangroves is greater that forty percent (40%) throughout the area (Environmental Effects Laboratory, U.S. Army Corps of Engineers, 1978).

Fringing mangroves and scrub mangroves are found throughout the Keys. However, scrub mangroves are more common in the Lower Keys than in the Middle and Upper Keys.

Salt Marsh and Buttonwood Associations (640). This mapping unit encompasses two plant associations that are sometimes collectively or individually referred to as the "transitional zone."

The salt marsh community is a wetland area subject to tidal influence where the vegetation is dominated by non-woody groundcovers and grasses. The salt marsh is usually present in the more waterward portion of this mapping unit. The vegetation may include (but is not limited to) the following non-woody species:

Batis maritima	Saltwort
Distichilis spicata	Salt grass
Fimbristylis castanea	Chestnut sedge
Monanthocloe littoralis	Key grass
Salicornia spp.	Glasswort
Sesuvium portulacastrum	Sea purslane
Spartina spp.	Cordgrass
Fimbristylis castanea	Chestnut sedge.

Woody vegetation that may be present includes the three species of mangroves, as well as buttonwood (_Conocarpus erectus_). However, the salt marsh community is distinguished by the dominance of non-woody plants, the woody species have a coverage of less than forty percent (40%; Environmental Effects Laboratory, U.S. Army Corps of Engineers, 1978).

The salt marsh community may be associated and intermixed with areas of almost bare ground, where the vegetation may be limited to mats of periphyton (i e., algae). These areas, which are also known as "saltwater coastal flats", "salt flats" or "salt barrens" (Environmental Effects Laboratory, U.S. Army Corps of Engineers, 1978) have generally been included in this mapping unit (map code 640) on the Monroe County maps.

The buttonwood association is the second plant association that is part of this mapping unit (map code 640). This association is usually present in the more landward zone of this mapping unit, and may intermix with more upland communities. Depending on the relatve dominance of plant species and other factors, the entire buttonwood association or a portion thereof may be classified as wetlands under State and Federal regulations. The vegetation may include (but is not limited to) the following species:

Borrichia spp.	Sea oxeye daisy
Bumelia celastrina	Saffron plum
Coccoloba uvifera	Sea grape
Conocarpus erectus	Buttonwood
Erithalis fruticosa	Black torch
Fimbristylis castanea	Chestnut sedge
Jacquinia keyensis	Joewood
Lycium carolinianum	Christmas berry
Maytenus phyllanthoides	Mayten
Spartina spp.	Cordgrass.

The buttonwood association is distinguished from the salt marsh association by the dominance of buttonwood trees, usually occuring as an open stand that permits the growth of an understory of groundcovers and shrubs. The buttonwood association is, in turn, distinguished from more upland communities by the presence of grasses and fleshy, halophytic groundcovers under its open canopy, and generally by the lack of an appreciable layer of humus and leaf litter.

Salt marsh and buttonwood associations are found throughout the Florida Keys.

Freshwater wetlands (641). These are wetland areas with either standing water or saturated soil, or both; where the water is either fresh or of very low salinity. The vegetation is characterized (but not limited to) the following species, which are capable of growth and reproduction in saturated soil conditions:

Cladium jamaicensis	Saw grass
Conocarpus erectus	Buttonwood
Eleocharis celluosa	Spike rush
Laguncularia racemosa	White mangrove
Rhizophora mangle	Red mangrove
Typha spp.	Cattail.

Freshwater wetlands are found only in the Lower Keys. It should be noted that some of the freshwater wetlands are one (1) acre or less in size, and thus are too small to appear on these maps. This is particularly true of cattail marshes. Many of these smaller areas occur in tropical hardwood hammocks or pinelands.

Beach with Associated Berm (710). This mapping unit is distinguished by its geomorphological characteristics rather than its vegetation. A beach is an area of bare, unvegetated sand along a shoreline. A berm is a mound or ridge of unconsolidated sand that is immediately landward of, and usually parallel to, the shoreline and beach. A berm is higher in elevation than both the beach and the area landward of the berm. In the Florida Keys, the sand is calcareous material that is the remains of marine organisms such as corals, algae, molluscs, etc.

In some locations there are berms without a beach being present along the shoreline. Instead, there is a narrow band of fringing mangroves along the waterward edge of the berm. These areas are mapped as Beach with Associated Berm (map code 710), as the mangrove fringe is too narrow to be distinguished on these maps.

The height and width of berms in the Keys is highly variable. They may range in height from slightly above mean high water to more than seven (7) feet above mean sea level. The width of berms in the Keys varies from tens of feet to more than 200 feet.

The vegetation on berms, which is dependent on their elevation and width, is also highly variable. There may be only groundcovers such as sea oats (*Uniola paniculata*), cordgrass (*Spartina* spp.), Keys spider lily (*Hymenocallis latifolia*) and various wetland groundcovers. Other berms may support tropical hardwood hammock vegetation. On the wider berms various plant associations may exist as bands running generally parallel to the shoreline.

Within some fringing mangrove forests along open water shorelines there are very low and narrow storm berms that are vegetated exclusively by mangroves and associated wetland vegetation. Because of their small size and enclosure by the mangrove forest, these features are mapped as mangroves rather than berms.

Beaches and berms occur from Upper Matecumbe Key through the Lower Keys.

Disturbed (Bare/Vegetation Unknown - 740.0). These are areas that have been disturbed by human activities (e.g., deposition of fill, land clearing) on which there are large areas of bare substrate, or where the site is obviously disturbed but the vegetation could not be determined by ground-truthing because the site was not accessible to County personnel. This mapping unit also includes disturbed areas where a groundcover of grasses is maintained by mowing.

Disturbed with Hammock (740.1). These are areas that have been disturbed by human activities, on which the vegetation is dominated by tropical hardwood hammock, as described earlier. The vegetation may either be a remnant of the vegetation that existed prior to the disturbance, or has colonized the site after the disturbance. Examples of these areas are sites that have been partially or completely cleared and the vegetation is pioneering hammock, or hammock areas which have been extensively divided by roadways for a subdivision.

Disturbed with Mangrove (740.2). These are areas that have been disturbed by human activities, on which the vegetation is dominated by mangrove communities, as described earlier. The vegetation may be either a remnant of what existed prior to the disturbance or has recolonized the site after the disturbance. An example of such an area would be a mangrove community that was impounded by fill and cut off from tidal flow, and the mangroves have suffered a noticeable decline.

Disturbed with Salt Marsh and Buttonwood (740.3). These are areas that have been disturbed by human activities, on which the vegetation is dominated by salt marsh and buttonwood associations, as described earlier. The vegetation may be either a remnant of what existed prior to the disturbance, or has colonized the site after the disturbance. An example of such an area would be a wetland site that had been filled, and the vegetation that regrew on the fill is dominated by salt marsh and buttonwood species, due to either the salt content of the fill, its low elevation relative to tides or other factors.

Disturbed Beach/Berm (740.4). These are beaches or berms that have been disturbed by human activities. Possible disturbances include bulkheading, deposition of limerock fill, excavation or introduction of non-native plants such as Australian pine (*Casuarina* spp.) and Brazilian pepper (*Schinus terebinthifolius*) that now dominate the site.

Disturbed with Exotics (740.5). These are areas that have been disturbed by human activities where the vegetation is now dominated by exotic (i.e., non-native) plant species such as Australian pine (*Casuarina* spp.) or Brazilian pepper (*Schnius terebinthifolius*).

Disturbed with Slash Pine (740.6). These are areas that have been disturbed by human activities (e.g., partial or complete land clearing) where the vegetation is dominated by slash pineland species, as described earlier. The vegetation may be either a remnant of what existed prior to the disturbance, or has recolonized the site after the disturbance.

BACKGROUND OF MONROE COUNTY VEGETATION MAPPING

The vegetation mapping program utilized two pre-existing sets of vegetation maps as its data sources:

1) The Florida Keys Hardwood Hammock Atlas, developed in 1977 as part of a project sponsored by the Florida Cooperative Extension Service and the National Audubon Society;

2) Vegetation base maps for the Florida Keys Coastal Zone Management Study, developed in 1974 by the Florida Coastal Coordinating Council.

Both of these map sets were drawn at a scale of 1"=2,000', which is the same scale as the County's land use base maps.

Because both of these map sets are somewhat outdated with regards to development, the current extent of developed lands was taken from more recent maps from the Department of Community Affairs, also drawn at the same scale (1"=2,000').

The resulting maps of vegetation and natural features were extensively checked and revised by the Planning Department's biologists, who are familiar with the vegetation in many areas of the Keys as a result of work experience. Available aerial photography (black and white, 1"=600', Real Estate Data, Inc.) was also used as another source of information.

A program of ground-truthing was conducted throughout the Keys by the biologists in order to visit a number of areas where the vegetation appeared to be in error on the original data maps and could not be resolved from available aerial photography.

REFERENCES

Environmental Effects Laboratory. 1978. Preliminary Guide to Wetlands of Peninsular Florida - Major Associations and Communities Identified. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical report Y-78-2. 66 pages (plus appendices).

Florida Coastal Coordinating Council. 1974. Florida Keys Coastal Zone Management Study. Fla. Dept. of Natural Resources. Tallahassee, Florida. 138 pages.

Lugo, A.E. and S.C. Snedaker. 1974. The Ecology of Mangroves. Annual Review of Ecology and Systematics. 5:39-64.

Odum, W.E., C.C. McIvor and T.J. Smith, III. 1982. The Ecology of the Mangroves of South Florida: A Community Profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/24. 144 pages.

ATTACHMENT 6

MON-TITLE #7sce 09/29

TENTATIVE DRAFT NO. 1

FLORIDA KEYS GROWTH MANAGEMENT PLAN

Background Data Elements

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MON-1 #8sce 09/29

TENTATIVE DRAFT NO. 1

DRAFT BACKGROUND DATA ELEMENTS OF A GROWTH MANAGEMENT PLAN FOR THE FLORIDA KEYS

THIS DOCUMENT CONTAINS A SERIES OF BACKGROUND DATA ELEMENTS PREPARED BY THE MONROE COUNTY PLANNING STAFF AND THE COUNTY'S GROWTH MANAGEMENT CONSULTANTS. THE WORKING TABLE OF CONTENTS FOR THE PROPOSED IS INCLUDED; HOWEVER, **ONLY THOSE ELEMENTS SET OUT IN ALL CAPS AND BOLD TYPE ARE INCLUDED IN THIS DRAFT.**

THE DATA IS BEING PUBLISHED IN DRAFT FORM IN ORDER THAT ITS ACCURACY CAN BE CONFIRMED OR CORRECTED THROUGH PUBLIC INPUT AND PARTICIPATION. A SERIES OF PUBLIC WORKSHOPS WILL BE CONDUCTED ON SEPTEMBER 18, 19 AND 20 AT PLANTATION KEY, MARATHON AND KEY WEST RESPECTIVELY.

CORRECTIONS, QUESTIONS OR CONCERNS SHOULD BE DIRECTED TO:

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FLORIDA KEYS GROWTH MANAGEMENT PLAN
LAND USE

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VOLUME I*

* **NOTE:** This is a working Table of Contents for the land use volume of the Florida Keys Growth Management Plan. Only those portions which are indicated in bold and capitals are included in this draft.

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(b) income sources;
(c) real estate transactions;

(i) type of product;
(ii) per unit value;

aa) single-family residential
bb) multi-family residential
cc) hotel/resort
dd) commercial, and
ee) industrial; and

(iii) purchaser identification.

aa) ages
bb) household character, and
cc) existing or prior residency; and

(d) Public revenues;

(2) Trends;

(a) income levels;
(b) income sources;
(c) real estate transactions:

(i) type of product;
(ii) per unit value;

aa) single-family residential
bb) multi-family residential
cc) hotel/resort
dd) commercial, and
ee) industrial; and

(d) public revenues.

(3) Forecast:

(a) income levels;
(b) income sources;
(c) real estate transactions:

(i) type of product;
(ii) per unit value:

aa) single-family
bb) multi-family
cc) hotel/resort
dd) commercial, and
ee) industrial; and

(iii) purchaser identification.

aa) ages
bb) household character, and
cc) existing or prior residency; and

(d) public revenues.

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I.

THE ENVIRONMENT

A. NATURAL ENVIRONMENT

(1) GEOMORPHOLOGICAL AND CLIMATIC OVERVIEW OF THE FLORIDA KEYS

Discovered by Ponce de Leon on May 12, 1513, the Keys have always fascinated those who have come in contact with them. Lying along the New World trade routes and blessed with a semi-tropical climate, their history has been intimately tied to the ocean from which they arose.

The Florida Keys proper are an elongate, arcuate chain of low lying islands over 220 miles in length, extending from the southeastern tip of the Florida Peninsula, more properly called the Florida Plateau or Florida Platform. They extend from Soldier Key at the northernmost end of the chain, to the Dry Tortugas to the south and west at the other end. They are bounded by the Straits of Florida on the Atlantic side and separated from the mainland by Biscayne Bay, Barnes Sound, Blackwater Sound and Florida Bay (White, 1970; Brooks, 1982).

Physiographically, the Keys belong to what has been called the Southern Zone of the Coastal Lowlands by the Florida Geological Survey (See Figure 1), also referred to as the Gold Coast and Florida Bay (Brooks, 1982). This area lies south and southeast of Lake Okeechobee, is primarily underlain by Pleistocene limestones and is characterized by low relief, poor drainage and extensive areas of coastal mangrove swamps (See Figure 2) (Brooks, 1982).

The highest point in the Keys, only 18 feet above sea level, lies on Windley Key. Because of its generally low elevation, mostly less than 5 feet above sea level, most of the islands are bordered by mangrove swamps, particularly on the lower energy Florida platform side. Sandy beaches are less common and are mostly restricted to the higher energy beaches on the Atlantic side of the larger islands. All told, mangroves cover nearly half of the total area of the Keys (Hoffmeister, 1974). Geologically and physiographically, the Florida Keys can be divided into three main areas: the Coral Reef Keys, more commonly known as the Upper Keys; the Oolitic Keys, better known as the Lower Keys; and, some 50 miles to the west, the Dry Tortugas (White, 1970). Miami Beach, Virginia Key and Key Biscayne are barrier islands which receive their sediment supply from the mainland. Being geologically different, they are not considered part of the Florida Keys (Brooks, 1982).

Figure 1: PHYSIOGRAPHIC DIVISIONS OF THE FLORIDA PENINSULA TIDE. FLORIDA GEOGRAPHICAL SURVEY.

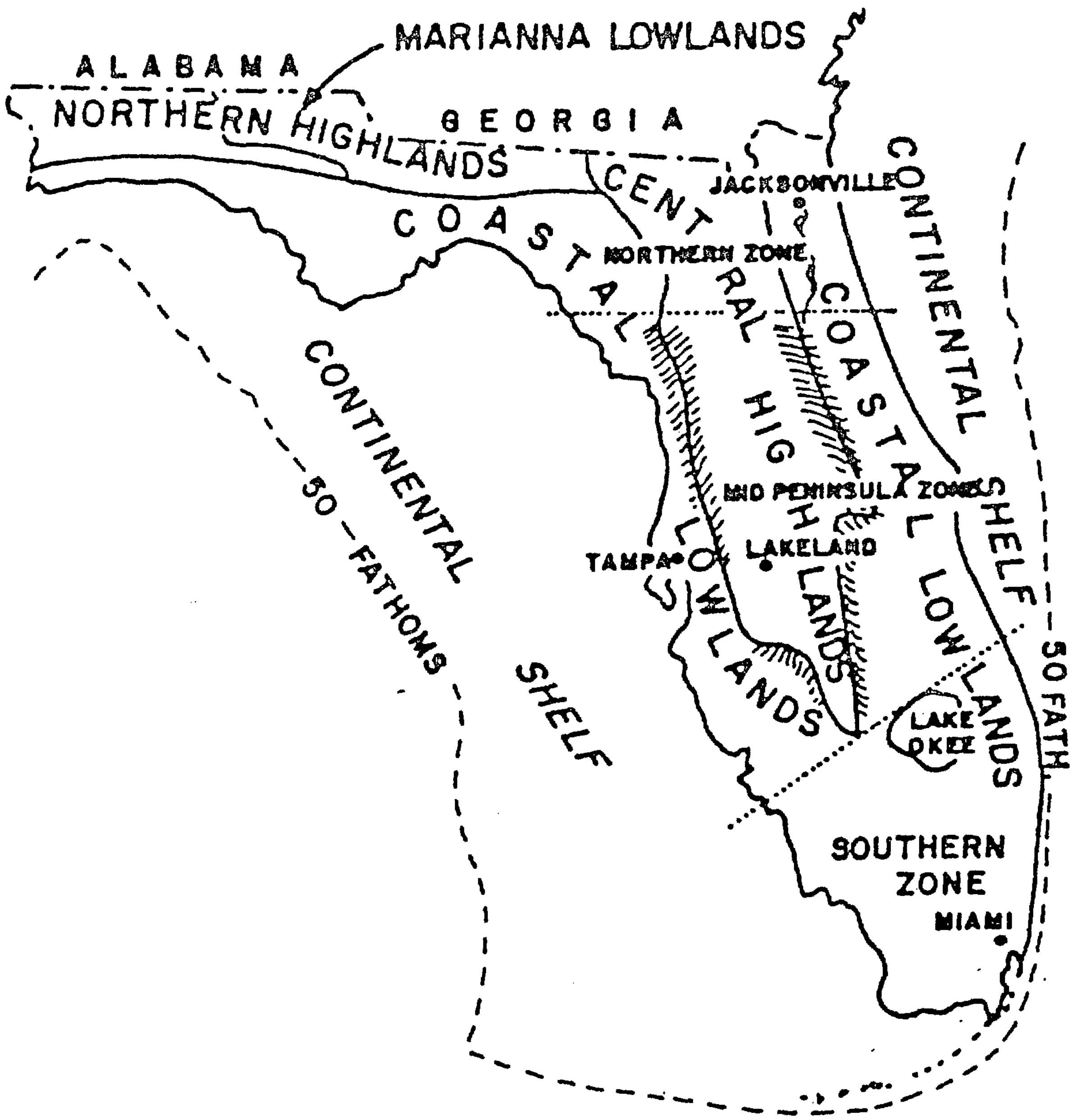
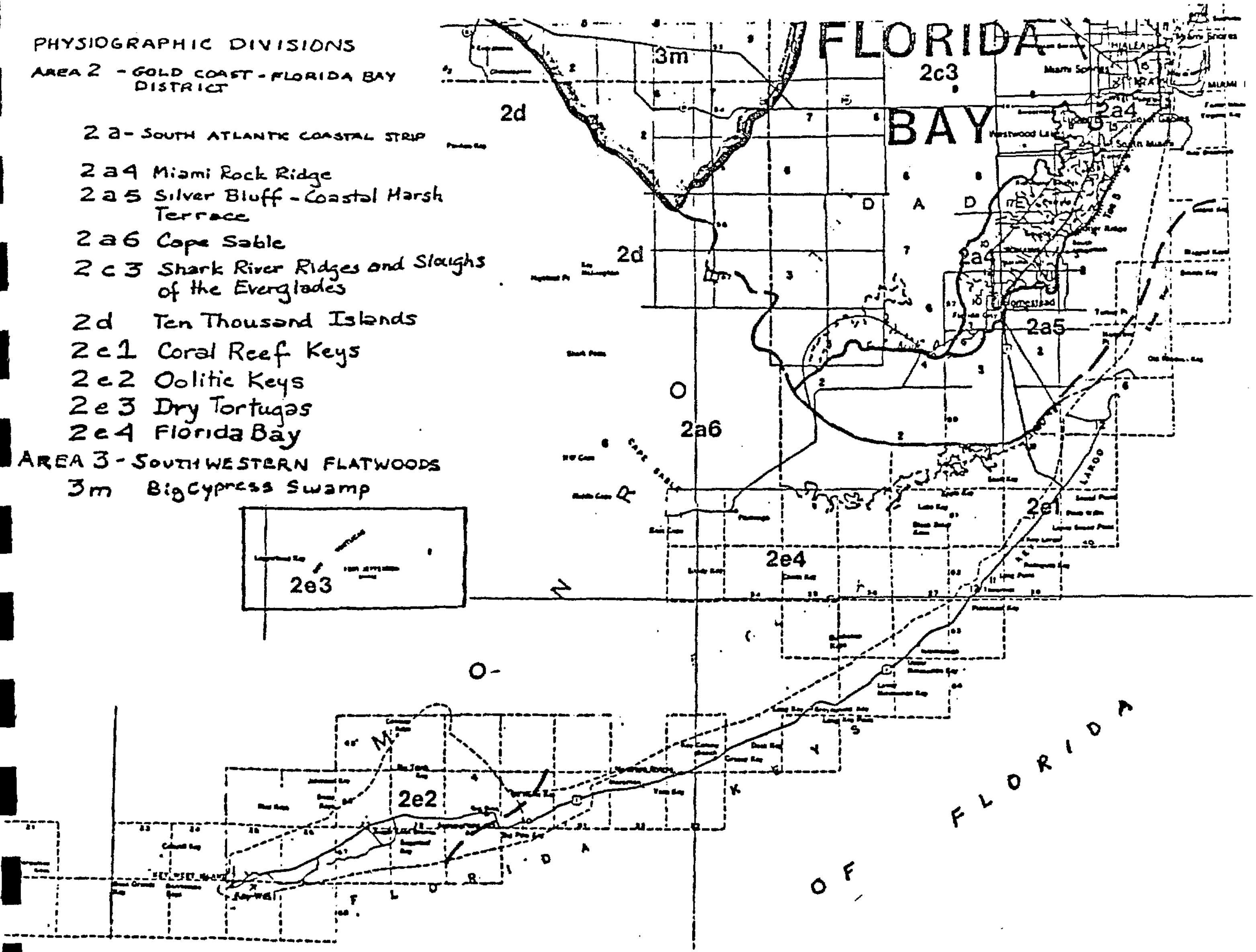


Figure 2: PHYSIOGRAPHIC DIVISION IN SOUTH FLORIDA REPRODUCED FROM BROOKS, 1982.



The Upper Keys

As their other name implies, the Coral Reef Keys are a linear chain of islands made up primarily of limestone coral rock. The main axis of the islands lies parallel to the axis of the chain. They extend from Soldier Key to the North, to the lower (southern) end of the Big Pine Key. On their seaward side lies a well developed reef tract composed of an outer fringe reef which borders the inner edge of the narrow continental shelf that averages a mere 4 miles in width. Between the Keys and this relatively continuous outer fringe reef, shallower banks and deeper channels dotted with patch reefs run parallel to the islands. These living reefs, unique in the United States, are best developed in the Upper Keys area. Because corals are exceedingly sensitive to turbidity, their development is favored by the long orientation of the islands and the limited number of channels between them. This particularly fortunate combination of circumstances acts to block the influx of carbonate muds from the bays and prevents silting of the reef tract (Brooks, 1982; Hoffmeister, 1974).

The Lower Keys

The Lower Keys are primarily composed of oolites, small spherical grains of calcium carbonate, cemented together to form a limestone. The axis of the islands runs at right angles to the general trend of the chain rather than parallel to it as in the Upper Keys. The islands are separated by numerous long narrow channels. They extend from Big Pine Key (excepting the southern tip of the island which belongs to the Upper Keys) to the Marquesas. The modern coral reefs associated with the Lower Keys lie mostly to the south of the islands and are less well developed than the northern reefs, no doubt owing to the fact that the channels which separate the islands provide ready transfer of the carbonate muds from the Gulf to the reef tract. The constant presence of mud increases the turbidity in the water and inhibits reef growth somewhat.

The Dry Tortugas

Some seventy miles to the west of Key West, the Dry Tortugas represent the last outlier islands of shallow sediments of the Florida Platform. They are primarily composed of carbonate sands and mud of biological origin which overlie an underpinning of Key Largo limestone.

A. Geology and Stratigraphy

Little is known of the earliest history of the southern part of the State of Florida as data are notably absent due to the paucity of deep wells. It is known that basement rocks in the central and northern part of the state range in depth from 3,000 feet in the northern part of the state to some 12,000 feet near Lake Okeechobee. In character they resemble rocks associated with the Appalachians. In the southern part of the state, however, the deepest non-sedimentary rocks penetrated are basaltic submarine volcanics (See Figure 3) (Bass, 1969). They are overlain by a wedge of sedimentary rocks that rapidly thickens southwardly and exceeds a thickness of 20,000 feet in the Keys. It is worthy of note that such volcanics are commonly associated with areas where the crustal plates separate. Reconstructions of Pangea, the giant land mass that existed before the present continents assumed their modern shape and location, shows that the boundary between North America and Africa crossed the tip of Florida. If such reconstructions are correct, the abrupt deepening of the basement rocks in South Florida would mark the line of separation between these two continents when Pangea broke up. The presence of submarine volcanics would therefore confirm such an interpretation. In any case, it is generally accepted that South Florida is an area where sediments prograded over oceanic crust. (See Figure 4) (Shurbet, 1968)

Although Mesozoic sediments represent thicknesses well in excess of 10,000 feet (Puri and Vernon, 1964), only the more recent Cenozoic sediments have a direct bearing on the history and the formation of the Keys. Of these the most important are the sediments deposited since Miocene time. Although these sediments give us an excellent record of the past environments of South Florida, much controversy still surrounds their age and in some cases their exact stratigraphic relationships. Reconstruction of the past is further complicated by the fact that the relationship between land and sea has not been static. (See Figure 5)

It is well known that the advent of glaciation in higher latitudes affected sea level. During glacial periods, when water accumulates on land in the form of ice, sea level drops. Conversely, during periods of climatic amelioration, sea level rises as water is returned to the sea. It is generally estimated that if all the water presently tied up in glaciers were returned to the oceans, sea level would rise by some 200 feet. Conversely, during glacial maxima, sea level dropped by as much as 350 below present level. It is easy to see that an area such as the Keys which lies but a few feet above present sea level would be markedly affected by the 500+ foot oscillations which have affected the world's coasts since Middle Tertiary Miocene times. These fluctuations are relatively rapid when measured against geologic time. Indications are that sea level has risen some 8 to 10 inches during this past century alone. Other evidence, such as the presence of peat under Crane Key 4 to 10 feet below present sea level indicates a much lower sea level a mere 4000 years ago. Some 20,000 years ago, sea level may have been as low as 450 feet below present level (See Figure 6). Although the general sequence of events is relatively clear, there is still considerable argument as to the precise age of a specific event (Brooks, 1973; Alexander, 1974; Fairbrige, 1974).

Figure 3: BASEMENT MAP OF THE GULF OF MEXICO AND ADJOINING STATES (BROOKS - 1972)

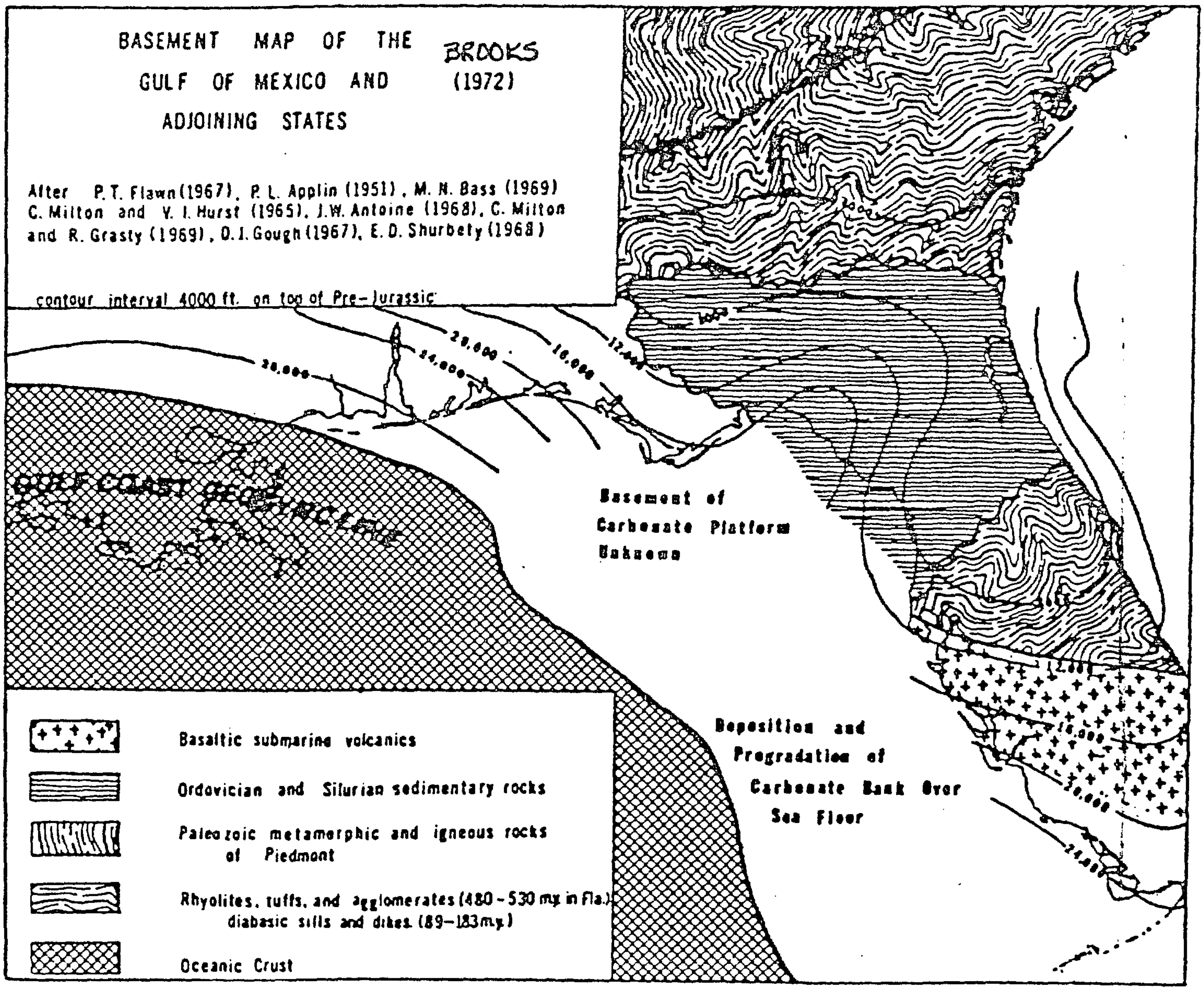


Figure 4: GENERALIZED GEOLOGIC CROSS SECTION THRU FLORIDA (Fla. State Geol. Surv. Bull. 5).

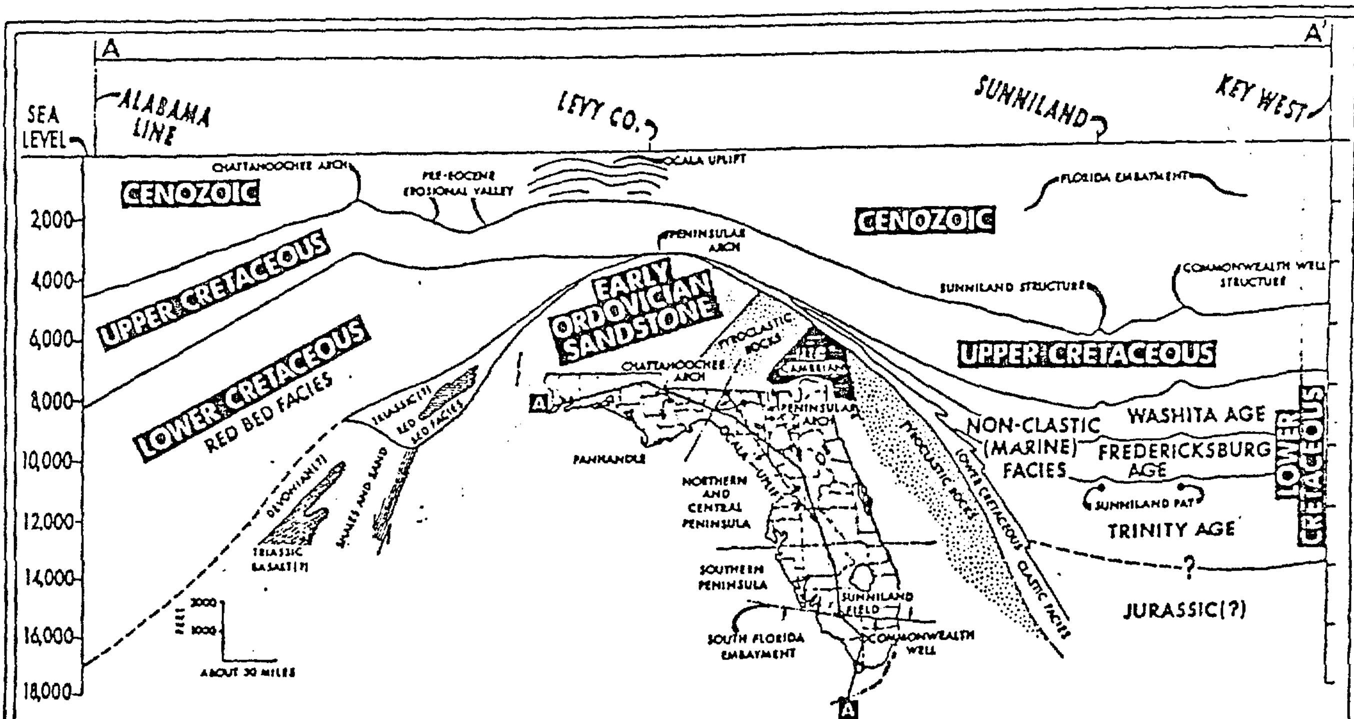


Figure 4. GENERALIZED GEOLOGIC CROSS SECTION THRU FLORIDA

Fla. State Geol. Surv. Bull. 5

Figure 5: STRATEGRAPHIC RELATIONSHIP BETWEEN THE UNITS (Puri and Vernon, 1964)

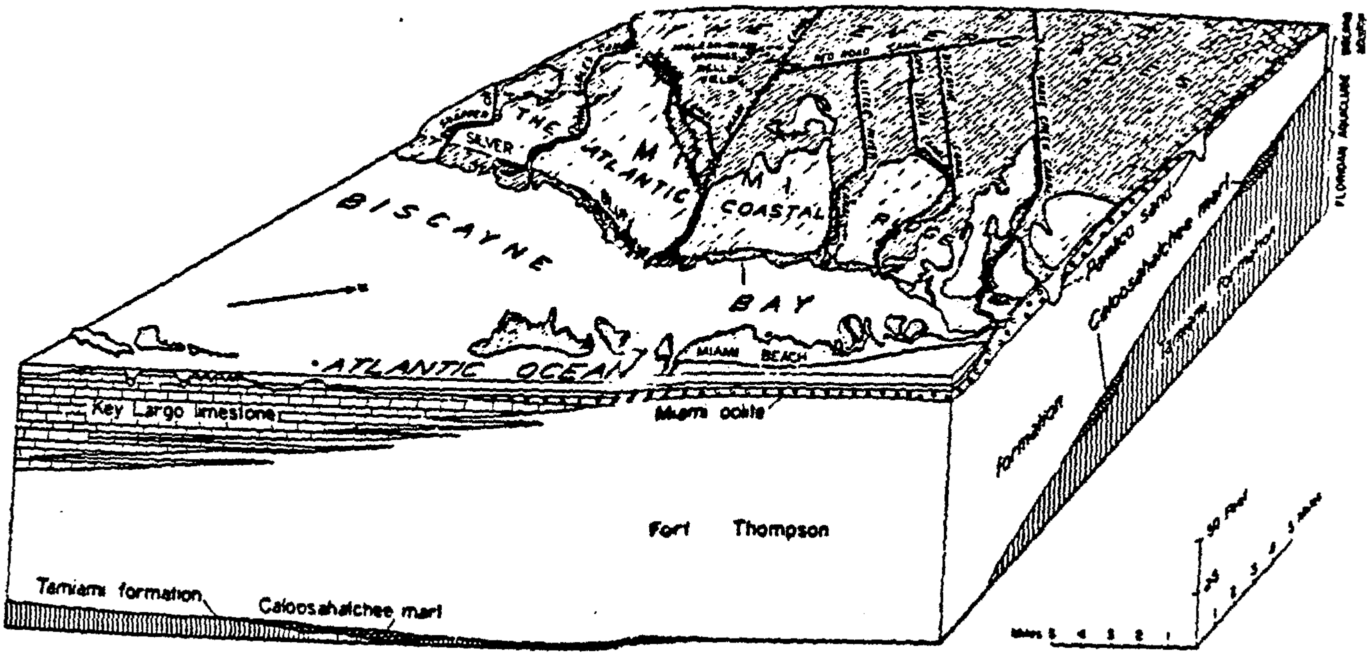
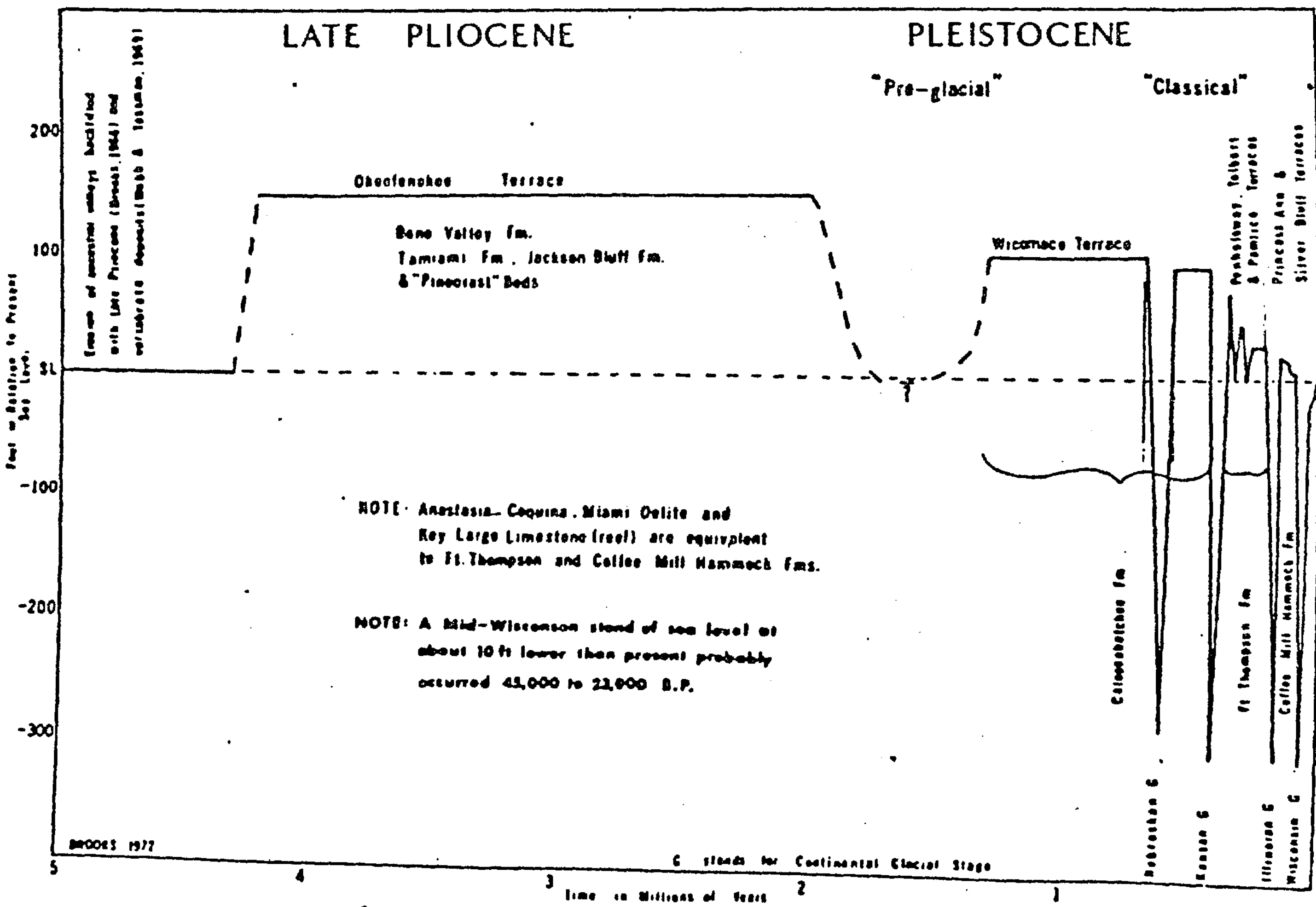


Figure 6: GLACIAL EUSTATIC SEA LEVEL CHRONOLOGY BASED UPON STRATIGRAPHIC EVIDENCE IN FLORIDA (Brooks, 1968, 1972).



The most important formations having a bearing on the geologic history of the Keys are, in decreasing order of age: the Tamiami Formation; the Caloosahatchee-Fort Thompson formation; the Miami Limestone, the Key Largo Limestone; and the Key West Limestone. Although the age relationship between the first three formations is quite clear, it is less certain that the last three formations represent clearly distinct events rather than nearly contemporaneous environmentally controlled facies (See Figures 7 and 8) for the surface distribution of these formations.

The Tamiami Limestone

The Tamiami Limestone is the oldest formation that outcrops in South Florida and underlies much of this part of the state. It is a tan to light grey limestone, quite variable in appearance, ranging from dense, to sandy, clayey and shelly, with some sandy units and some reef rock units. Near Miami, it reaches a maximum thickness of 150 feet (Parker, et al., 1955). Westward, it thins rapidly.

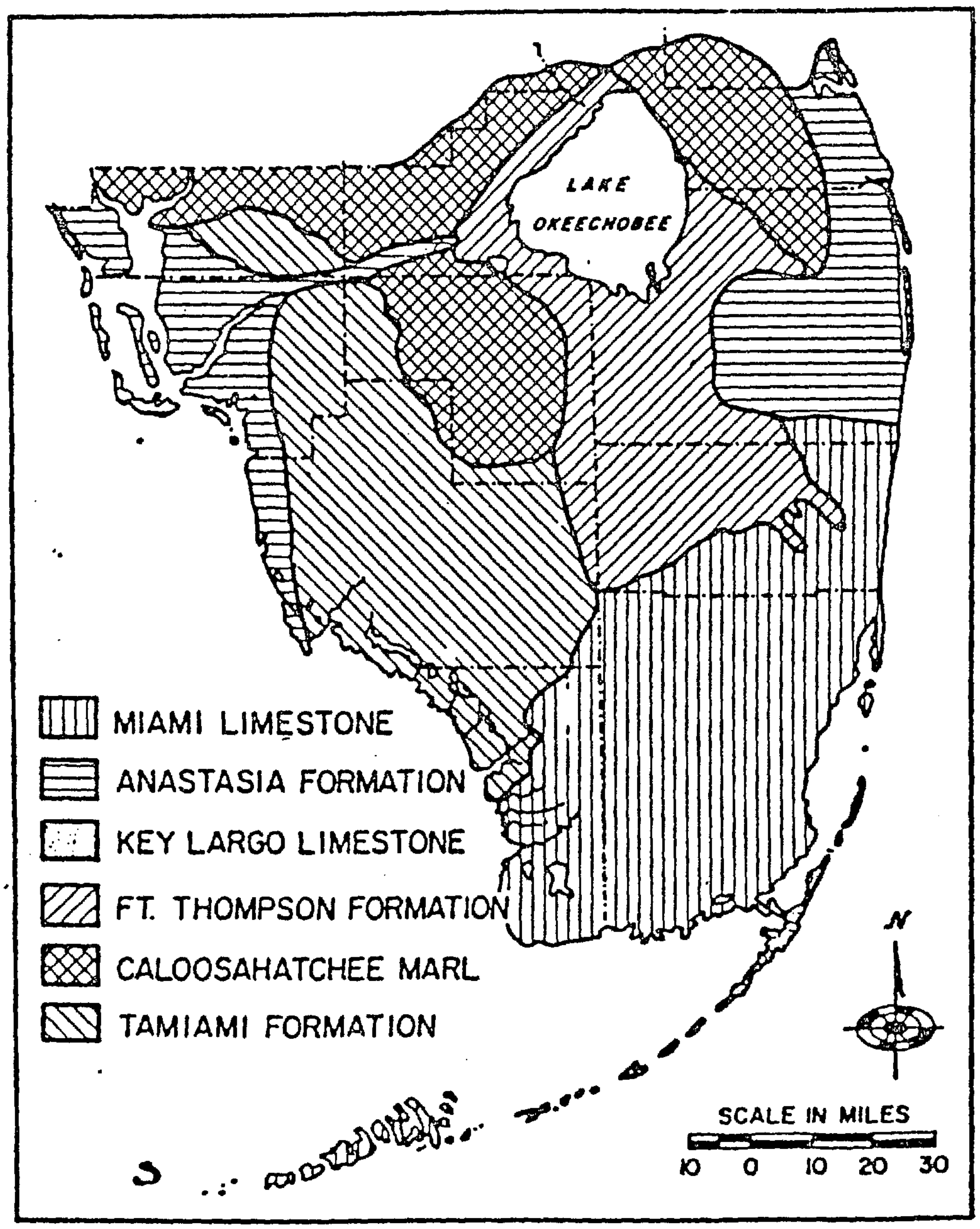
In its upper portion, some 15 feet thick in the Miami area, it is one of the most permeable and prolific formations of the Biscayne Aquifer (Parker, et. al., 1955; Stringfield, 1966; Parker and Cooke, 1944). According to Dubar (1974) the upper portion is separated from the lower portion by an unconformity. It is not clear whether this stratigraphic separation corresponds to a hydrologic separation as well. In the Miami area the upper productive zone is composed of permeable limestones, underlain by relatively impermeable marls and limestones of the Lower Tamiami and Hawthorne Formations, which, in part, form the confining beds between the deeper Floridan Aquifier and the shallower Biscayne Aquifier. Although the Floridan has sufficient water pressure to allow artesian flow in the Keys, the high concentration of dissolved materials renders the water unfit for public consumption. Pennekamp Spring on Key Largo is a 6-inch artesian well 1,300 feet deep into the Florida Aquifer. It has a chloride concentration of 2,440 mg/l, nearly ten times the recommended U.S. Public Health Service levels (Rosenau, et al., 1977).

The Tamiami Limestone has generally been assigned a Miocene age, but more recent faunal correlations suggest that it may be Pliocene (Brooks, 1982; Dubar, 1974).

The Caloosahatchee-Fort Thompson Formation

Like the Tamiami Formation, these formations thicken coastward. In the areas of the Keys, these formations, if indeed there are more than one, are primarily represented by the Fort Thompson Formation. They represent an extremely complex series of interbedded clastic and shell deposits formed during the various transgressions and regressions of the sea associated with Pleistocene glacial events.

Figure 7: GEOLOGIC MAP OF SOUTHERN FLORIDA (Hoffmeister, 1974).



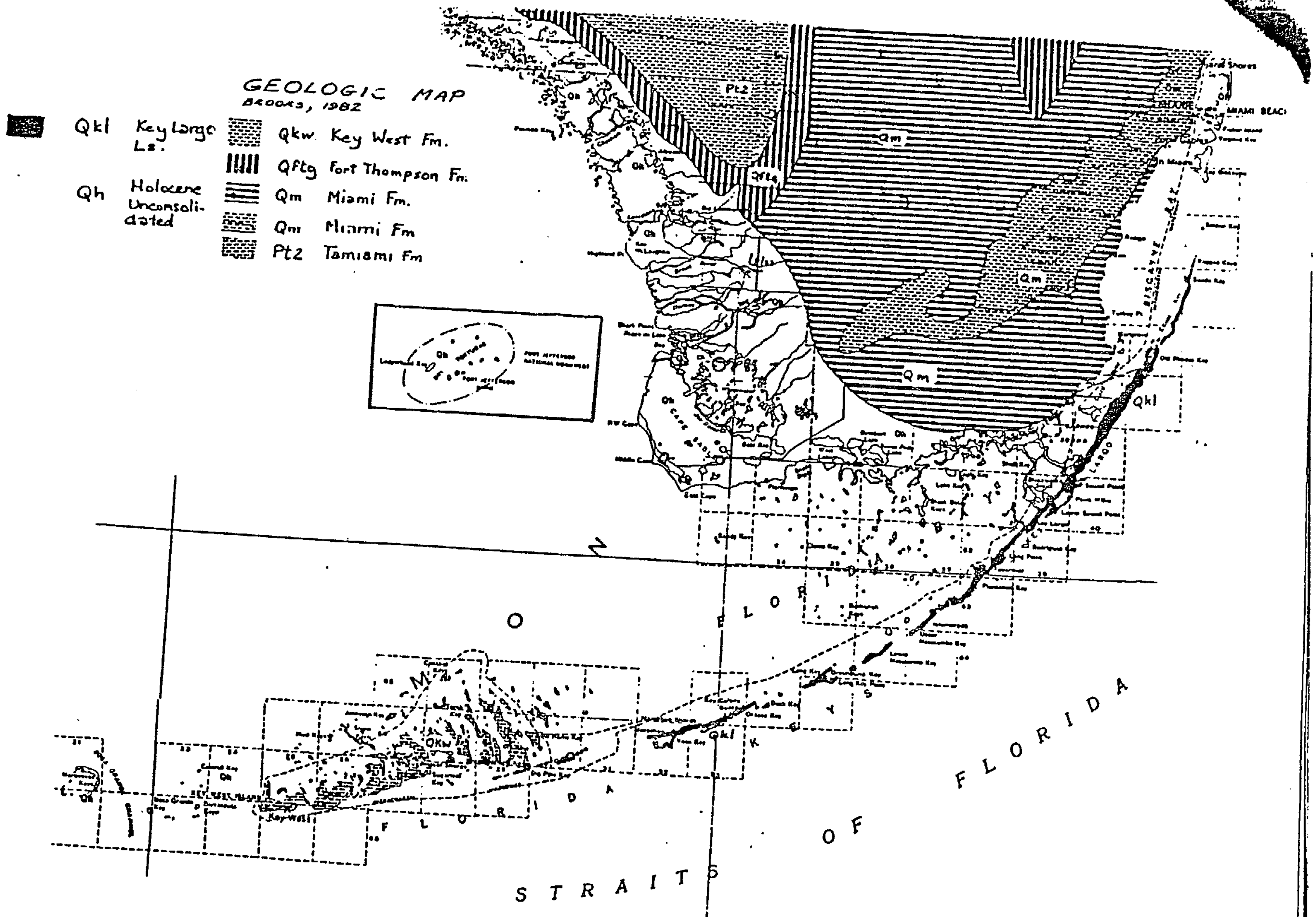


Figure 8. ~~Geologic Map of South Florida (Brooks, 1982)~~.

Up to 70 feet thick near Miami, it thins southward and westward (Dubar, 1974). Although locally productive, the dense, hard limestones and intercalated muds and marls of the Fort Thompson render it somewhat less permeable than overlying and underlying units (Parker and Cooke, 1944; Stringfield, 1966). No doubt some of the Fort Thompson formation is contemporaneous with the strata which will be discussed below and merely represents different environmental conditions. However, exact contemporanity has not been determined at present time (Brooks, 1973, 1982; Dubar, 1974).

The Miami Limestone

The Miami Limestone is the main rock outcrop in the southeastern part of the Florida peninsula. It is the medium to hard limestone, white to yellowish in color, oolitic in places, rich in bryozoans in part, and may also contain some quartz sand. It underlies most of the Florida Bay where it is covered by varying thicknesses of calcareous mud derived from the disintegration of calcareous algae. This limestone is primarily represented by two environmental facies -- the oolitic and the bryozoan.

The bryozoan facies underlies much of the oolitic; but landward of the Miami area, the oolite thins and disappears while the bryozoan facies persists. Eastward, towards the Upper Keys, the bryozoan facies interfingers with the Key Largo Limestone. Presumably when water was higher than at present, the environment was similar to the present environment of the Bahamas, where today we also find oolitic mounds on the oceanic side of the platform with bryozoans thriving behind the mound. The presence of the reefs of the Key Largo Limestone acting as a barrier encouraged the formation of oolites in the waters behind this barrier, while further back, protected by the reef and the accumulating ridge of oolites, bryozoans flourished. When sea level dropped during an ensuing glacial episode, these bryozoan and oolitic beds of the Miami Limestone were exposed subareally and the sediments were cemented as rainwater deposited calcite between the grain spaces. Similarly, in the Lower Keys, a second mound of oolite developed on the Florida Bay side of the Key Largo Limestone reef. As the mound increased in size because of extensive precipitation of calcium carbonate, it slowly overwhelmed the reef. The contact between these two formations (i.e. Key Largo Limestone and Miami Oolite) can be seen in Big Pine Key. From there, the Miami Oolite progressively thickens westward to reach 35 feet near the west end of the lower Keys (Hoffmeister, et al., 1964; Hoffmeister, 1974; Dubar, 1974). As in the North, in the Miami area, subsequent exposure due to lowering of sea level allowed the oolite mound to harden. However, because this mound was not protected by a reef line as in the North, when sea level rose again it concentrated its erosional energy along the relictual tidal channels which had formed at the time of deposition of the oolite bank and cut the long parallel channels which now separate the Lower Keys.

Both the Miami Limestone and the Key West Limestone (if indeed they are distinct) are porous limestones, containing numerous vertical solution features most likely formed during the Pleistocene. Because these features are not commonly connected, water does not move laterally as readily as in the Key Largo Limestone and they provide an excellent supply of fresh water (Parker and Cooke, 1944; Parker, et al., 1955).

The Key Largo Limestone

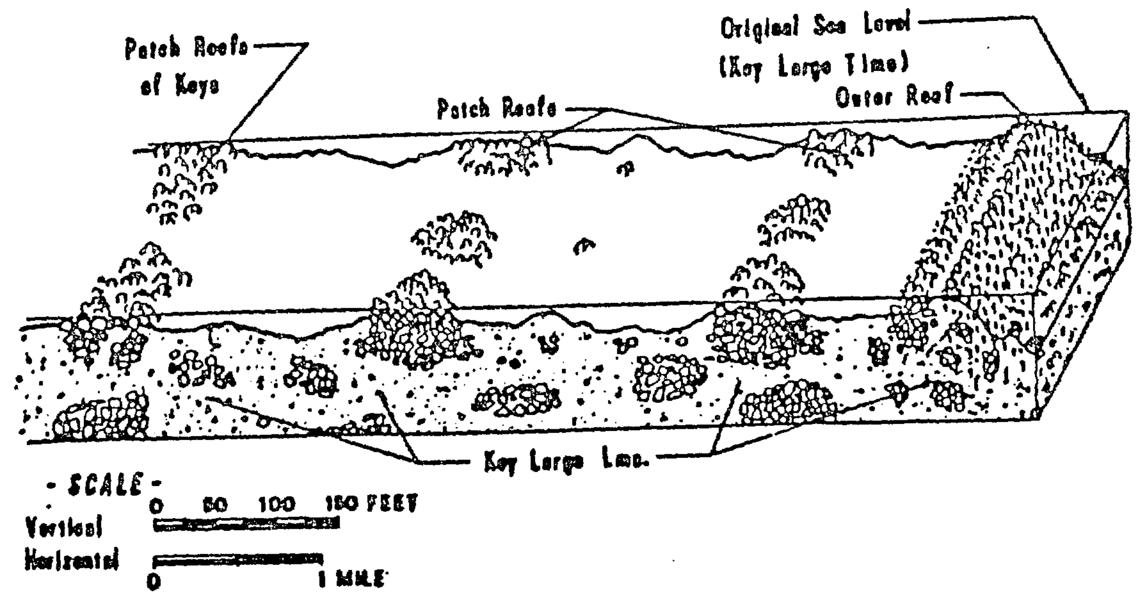
The Key Largo Limestone outcrops at the surface from Soldier Key to the southernmost end of Big Pine Key, over a distance of 110 miles. However, subsurface drillings indicate that it originally extended over twice its exposed length, from Miami to the Dry Tortugas. It varies in thickness from 70 to over 170 feet. It is a fossil coral reef whose main structure is a network of coral heads with intervening spaces filled with detrital reef material. Star coral, and less commonly brain corals, are the dominant species found in the exposed Key Largo Limestone indicating that the reef that can now be seen was a patch reef. Drilling seaward of the presently exposed part of the Key Largo Limestone reveals the presence of moose horn coral, a species characteristic of present fringe reefs. No doubt, the lowering of the sea which allowed cementation of the Miami Limestone also killed the reef as it emerged. The subsequent rise of the sea which reshaped the oolitic limestone of the Lower Keys, also destroyed most of the outer fringe reef. Only the inner patch reef is visible today and forms the backbone of the Upper Keys. (See Figure 9).

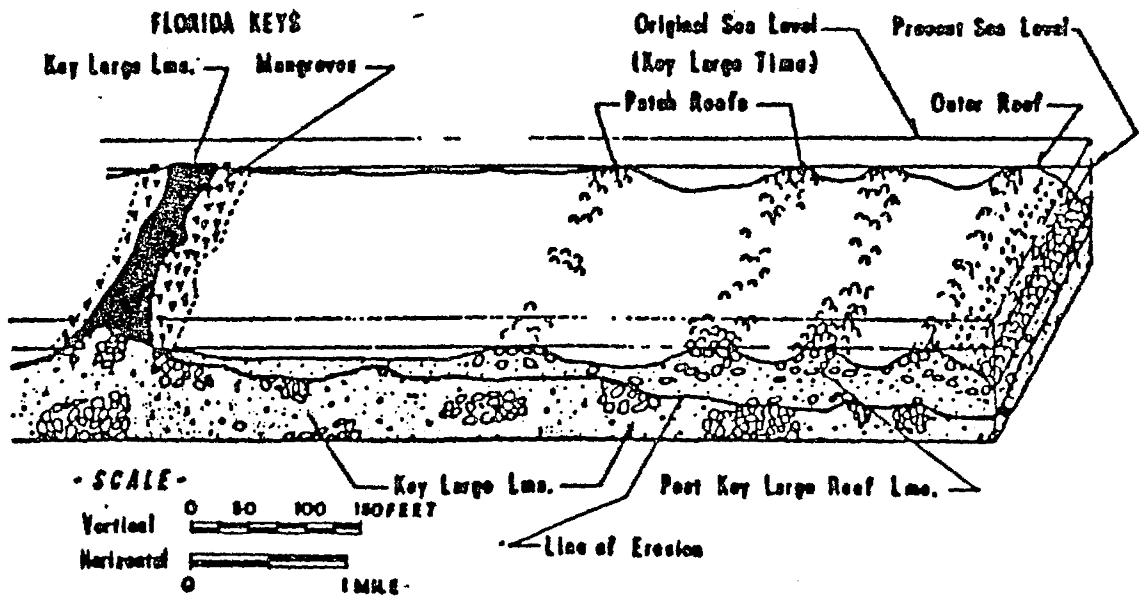
The Key Largo Limestone is a very porous coralline limestone. It is riddled with solution features and voids, allowing water ready passage, both vertically and horizontally. Although potentially an excellent aquifer, it contains very little fresh water because its permeability allows ready outflow (Hoffmeister and Multer, 1968; Hoffmeister, 1974; Parker, et al., 1955).

The Key West Limestone

There is doubt in some authors' minds whether the oolitic limestone which forms the lower Keys is in fact distinct from the Miami Limestone. Those (starting with Sellars (1909)) who have maintained that it is not, have insisted that the oolite which covers the lower Keys is a separate formation and have therefore given it the name of Key West Limestone (see Brooks, 1982). Although there is argument as to the contemporaneity of the events discussed, or the specific formations present, there is little or no disagreement as to the environmental conditions which prevailed or the mode of formation of these deposits.

Figure 9: A RECONSTRUCTION OF ENVIRONMENT DURING KEY LARGO LIMESTONE FORMATION TIME (above); PRESENT CONDITIONS (below) (Hoffmeister, 1974).





B. Groundwater in the Keys

Although the Miami area has a relatively ample supply of fresh water (albeit increasingly depleted by ever-growing demand), such is not the case in the Keys despite similar regional geology. Surrounded as they are by salt water, their fresh water resouces are meager at best, and too often nonexistent. Fresh water lenses of the Biscayne Aquifer exist primarily on Big Pine Key and Key West, as well as on No Name, Cudjoe and Upper Sugarloaf Keys. Dependent as they are on rainfall for recharge, local supplies are further limited by runoff, evaporation and transpiration and outflow from the aquifier (Parker, et al., 1955; Klein, 1970; Hanson, 1980).

Although the Upper Keys receive more rainfall than the Lower Keys, they have virtually no fresh water supplies. Because the voids in the underlying Key Largo Limestone are interconnected horizontally, percolating rainwater is not confined laterally, resulting in increased outflow. For the same reason, saltwater readily rises and passes through the aquifier in response to tidal influences. This results in increased mixing and dissipation of the fresh water (Parker, et al., 1955; Chesher, 1974).

Because the Miami (or Key West) Oolite in the Lower Keys has fewer lateral connections than the Key Largo Limestone, outflow is slower. Tidal amplitude is lower as well resulting in less mixing (Parker, et al., 1955; Cheshner, 1974; Hanson 1980). Cementation crusts within the oolite also tend to limit evaporation.

Despite the presence of some fresh water lenses, it is not expected that groundwater supplies of the Keys will ever provide a significant amount of fresh water. Nevertheless, large withdrawals would severely impact the limited supply available with concommitant salt water intrusions. Additionally, ditching such as that reported by Alexander and Dickson (1972) provide ample evidence of the portentially adverse effect of human interference.

C. Tides

Tides effect nearly one million acres of estuaries and tidelands in Florida, and their rise and daily and secular variations intimately affect natural ecosystems and human activities alike.

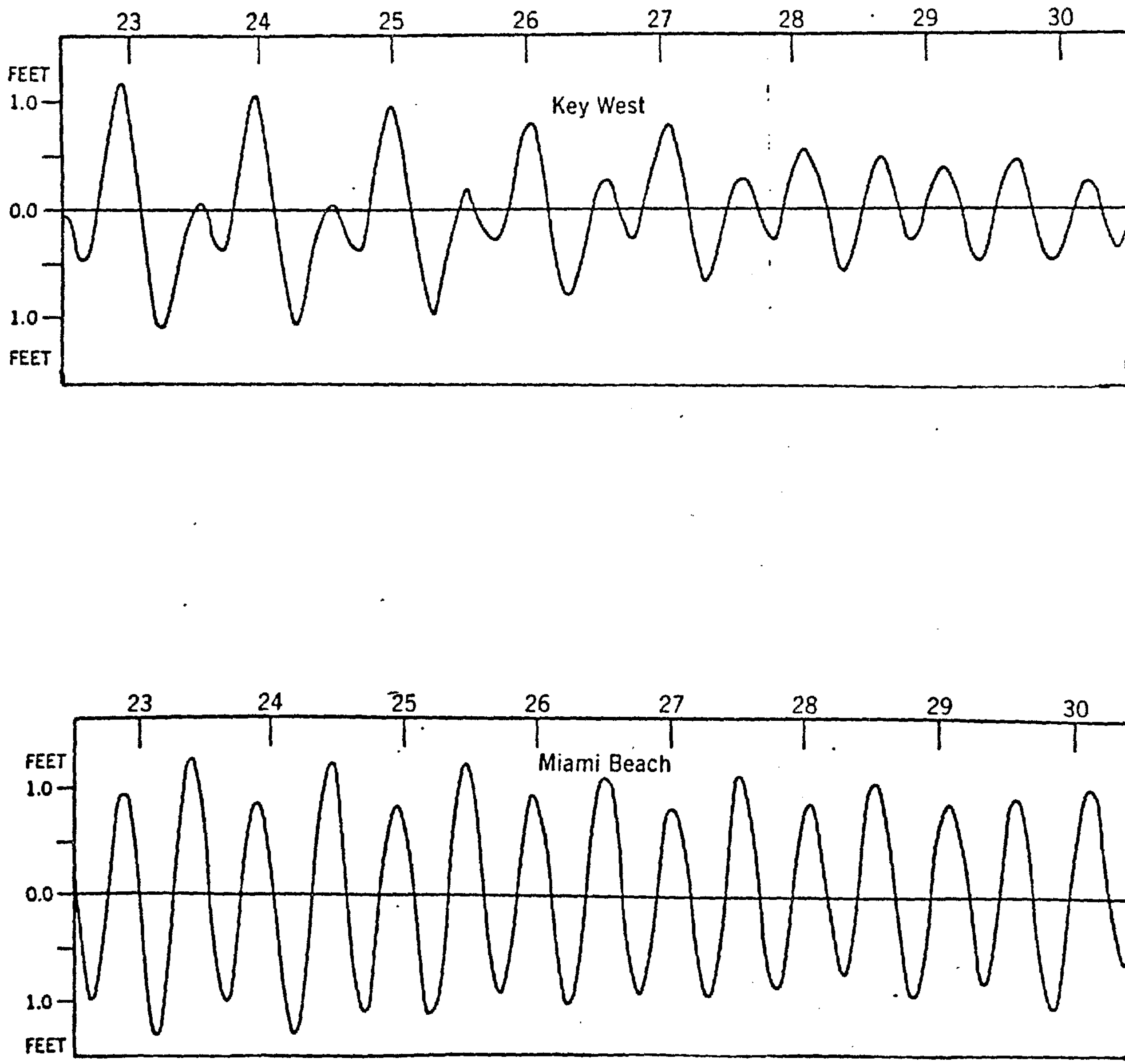
The knowledge that tides are linked to the motion of the sun and the moon has been known since antiquity. However, the basic explanation for tides, namely the interaction between the gravitational forces of the Earth-Moon-Sun system, did not come forth until Newton's time. Because the moon is the closer body to the Earth, its influence is preeminent. Bodies of water which face the Moon are closer to it and therefore are subjected to greater forces. Being less rigid than the solid earth, the body of water facing the Moon is subjected to greater acceleration than the remainder of the system and bulges towards the Moon. Oceans on the opposite side of the Earth, being farthest away, will experience a lower gravitational gradient than the Earth and, experiencing less accleration, will bulge away from the Earth. Thus, interaction of gravitational forces will give rise to two bulges, once facing the Moon, the other at its antipodes. As the Moon passes a given point on the surface of the Earth 50 minutes later each day, each point on the surface should experience two high tides and two low tides during each tidal day of 24 hours and 50 minutes.

The attraction of the Sun, albeit weaker than that of the Moon because of its greater distance from the Earth, will have a similar effect on bodies of water. Depending on the relative positions of the three bodies, the gravitational pull of the Sun may reinforce that of the Moon to cause the greater than normal tides called spring tides. During periods when they partially cancel each other lower than average tides called neap tides occur.

These effects are further complicated by a host of factors. Because the planetary bodies travel in elipses rather than circles, Earth-Sun and Earth-Moon distances vary continually. Furthermore, the angle between the Earth's Equator and the Sun varies by 47 degrees over a period of a year. Similarly, the Moon's position will shift from 28.5 north to 28.5 south of the Equator over a period of a month. To complicate matters even further, tidal bulges are not free to move over the surface of the Earth as the various ocean basins are separated by continents. Further, tides in a given locality are affected not only by the gross topography (Gross, 1977). Once put into motion, the water in a particular basin will begin to oscillate with a frequency natural to that basin. Apparently, the natural frequency of the Gulf of Mexico is 24 hours. As such it naturally responds more readily to diurnal tidal forces and the Gulf is characterized by a diurnal regime of one high and one low tide per tidal day (Marmer, 1954). In contrast, the Atlantic basin exhibits two high tides and two low tides of nearly equal amplitude per tidal day. Such a regime is referred to as semi-diurnal (See Figure 10).

It is not surprising that Key West, lying as it does at the edge of both basins, will exhibit a mixed tide pattern (See Figure 10). Although there are two highs and lows per tidal day, they are of inequal amplitude. In the Keys proper, tides are semi diurnal north of Key Largo and below Key Largo they are of the mixed type. The amplitude of tides tends to be lower in low latitudes and indeed the tidal range at the Miami station is only on the order of 2.5 feet (Marmer, 1954; Provost, 1973). Furthermore, the tidal range along the continental slope break decreases southward along the Keys to Key West where it is on the order 1.1 feet (Provost, 1973).

Figure 10: TIDE CURVES, MIAMI BEACH AND KEY WEST, JUNE 23-30, 1948 (Marmer, 1954).



There is a marked delay in tides between the east and west side of the Keys which is commonly attributed to friction (Enos, 1977). No doubt it is also related to local topography and to the characteristics of Florida Bay. Because it is a small shallow restricted basin, Florida Bay does not exhibit large tides; in fact, their amplitude is on the order of 0.5 feet, leading to a marked water gradient between the two sides of the Keys. Consequently, at high tide there is substantial water inflow into Florida Bay from the Atlantic. The magnitude of this difference is related to the number of openings between the two systems. In the Upper Keys where the islands act as a barrier, and few openings connect the Atlantic to Florida Bay, the water gradient is quite marked. In the Lower Keys where the islands lie parallel to the tidal flow direction and where the openings are common, the gradient is much less (Enos, 1977).

Tidal amplitudes are also influenced by meteorological conditions. Changes in barometric pressure influence the height of the water column. Theoretical calculations indicate that tidal height may rise up to one foot for every one inch decrease of barometric pressure. Even greater than barometric effects are changes in tides induced by the wind. In shallow areas, the wind may force a large amount of water against a coastline inducing not only a greater amplitude in the tides but also tidal currents as the water is forced to move laterally in response to the gravitational gradient. Both these effects are common during hurricanes where the tidal surges up to 25 feet have been recorded.

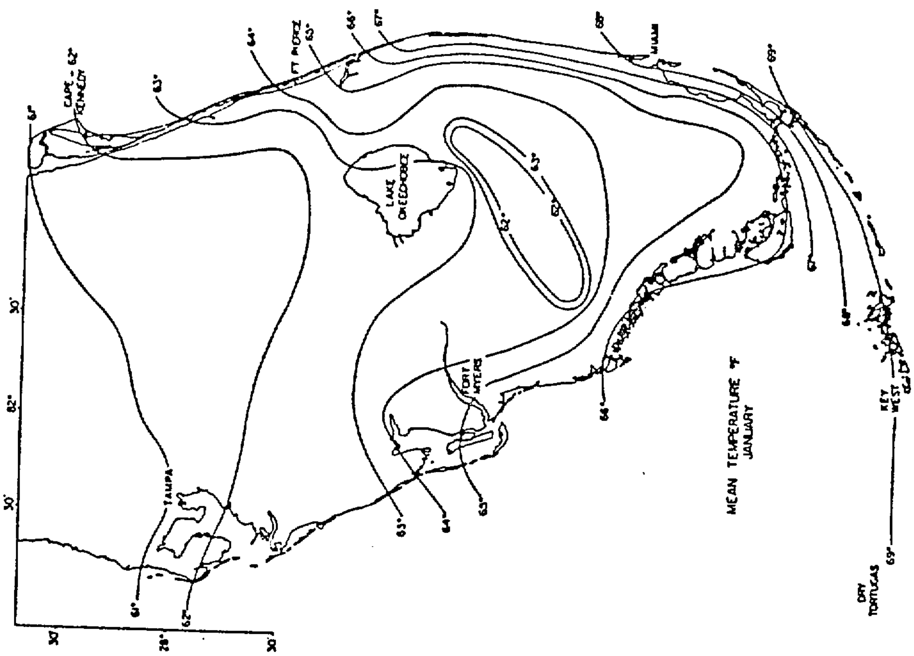
Lastly, tide amplitude is also affected by long range variations in sea level. Careful record-keeping indicates that amelioration of climate has led to an historical rise in sea level. Along the Atlantic Coast, sea level has crept up at the rate of one foot every 72-125 years approximately averaging one foot per century. This rise seems slower in Key West where the average rise is closer to one foot in 143 years (Provost, 1973). Little is known, however, about the causes of these variations.

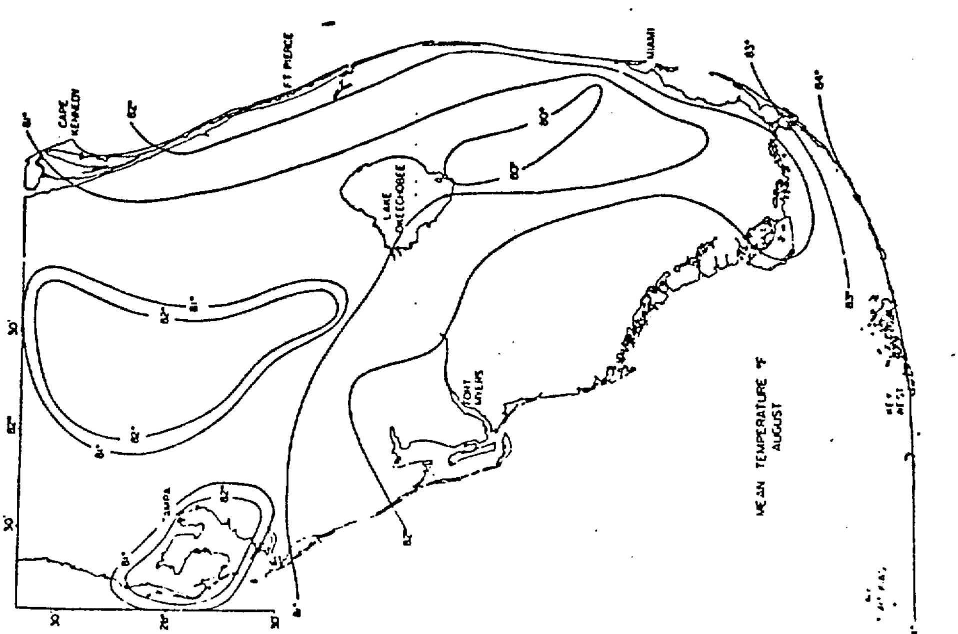
D. Climate

Lying in the zone of the trade winds, the Keys experience a subtropical savanna type climate characterized by warm summers and mild dry winters (Bradley, 1972). The mean annual sunshine is 3,300 hours, ten percent more than the peninsula to the north, and average daily solar energy reaching the Keys has been calculated at 447 langleys (Dames and Moore, 1978).

The mean annual temperature ranges from 77 degrees F in the Lower Keys to 76 degrees F in the Upper Keys. The mean temperature for January, the coldest month, is 69 degrees F, while August, the hottest month, has a mean of 84 degrees F (Thomas, 1974). (See Figure 11) One striking aspect of the isotherms is how closely they follow the coastline from the Dry Tortugas to

Figure 11 : MEAN TEMPERATURE FOR JANUARY AND AUGUST, (Thomas 1974).





Ft. Pierce. This is primarily due to the meliorative effect of the warm marine waters which bathe the Keys, and the presence of the warm Gulf Stream along the coast (Jordan, 1973).

Yearly rainfall in the Keys ranges from 35-45 inches, although it may be as little as 20 inches or as much as 60 inches in a given year. Most of the rainfall comes during the wet season, the summer months from May to October, and has a pronounced biomodal distribution (Thomas, 1974). Most of the rain falls during May, June, September and October. (See Figures 12 and 13) During these months, the Keys lie in a low pressure through area between two anti-cyclonic cells. As this trough shifts into the Gulf during July and August, rainfall decreases. Thunderstorms are the primary source of water during the wet season. Ninety percent of the 60 to 80 storms which occur each year form during the wet season when approximately 35% of the days report thunderstorms due in large part to convective processes (Jordan, 1973). As the moist, oceanic air heats up over the land during hot summer days, it becomes unstable and rises. Moisture condenses forming thunderstorms. This process is favored by the orientation of the Keys virtually at right angles to the prevailing easterlies. Occasionally, tropical cyclones will also add to the water budget of the Keys (See Section on Hurricanes).

During the dry winter season, most of the rainfall is due to cold fronts, which pass over the area on the average of once a week. Winter rainfall, however, accounts for less than one third of the precipitation in the area (Thomas, 1974).

There is a net decrease in precipitation southward, presumably for two reasons. Winter cold fronts do not pass into the Lower Keys as often as they do in the Upper Keys. Further, convective thunderstorms do not develop as readily over small islands as they do over the mainland. This also accounts for the fact that the Lower Keys show less marked seasonal differences than the Upper Keys.

Winds are relatively mild, averaging 11-12 knots throughout the year, with highest winds occurring during the winter months (November through April) and decreasing during the summer, although wind velocities nearing 250 mph were associated with the great hurricane of 1935 (Jordan, 1974; Gentry, 1974). (See Figure 14) Because the Keys lie in the area of the trades, wind direction is generally easterly. An excellent synopsis of the general climate of the area can be found in Schomer and Drew, 1982.

E. Hurricanes

No climatic discussion would be valid without mentioning tropical cyclones. Almost invariably spawned in the latitudes from 5 to 20 N, these areas of low pressure vary in intensity and degree of organization. Cyclones with poorly defined circulation and winds of less than 38 mph are called tropical disturbances or

Figure 12: AVERAGE ANNUAL RAINFALL IN INCHES (Thomas, 1974).

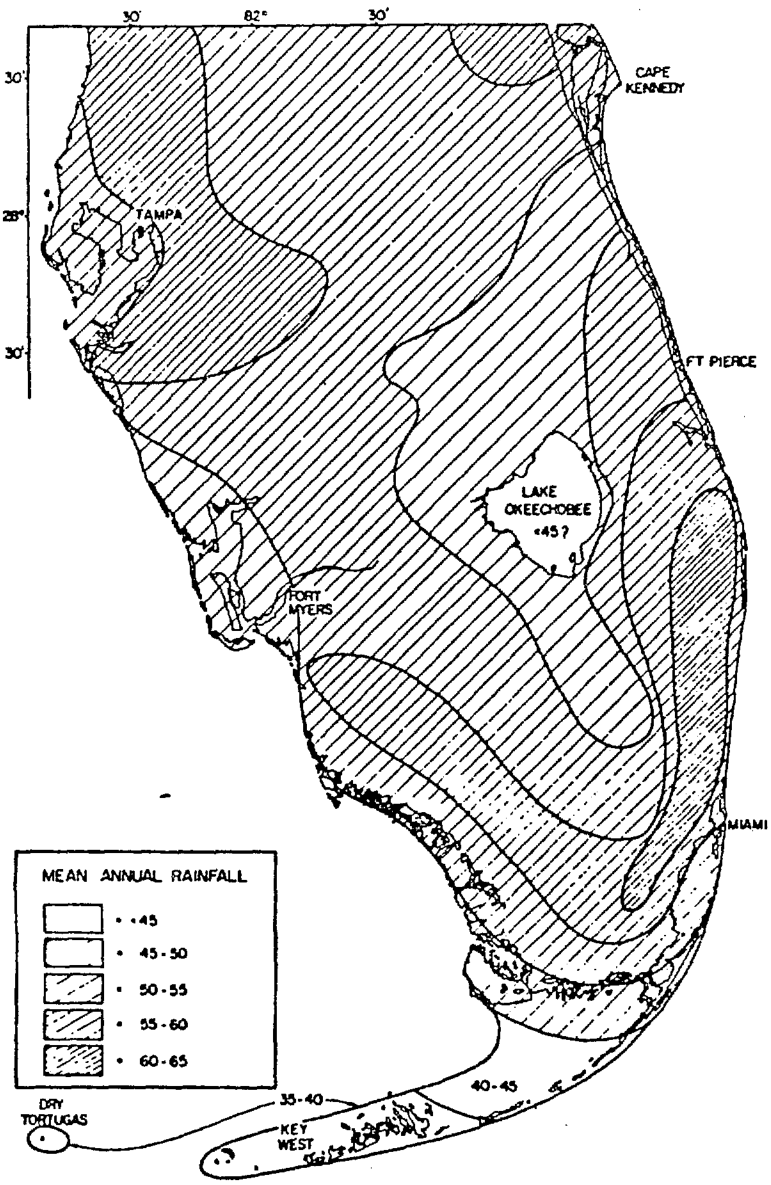


Figure 13: AVERAGE MONTHLY RAINFALL FOR THREE REPRESENTATIVE STATIONS IN STUDY AREA (Schomer and Drew, 1982).

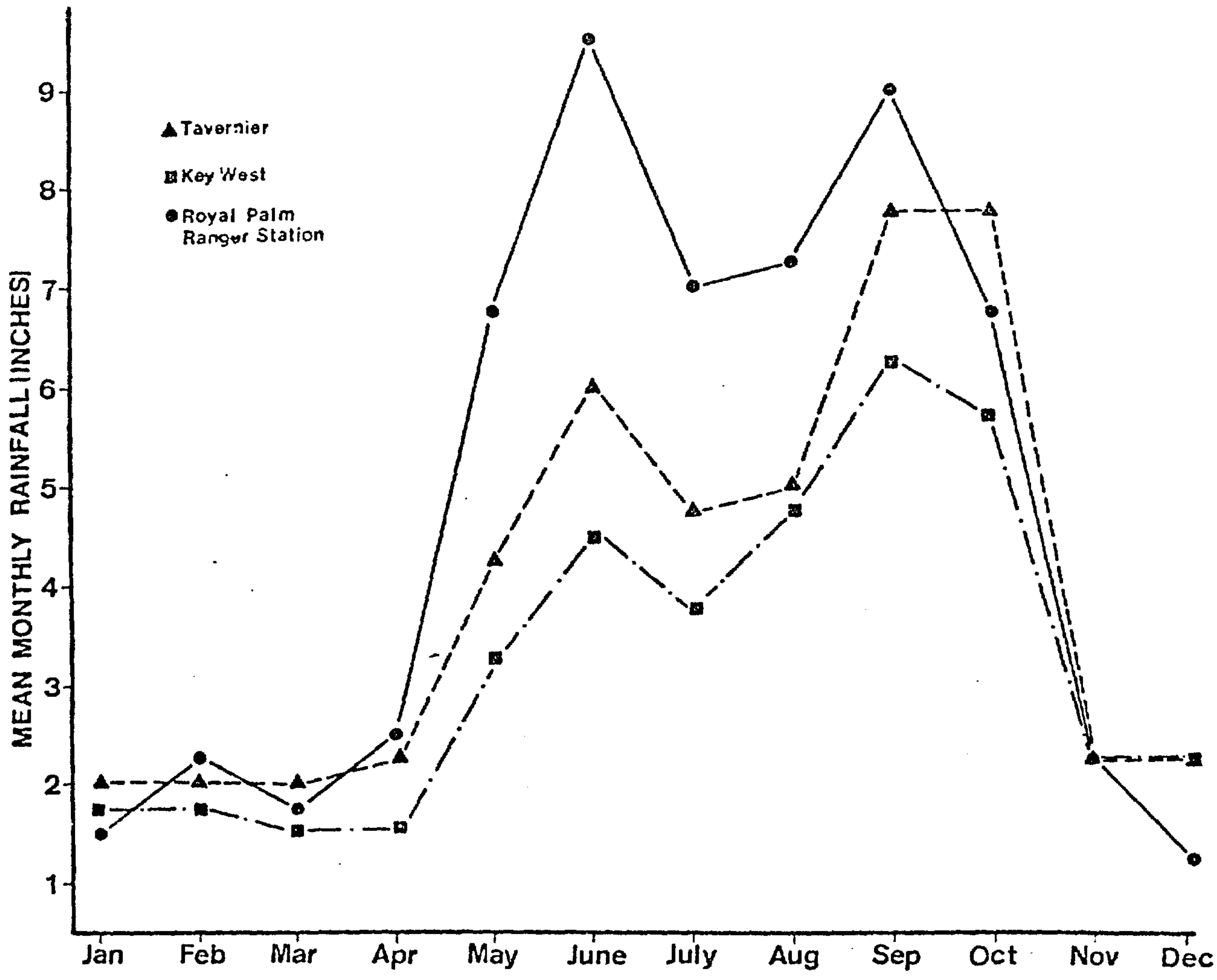
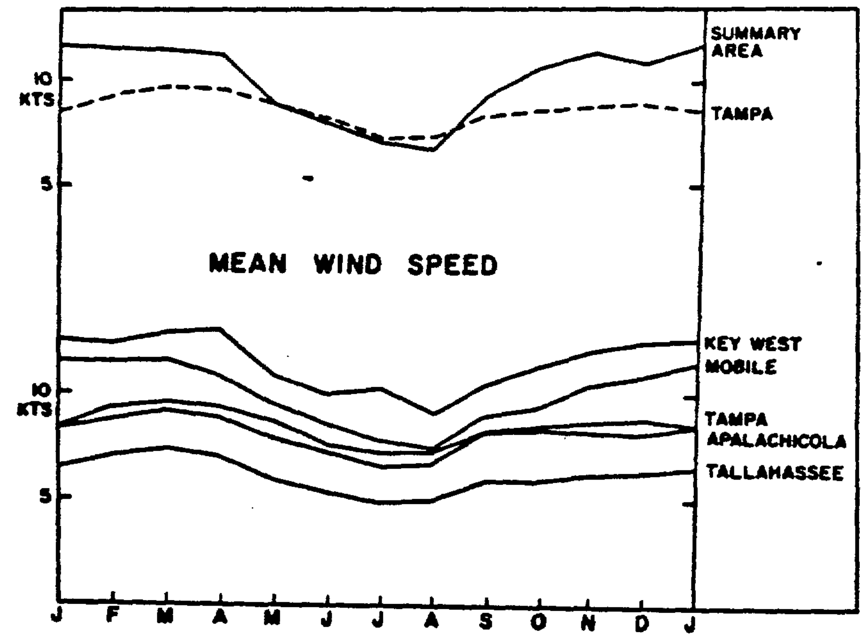


Figure 14: SEASONAL DISTRIBUTION OF MEAN MONTHLY WIND SPEED (Jordan, 1973).



depressions. If the circulation pattern becomes closed, and the maximum winds exceed 38 mph the depression is reclassified as a tropical storm. When the maximum winds exceed 74 mph the storm becomes a hurricane. Should the maximum sustained winds exceed 125 mph, it is referred to as a great hurricane (Gentry, 1973).

Hurricanes commonly begin as a wave or disturbance in the trade winds. If this wave intensifies, a counterclockwise circulation cell begins. As it gains energy from the condensation of moisture carried upward in the center of circulation, the pattern intensifies into a tight spiral extending hundreds of miles outward from a central low pressure zone (called the eye) commonly 10 to 20 miles wide. In the eye, where pressures may be as low as 940 millibars, the winds are relatively calm (20 mph or less)
and the sun may even break through the clouds. Virtually without transition as one leaves the eye, wind velocity jumps to over 200 mph in some of the great hurricanes. Torrential rains and severe thunderstorms ring the eye to heights of 40,000 feet and some 30 miles outward. Winds often reach 50 mph even 100 miles out from the eye, and the circulation system may extend over 300 miles from the center. Thus, a single storm may affect the entire Keys (Miller, 1971).

Dependent, as these cyclones are, on warm moist air for their energy supply, it is not surprising that they are most common during the summer months. In the area of the Keys, there were 38 hurricanes from 1901-1971 (Jordan, 1973). Nearly 80% occurred during the months of August, September and October, while the months of November through May accounted for only 10% of all the hurricanes. October alone accounted for 37% of these hurricanes. Similar data for the North Atlantic confirm this pattern. It should be noted that although yearly patterns are clear, no long range pattern has been detected.

Hurricanes release tremendous amounts of energy. A single storm may release 300-400 billion kwh per day. During the same period of time, 10-20 billion tons of water will fall in the form of rain during the average nine day life of a hurricane (Miller, 1971). On the average, 6-12" of rain will fall on a given location; although some storms are virtually dry, one tropical cyclone dropped 35" of rain in Trenton, Florida in three days in 1941 (Gentry, 1973). Much depends of course on the path and characteristics of a particular storm. On the average, they move over the surface at the rate of 12 mph. They tend to be slower below 30 degress N latitude while steered West or Northwest by the easterly trades. Once they enter the westerlies, they tend to veer to the northeast and commonly accelerate. Forward speeds up to 50 mph have been reported. As the storm moves over the colder waters of the North Atlantic or over land, less moisture becomes available, the storm loses energy and coherency and ultimately dissipates.

Because of their large size, their common occurrence and the enormous amount of energy they release, hurricanes pose a particular danger to all the areas they affect. In coastal areas such as the Keys three primary effects are associated with hurricans; wind, waves and storm surges.

Wind: As the dynamic pressure of the wind increases with the square of the wind velocity, tremendous pressures are exerted on vegetation and structures. A hurricane with winds of 75 to 100 mph can generate pressures of 75 lb/sq ft, enough to destroy mobile homes and cottages. As the wind flows around structures it creates pressure differentials which are sufficient to collapse them. The passage of the intense low pressure center over sealed buildings can have a similar effect (Stursa, 1973).

Waves: Because of the intense winds and the long duration of these storms, they generate large waves commonly 35 feet in height, but reaching up to 50 feet. As these waves reach the shoreline, they erode beaches, highways, undermine structures and rework sediments. Developed coastal areas where beach berms have been removed and canals that have been cut to the shore are particularly vulnerable to storm wave action.

Storm Surges: Perhaps the greatest danger to low lying areas such as the Keys is the storm surge which may be associated with any hurricane that approaches or crosses a coast. The storm surge is commonly composed of three elements that reinforce each other. First, as the low pressure center passes over an area, sea level will bulge below the low pressure area by as much as two feet because of the decreased barometric pressure. Second, because the shoreline acts as a barrier, the water is piled up against land by winds. Third, high tides may combine their amplitude with the rise in water from the other factors. In Pass Christian, Louisiana, in 1969, the storm surge reached 25 feet, the highest surge recorded in the Keys reached near 18 feet during the "Labor Day" Hurricane of 1935 (Gentry, 1973; Sursa 1973). While such a rise is extreme, surges in excess of ten feet are not uncommon and if one visualizes storm waves up to 20 feet in height superimposed on these surges, one can readily understand the potential destructiveness of a large hurricane. Associated with tidal surge flooding and wave pounding are surge currents which are responsible for sediment reworking and transport. Although surges are common phenomena, their amplitude and destructive potential are difficult to predict, depending as they are on a host of factors such as wind speed, direction, fetch, water depth, basin and coastal shape as well as currents, tides and seiches, to name but a few.

Secondary effects of hurricanes may include damage to vegetation as well as marine biota because of sudden changes in temperature and salinity, as well as direct effect on the aquifer by flooding recharge areas (Stursa, 1973; Craighead and Gilbert, 1962). In extreme cases, entire coastlines have been obliterated. It should be borne in mind, however, that hurricanes are natural parts of ecosystems and water budgets of many areas. With the passing of the years and a better understanding of these severe storms, loss of life has drastically decreased, even though because of increased development of the coastlines property damage continues to rise steadily.

The effects of hurricanes on the Keys' natural ecosystems can be devastating. The storm surge and associated wave action especially impact shoreline systems such as salt ponds, beaches, berms and mangrove communities. Hurricane Donna substantially changed shorelines throughout the Upper Keys. Some smaller Keys were practically obliterated, some were severed, and in many areas low dune ridges were stripped of vegetation (Craighead and Gilberg, 1962). The effect of such disturbance is to return these systems to a pioneer seral stage. Craighead and Gilbert (1962) further noted that these forces dispersed Red Mangrove (Rhizophora mangle) seeds several miles inland and certainly represented the source of the extensive inland stands of this species.

The winds of severe hurricanes will directly uproot much of the vegetation in the path of the eye and defoliate most of the remainder. While much defoliated vegetation produces new foliage, some species, especially mangroves, may be characterized by high mortality for reasons that are unclear, although high soil hydrogen sulfide generated by anaerobic decomposition of newly deposited organics may be a major factor (Craighead and Gilberg, 1962).

While mangroves were often decimated by hurricanes, some species of upland vegetation fared much better. Especially wind-resistant species are:

Cabbage Plam	Sabal palmetto
Royal Palm	Roystonea elata
Live Oak	Quercus virginiana
Strangler Fig	Ficus Aurea
Mastic	Sideroxylon foetidissimum
Lysiloma	Lysiloma bahamensis
Slash Pine	Pinus elliottii

Areas affected by storm surges may be temporarily damaged by the increased salinity of water or soil. If drainage is poor, as in some wetland areas, recovery may take several years (Stursa, 1973), but the torrential rains that accompany hurricanes tend to offset this damage and the region's high annual rainfall tends to leach away deposited salts and promote a faster recovery in most plant communities.

Since hurricanes are recurring natural phenomena, most Keys biota have evolved some degree of accomodation. Consequently, a fairly predictable successional sequence tends to generate anew the destroyed system. One factor that can complicate this recovery, however, is the introduction of propagules of exotic plant species. Many such species, especially Brazilian Pepper (Schinus terebinthefolius) and Australian Pine (Casuarina equisetifolia) are opportunistic forms that rapidly colonize disturbed sites and may delay or adversely affect ultimate recovery. Further, the latter species is very salt tolerant and tends to suffer less than many native species when exposed to subsequent storm surges (Alexander, 1968).

Another major impact of hurricanes on upland systems is the removal or reduction of the thin humus layer that overlies the limestone. The significance of this humus is discussed elsewhere but it can be stated here that its diminution sets back the successional sequence to an earlier seral stage in which many environmental variables (temperature, surface moisture) become more extreme.

(2) CORAL REEFS

Coral Reefs are among the Earth's most complex and productive natural systems. These shallow water ecosystems rest on a limestone substratum of their own production in stable environmental conditions. The saltwater environment is warm (above 70 degrees F.) and transparent enough to access to the intense bright light required by many reef inhabitants.

The structural framework of coral reefs is composed of colonies of tiny organisms collectively called coral. These organisms extract calcium and carbonate ions from seawater to secrete calcareous chambers within which they live. The growth of a coral reef, therefore, represents the collective actions of the many individuals comprising these colonies and is a slow process. This structural framework provides food and/or habitat for a vast number of organisms.

The principal extant reef builders are hermatypic corals (DiSalvo & Odum, 1974) whose symbiosis with unicellular algae called zoosanthellae provides a mechanism for maximizing reef growth. The algal species occur in the endodermal tissue of their host where they are protected by its calcareous skeleton, which is spacially oriented to insure illumination. This advantage is maximized in associations with the many corals whose polyps are extended out of this structure during daylight hours (Wainwright, 1967). These algae provide their host with oxygen as a metabolic byproduct of photosynthetic activity and organics (Muscatine, 1967.)

The coral reefs of the Florida Keys are at the northern edge of the geographic range of these systems. Consequently, their structural organization may differ somewhat from the classic patterns observed in most Caribbean reefs where physical conditions are more constant. Nonetheless, the pattern of Keys reefs approaches the "barrier reef" model originally advanced by Charles Darwin.

The most seaward component of this barrier complex is an outer reef system that develops at the crest of an escarpment (See Figure 8) at the outer edge of the shallow continental shelf that occurs along the Atlantic edge of the Keys. Because of the linear regularity of this geomorphological feature, outer reefs tend to be linear systems that parallel the Keys.

Landward of the outer reef lies a shallow lagoon system that is characterized by less structural regularity of its coral components. These patch reefs are of scattered and irregular distribution, shape and size. Differences in the physical environments of the barrier and patch reefs are reflected in the differing morphologies of their dominant coral species. The patch reefs of the lagoon area live in shallow water that is more strongly influenced by wave action that can increase turbidity, and by weather changes that can result in a range of thermal variation unknown in the deeper waters of the outer reef. The evolutionary accomodation to these conditions has been the predominance in the patch reefs of massive boulder-shaped corals whose morphology is better able to withstand the high wave energy and concommitant turbidity.

The corals along the outer reef do not experience such stressful conditions. Here the thermal condition is stabilized by the influence of warm Gulf Stream waters and sediments that could contribute to turbidity are instead transported into the ocean's depths by the zone's many sand channels. As a consequence, the outer reef is inhabited by many corals with branched and plated morphologies.

Further, there exist discontinuities in Keys barrier reef distribution that reflect geographic discontinuities in the archipelago itself. The chain of islands that comprise the Upper Keys constitute a continuous barrier to the exchange of water between Florida Bay and the Atlantic. Consequently, the Gulf Stream's thermally moderating influence is more constant here than in the Lower Keys where the archipelago is fragmented and seasonal thermal variations are more profound. Further, these passages in the Lower Keys indirectly allow the generation of turbid water. The consequence of these differences is that major reef development in the lower Keys are limited to the "shadow zone" south of major islands (e.g., the Samba reefs south of Looe Key) where environmental conditions are more constant.

Biota

There are over 6000 patch reefs between Miami and the Marquesas Keys (Schomer & Drew, 1982). Most occur in areas of sand, mud, or rock substrate located in a band two to four miles from the islands between Hawk Channel and the outer reefs (Marszalek, et al., 1977).

There are two basic types of patch reefs (Marszalek, et al., 1977; Jaap, 1982)--dome patch reefs and linear patch reefs. Dome patch reefs usually occur in clusters in water depths of less than 30 feet and vary in size from a few meters to more than 700 meters (Schomer & Drew, 1982). They are typically circular or eliptical and are surrounded by a halo of barren substrate. The community's biota varies greatly depending on reef age and environmental condition (Jaap, 1982), but typically consists of scleractinian and alcyonarian corals, other coelenterates, mostly erect sponges, echinoderms crustaceans, molluscs, red and green algae, and a variety of fishes.

Jones (1977) described a successional sequence for dome patch reefs in which the pioneer corals are likely to be Porites porities, Manicina areolata, and Favia Fragum. These forms are replaced by massive primary reefbuilding corals like the starlet coral (Siderastrea siderea), the brain corals (Diploria labrinthiformis and D. strigosa), star corals (Montastrea annularis, and M. cavernosa), the finger corals (Porites porites and P. Furcata), and Colpophyllia natans.

The coral assemblage of linear reefs is similar to that of patch reefs, but elkhorn coral (Acropora palmata) joins Montastrea annularis as a principal reefbuilder. Linear reefs usually occur seaward of dome patch corals and lie roughly in a chain parallel to the outer reefs. Both types of reefs commonly have the algae Gonialithon sp. and Halimeds opuntia, numerous erect sponges, bivalves of the genera Arca, Lithophaga, and Barbatia, the gastropods Strombus gigas and Corallophils abbreviata, spiny lobsters (Panulirus argus), stone crabs (Menippe Mercenaria), the echinoids Diadema antillarium and Echinometra lucunter, numerous ostracods, bryozoans, foramini-fera, ostracods, and fishes (Enos, 1977; Multer, 1977, Jaap, 1982). Table 1 lists some of the common fish species of patch reefs.

Outer reefs are located at or near the shallow shelf break. The elongated reefs form a discontinuous belt that is best developed seaward of Key Largo and the lower Keys. The biota of the outer reefs include Porites astreoides, Lettuce Coral (Agaricia agericites), Clubbed Finger Coral Porites porites), Siderastres sidera, Elkhorn Coral (Acropora palmata), Staghorn Coral (A. cervicornis), Pillar Coral (Dendrogyra cylindrus), Gorgonia ventalina, Plexaura complanata, Diploria clivos, the alcyonarians Plexaura flexuosa, Pterogorgia citrina, and Eunicea mammosa, the hydrozoan Millepora complanata, the green algae Halimeda, the brittle stars Ophiothrix orstedii and Ophocnida sp., and coralline algae. These are a small fraction of the total species assemblage of outer reefs. Kissling (1977) identified from nine outer reefs off the Lower Keys over 350 macrobenthic species including 42 species of stony corals, 41 species of soft corals, and 21 species of brittle stars. It is further estimated that over 300 fish species inhabit these reefs. Some of the more commonly occurring fish species are listed in Table 1.

Few other vertebrates occur with regularity.

Three species of sea turtle may occur with varying frequency in coral reef although all utilize other habitats. These are the atlantic Ridley (lepiochelys kempi), Atlantic Green Turtle (Chelonia mydas mydas), and Atlantic Loggerhead (Caretta caretta caretta). Bottle-nosed Dolphins (Tursiops Truncatus) may also be occasionally observed in or near reefs, but it is not a principal habitat for this species. All four of these vertebrates are listed by federal and/or state agencies as threatened/endangered.

TABLE 1. Common fish species of Keys coral reefs.

Outer Reef

Creole Wrasse	Clepticus parrai
Blue Chromis	Chromis cyanea
Brown Chromis	Chromis multilineata
Rock Beauty	Holacanthus tricolor
Parrotfish	Scarus spp.
Hogfish	Lachnolaimus maximus
Sargeant Major	Abedefduf saxatilis
Bluehead	Thalassoma bifasciatum
Striped Grunt	Haemulon striatum
Smallmouth Grunt	Haemulon chrysargyreum
Bluestriped Grunt	Haemulon Scirus
French Grunt	Haemulon flavolineatum
Spanish Grunt	Haemulon macrostomum
Grey Angelfish	Pomacanthus arcuatus
Grey Snapper	Lutjanus griseus
Glassy Sweeper	Pempheris schombergki
Porkfish	Anisotremus virginicus
Bicolor Damselfish	Pomocentrus partitus
Flamefish	Apogon maculatus
Squirrelfish	Holocentrus ascensionis
Pearly Razorfish	Hemipteronotus novacula
Siminole Goby	Microgobius carri
Slendor Mojarra	Eucinostomus pseudogula

Eyed Flounder	Bothus ocellatus
Ballyhoo	Hemiramphus brasiliensis
Scaled Sardine	Harengula pensacolae
Lane Snapper	Lutjanus synagris
Yellow Stingray	Urolophus jamaicensus
Gag Grouper	Mycteroperca microlepis
Nassau Grouper	Epinephelus striatus
Snowy Grouper	Epinephelus nireatus
Jewfish	Epinephelus itajara
Yellowtail Snapper	Ocyurus chrysurus
Barracuda	Sphyraena barracuda
Spanish Hogfish	Bodianus rufus

Patch Reef

Sergeant Major	Abedefduf saxatilis
Bluehead	Thalassoma bifasciatum
Parrotfish	Scarus spp.
French Angelfish	Pomacanthus paru
Black Grouper	Mycteroperca bonaci
Blue Tang	Acanthurus coeruleus
Bluestriped Grunt	Haemulon sciurus
Black Grouper	Mycteroperca bonaci
Gag Grouper	Mycteroperca microlepis
Nassau Grouper	Epinephelus striatus
Snowy Grouper	Epinephelus nireatus
Jewfish	Epinephelus itajara
Yellowtail Snapper	Ocyurus chrysurus
Barracuda	Sphyraena barracuda
Spanish Hogfish	Bodianus rufus

Impacts

The great diversity of coral reef biota is either directly or indirectly dependent on a stable physiochemical environment. Any modification of these conditions can be expected to result in changes in the function and structure of reef ecosystems. Of Particular significance are possible modifications of temperature, salinity, light intensity, and sedimentation patterns.

Great mortality of reef biota has been recorded as a result of exposure to high temperatures and to the atmosphere in shallow reef systems during extremely low tides (Mayer, 1914; Glynn, 1968). Similar man-induced reef disturbance has been documented and is attributable to thermal effluents from a power plant in Biscayne Bay that caused coral death as far as 1-1/2 Kilometer away (Kaplan, 1982).

Most of the processes that damage reefs, however, may be exacerbated by human development in or modification of the Keys upland or shore habitats. Dredge and fill operations, for example, generate large amounts of sediments that may reach reefs and kill or damage coral and other sedentary animals and plants that are unable to clean their surfaces. Upland development also indirectly generates sediments that can damage reefs. Clearing of terrestrial habitats directly exposes soil to the actions of wind and water, whereas an anastomosing network of roots holds soil in place in unaltered habitats. Ultimately, most lost sediment will find its way into offshore waters. Nonetheless, it is unlikely that the impact of such human activities can generate levels of turbidity that approach those associated with the wave energies of severe storms. In particular, the soil of upland areas is such a meager resource that it can contribute little to such processes. Some inwash from terrestrial areas, especially from Florida Bay, has always occurred naturally, and severe weather can similarly increase siltation regimes, but the location of the Keys' living coral reefs represents an accomodation to these influences that has been reached through geologic time. Changes in the rate of sediment generation and release into offshore waters may upset an equilibrium that will not be reestablished for centuries.

Upland development also indirectly generates sediments that can damage reefs. Clearing of terrestrial habitats directly exposes soil to the actions of wind and water, whereas an anastomosing network of roots holds soil in place in unaltered habitats. Ultimately, most lost sediment will find its way into offshore waters.

An associated problem is the concommitant loss to coral reefs of nutrients that promote eutrophication in all aquatic systems. This process, which is exacerbated by nutrient release from septic tanks, promotes "blooms" of microorganisms that can cloud the water and reduce light penetration for days at a time. The devastating effects of these processes have been documented for Hawaiian reef systems (Banner, unpubl. ms.) where there occurred a decimation of reef biota. State and County regulatory legislation now exists to prevent or mitigate many of the aforementioned environmental damage.

In addition to such indirect damage caused by modifications in the physical environment, direct damage constitutes a major problem to Keys coral reefs. The increased presence of humans in these areas resulting from tourism and Keys population growth has impacted these systems in several unfortunate ways. Because coral growth is so extremely low, any direct damage to the reef infrastructure may be viewed as simipermanent. Corals broken by collectors and ship anchors or ship hulls, for instance, represent aspects of this problem that have been worsened by the high level of human presence here. The potential for extensive physical damage was realized earlier in 1984 when a commercial vessel became grounded on a Keys reef system. Extensive breakage of the reef structure was caused by both the impact of the vessel's hull and its chain and anchor, as well as those of rescue vessels, during attempts to free it. Physical damage may result as well from natural forces such as high wind and associated waves (Glynn, et al., 1964). Selective removal of fish (by spearfishing) and mollusc shells can also produce changes in reef trophic structure.

Oil spills may also adversely affect coral reefs. Laboratory studies have shown that floating oil can disrupt the normal feeding and cleaning activities of corals (Reimer, 1975), and physical contact for more than a few hours causes tissue death (Bak & Elgershuizen, 1976). The ability of corals to recolonize after disruption is greatly reduced by such exposure (Fishelson, 1973) and coral growth rate is reduced by short-term exposure (Birkeland, et al., 1976). Diaz-Pifferer (1962) noted that corals in oil spill areas showed a "bleached" appearance. In other areas of such coral discoloration, the cause has been found to be the loss of the symbiotic zooxanthellae that are so critical to coral metabolism and growth.

(3) THE SEAGRASS ECOSYSTEM

A. Introduction.

The seagrass community is a highly productive, faunally rich system that covers a larger area than any other ecosystem in Monroe County. Seagrass "meadows" provide abundant food and shelter for a myriad specis of fish, sea turtles, and invertebrates and thus probably represent the richest nursery and feeding grounds in South Florida's coastal waterways. Because many commercially important species depend on this system at some point during their life cycle, the continued health of seagrass meadows is critical to the long-term economic wellbeing of the Monroe County community.

While mangroves and coral reefs rarely abut, vast seagrass beds freely intermingle with both systems and bridge the areas between these divergent systems. As transitional habitats, they are important to many species of both adjacent ecosystems either seasonally, as a nursery area, or for regular nocturnal feeding (as in snappers and grunts). In addition to representing a primary resource for grazers, seagrasses provide vast amounts of energy via detritus which may cycle internally or be exported to mangrove or coral reef communities.

Seagrass meadows also are important in stabilizing sediments that woudl otherwise exist as shifting sand and mud. As such, they represent a critical element in preventing or at least regarding the loss of continental materials that would otherwise be lost by erosion to the ocean's depth.

To fully appreciate the functional importance of seagrass communities one must recognize the huge extent of their geographical range in southern Florida. Of the 10,000 Km2 (3,860 mi2) of seagrass in the Gulf of Mexico, over 8,500 Km2 (3,280 mi2) are in Florida waters, primarily in Monroe County (Zieman, 1982). Seagrasses cover over 80% of the sea floor in an area bounded by Cape Sable, north Biscayne Bay and the Dry Tortugas, an area of over 5,500 Km (2,120 mi) (Zieman, 1982). In an inventory of the estauries of Florida's Gulf Coast, McNulty et al. (1972) estimated that almost half of the region of Florida Bay west of the Keys and landward to the freshwater line to Cape Sable was submerged vegetation. By comparison, less than 7% of the area consisted of mangroves.

B. Biota.

Worldwide, there are approximately 45 species of seagrasses. In Monroe County, there are six species representing 4 genera and 2 families (See Table 1) While these comprise a small percentage of the hundreds of plant and animal species found in seagrass communities, they are clearly the most important forms because the other inhabitants depend, in some way, upon the presence of these seagrass species.

Turtle Grass (Thalassia testudinum) is the most robust and widespread of the seagrasses, forming extensive meadows throughout its range. Manatee Grass (Syringodium filiforne) is more surficially rooted than Turtle Grass and rarely forms extensive meadows occurring most commonly mixed with other species of in small dense monospecific patches. Shoal Grass (Halodule wrightii) is found primarily in disturbed areas that are devoid of Turtle Grass or Manatee Grass and is an important early colonizer of such sites. Overall, it is the most eurycious of the principal seagrass species in that it thrives in waters too shallow or too deep for the other species and is the most tolerant of all species to variations in temperature and salinity (Zieman, 1982). The three species of Halophila are small forms that are sparsely distributed in seagrass communities, seldom comprising an important trophic component.

All other plant species of seagrass communities are of considerably less trophic consequence. Only a few types of algae are capable of colonizing the bottom sediments, notably members of the genera Halimeda, Penicillus, Caulerpa, Rhipocephalus, and Udotea. Still other species of algae attach directly to the leaves of seagrasses.

TABLE 1

SEAGRASSES OF MONROE COUNTY (After Zieman, 1982)

Family and Species	Common Name
Hydrocharitaceae	
Thalassia testuctinum	Turtle Grass
Halophila decipiens	
Halophila engelmanni	
Halophila johnsonii	
Potamogtonacea	
Syringodium filiforne	Manatee Grass
Halodule wrightii	Shoal Grass

The successional sequence which generates a seagrass climax has been documented (Zieman, 1982) in "blowout" areas. These denuded areas may originate as a result of a sea urchin overgrazing, a large anchor dragging or a major storm. The initial scar is enlarged by water flow into a bare crescentic surface up to 10 meters wide. Pioneer colonizers of this unconsolidated surface are rhizophytic algae, especially species of Halimeda and Penicillus. Because their sediment-binding capacility is limited to their rhizoidal base, they never affect an area greater than a few centimeters away, but produce small consolidated sediment balls (Williams, 1981). After this initial sediment consolidation, a succession of seagrasses colonize the blowout surface. The first is Shoal Grass. In some sequences, Manatee Grass will next appear: it may be mixed with Shoal Grass at one edge and Turtle Grass (from undisturbed colony) at the other. However, Manatee Grass is the least constant member of this sequence and is frequently absent altogether. Thereafter, Turtle Grass colonizes the area and the climax is restored. The time required for recovery will vary depending on the size of the disturbance, wave intensity, and other factors but in Barbados, blowout restabilization took 5 to 15 years (Patriquin, 1975).

A large invertebrate fauna inhabits seagrass ecosystems. Conspicuous among epibenthic forms are the Queen Conch (Strombus gigas), the Spiny Lobster (Panulirus argus), the Bahamiam Starfish (Oreaster reticulata), and numerous sea urchins, most notable Lytechinus variegatus and Tripneustes ventricosus. Numerous epiphytic invertebrates glean a livelihood from seagrass areas by preying on the algae that grow on the leaves of seagrasses. Principal among these are a variety of gastropods (notably Cerithium mascarum, C. eburnum, Anachis sp., Astrea spp., Modulus modulus, Mitrella lunata and Bittium varium) and small crustanceans (especially Cymadusa coompta, Gammarus mucronatus, Melita nitida, Grandidierella bonnieroides, Palaemonetes pugio, P. vulgasis, P. intemedius, and Periclimenes longicaudus). Many invertebrates including the Pine Shrimp (Penaeus duorarum) and the Spiny Lobster utilize seagrass meadows for nurseries.

Diverse and abundant fish faunas also inhabitat seagrass communities. While few, if any, of the many permanent residents forms are of direct commercial value, these ecosystems are important nurseries and feeding areas for such species. These include the Sea Bream (Archosargus rhomboides), the Sheepshead (A. probatocephalus), the Gap Grouper (Mycteroperca microlepis), and the Redfish (Scriaerops oscellata). Other fish that extensively utilize seagrasses as nursery areas are:

Pinfish, Lagodon rhomboides
Spotted Seatrout, Cynoscion nebulosus
Spot, Leiostomus xanthurus
Silver Perch, Bairdiella chrysura
Pigfish, Orthopristi chrysoptera
White Grunt, Haemulon plumeri
Ocean Sturgeon, Acanthurus bahianus
Doctorfish, Acanthurus chirurgus
Spotted Goatfish, Pseudupeneus maculatus
Yellow Goatfish, Mulloidicthys martinicus
Gray Snapper, Lutjanus griseus
Lane Snapper, Lutjanus Synagris
Mutton Snapper, Lutjanus Analis
Dog Snapper, Lutjanus jocu
Yellowtail Snapper, Ocyurus chrysurus
Bucktooth Parrotfish, Sparisoma radians

Redtail Parrotfish, _S. chrysopterum_
Stoplight Parrotfish, _S. viride_
Redfin Parrotfish, _S. rubripine_
Striped Parrotfish, _Scarus croicensis_
Rainbow Parrotfish, _S. guacamaia_
Midnight Parrotfish, _S. coeruleus_
Emerald Parrotfish, _Nicholsina usta_

In areas where seagrass meadows abut coral reefs, many prominent species of reef fish move into seagrass areas to feed at night. Principal among them are members of the families Pomadasyidae, Lutjanidae, and Holocentridae.

The only reptile to whom seagrass constitutes a principal feeding habitat is the Green Sea Turtle (_Chelonia mydas_). Human predation has reduced _Chelonia_ populations to a level estimated at between .1% and 1% of their pre-Columbian abundance and have brought them to the verge of extinction. Presently, it is classified as a federal endangered species. Thus it is critical that all habitat critical to their survival, including seagrass meadows, be afforded protection from degradation.

Large numbers of birds are known to feed extensively in shallow seagrass meadows including the endangered (Federal Status) Brown Pelican, _Pelecanus occidentalis_. These are listed in Table 2.

Two aquatic mammals known to commonly utilize seagrass communities are the Caribbean Manatee (_Trichechus manatus_) and the Bottlenose Dolphin (_Tursiops truncatus_). While Bottlenose Dolphins are common in South Florida waters generally, they are not especially common in shallow seagrass meadows (such as in Florida Bay) because the extreme shallowness precludes swimming for such a large mammal. Caribbean Manatees are an exceedingly rare form whose low total population has resulted in their designation as an endangered species. Formerly the range of the Caribbean Manatee was considerably greater but the population now seems to be centered around the protected regions of Everglades National Park. A survey of the Everglades' Caribbean Manatee population by Odell (1976) found a total of 772 individuals; 46% were sighted in Whitewater Bay, 20% in the Gulf of Mexico, 23% in inland waters, and only 1% in Florida Bay. A later study (Odell, 1979) reported no sightings in Biscayne Bay.

TABLE 2

BIRDS THAT USE SEAGRASS FLATS IN SOUTH FLORIDA

(After Zieman, 1982)

Common Name	Species Name	Preferred Feeding Tide
Waders-primary:		
Great Blue Heron	Ardea herodias	Low
Great White Heron	A. herodias	Low
Great Egret	Casmerodius albus	Low
Reddish Egret	Egretta rufescens	Low
Waders-secondary:		
Louisiana Heron	E. tricolor	Low
Little Blue Heron	E. caerulea	Low
Roseate Spoonbill	Ajaia ajaja	Low
Willet	Catoptrophorus semipalmatus	Low
Swimmers:		
Double-crested Cormorant	Phalacrocorax auritus	High
White Pelican (winter only)	Pelecanus erythrorhynchos	High
Crested Grebe (winter)		
Red-breasted Merganser (winter)	Mergus serrator	
Flyers-plungers:		
Osprey	Pandion haliaetus	High
Bald Eagle	Haliaeetus leucocephalus	High
Brown Pelican	Pelecanus occidentalis	High

C. Disturbances.

The principal naturally occurring damage to seagrass communities results as a consequence of the tense wave action brought by hurricanes. The successional colonization of the resulting "blowouts" may require a decade or more as was discussed previously.

The greatest amount of direct damage to seagrass communities has come as a result of dredge-and-fill operations. Filled areas, of course, become the sites of developed features and cease to function as natural systems. But dredged areas as well are severely damaged by the change in sediment characteristics making them unsuitable for seagrass recolonization for long periods (Sieman, 1975). The indirect adverse effects of such activities include increased turbidity and depletion of dissolved oxygen. The former reduces light penetration and thereby restricts productivity of surrounding systems and congests the feeding apparatus of filter feeding animals. Oxygen depletion, a consequence of the oxidation of suspended organic materials, makes the system less hopitable to allaerobic organisms. Because dredged sediments are unconsolidated and easily suspended, the banks of fill areas can represent source areas for such turbidity for long periods. The ultimate ecological consequence of such activities is the destabilization and impoverishment of the affected ecosystems and significant economic loss for fisheries and recreation industries (Taylor and Soloman, 1968).

Zieman (1976) considers cuts from boat propellers to be the most common type of disturbance of South Florida's seagrass beds. Typically, 2 to 5 years are required for recolonization of such areas in turtle grass beds.

Eutrophication of seagrass communities may occur through the addition of nutrients from sewage or industrial wastes. The profusion of algal growth fostered by such enrichment increases turbidity and thereby reduces the photosynthetic efficiency of seagrasses. Further, the increased deposition of dead organic matter (algae, seagrass leaves) reduces the concentration of dissolved oxygen on the sea floor and thereby adversely affects the seagrass rhizones. In some cases (Taylor et al., 1973; McNulty, 1970) seagrass populations are severely reduced or eliminated by these processes.

Other documented declines in seagrass populations have been caused by oil spills (Zieman, 1982) and thermal pollution from power generating facilities (Zieman and Wood, 1975).

(4) MANGROVES

A. Introduction

Mangroves and the mangrove community have long been of special interest to naturalists and scientists. Literature on mangroves dates back to Theophrastus (305 B.C.), Plutarch (A.D. 70), Pliny (A.D. 77) and Arrian (A.D. 136). A significant body of literature, describing mangroves throughout the world, has accumulated since this early period. Recent research has involved efforts by numerous scientists of disciplines ranging from ecology and biogeography to molecular biology and microbiology. Comprehensive reviews of this work have been published by Lugo and Snedaker (1974) and by Odum et al (1982).

The more recent research has been directed towards determining the functional role of the mangrove community in marine ecosystems. This effort, in part, is a response to development pressures which have resulted in the elimination or degradation of many thousands of acres of Florida's wetlands. Consequently, a large and accessible data base is now available for use in land planning and resource management decisions.

B. Biota

The "mangrove community" is composed of a diverse association of salt tolerant plants that provide food and habitat for a characteristic fauna. The major environmental conditions that characterize this system are:

1. Loose, wet, saline soils.
2. Periodic tidal submergence.
3. Occasional tropical storms and/or hurricanes.
4. Low energy wave and current regimes.

The dominants of this association are the mangroves of which, in South Florida, there are three species. Red Mangrove (*Rhizophora mangle*) has characterisitc stilt, prop and aerial roots and bears the cigar-shaped, viviparous seedlings. Black Mangrove (*Avicennia germinans*) has "pneumatophore" breathing roots and gray-green leaves encrusted with excreted salts. White Mangrove (*Laguncularia racemosa*) has rounded leaves with a pair of salt glands on the petiole. The Buttonwood (*Conocarpus erectus*) is often associated with the mangroves but is not a dominant. It occurs more frequently in what is termed the "transitional zone" which lies on slightly higher ground between the mangroves and upland systems. Other plants commonly associated with the mangroves include a number of fleshy halophytes, e.g. Saltwort (*Batis maritima*), Glasswort (*Salicornia virginica*), etc.

In Florida, the Black Mangrove enjoys the most widespread distribution, ranging from St. John's County on the east coast and along the entire Gulf coast. Red and white Mangroves are less widely distributed; they range from Cedar Key on the west coast to north of the Ponce de Leon Inlet (Volusia County) on the east coast. The distributional range of Buttonwood is similar to that of the White and Red Mangroves. At the limit of their respective ranges, these plants do not form the type of dense association as is typical of the South Florida populations, but occur as scattered small trees. In some areas the mangrove association is replaced by Juncus or Spartina marshes.

According to Odum et al (1982), the four major factors that limit the distribution of mangroves and determine the extent of mangrove ecosystem development are 1) climate, 2) salt water 3) tidal fluctuation and 4) substrate. Odum cites work which shows that mangroves do not develop where the annual average temperature is below 66 degrees F or where water temperatures exceed the 107-113 degree F range. Contrary to popular belief, mangroves do not require salt water but are "facultative halophytes", i.e. they do not develop in freshwater environments only because they are not able to successfully compete with other plants.

Although tidal flow is not an essential for mangroves, it benefits them by carrying nutrients into the system, preventing excessive salt loading of soils and dispersing their propagules. According to both Odum et al. (1982) and Davis (1940), mangroves grow best in depositional envrionments with low wave energy since high wave energies prevent establishment of propagules, stress the root system and prevent accumulation of fine sediments. Wrack accumulations also tend to smother propagules and prevent their establishment.

The historically accepted pattern of mangrove zonation was initially described by Davis (1940). The seaward zone of the intertidal area is dominated by Red Mangroves occurring as a pure stand. Moving landward, Black and White Mangroves mix with the Reds in varying proportions and, on the higher ground, Buttonwood increases in frequency. This zonation scheme was also accepted as the successional sequence leading to the climax forest, the tropical hardwood hammock, with each zone equivalent to a seral stage. More recently, ecologists (Odum et al., 1982; Ball, 1980) have disputed this hypothesis and suggest these zonation patterns appear to result from the differential influence of physical factors on the competitive abilities of the mangrove species.

Lugo and Snedaker (1974) have classified mangrove systems into six types based upon their physical structure. The five that occur in the Florida Keys are overwash forest, fringe forest, riverine forest, basin forest, and scrub or dwarf forest.

Overwash forests are found on small keys or peninsulas. In many cases overwash forest is the only community which occurs on a small island. These forests are regularly overwashed by tides and often contain no land which rises above mean high water. All three mangrove species may be present, but Red Mangroves are usually the dominant form with canopy height ranging from 20 to 25 feet. Because of the regular tide sheet overflow, litter dows not accumulate and organic export rates are high. These are the preferred roosting and nesting areas for a number of birds since they are isolated from most predators of eggs and young, e.g. rats, raccoons and feral cats.

Along low energy shorelines mangroves form fring forests of variable width and canopy height ranging from 20-30 feet. The zonation pattern of fringe forests closely approximately the classical scheme. Low tide and current velocities allow for colonization by these trees and for the import and subsequent accumulation of sediments. The prop roots of Red Mangrove and the pneumatophores of Black Mangrove are particularly effective in sediment accumulation. Fringing forests which face open bodies of water to the north accumulative vast amounts of detritus, much of which is generated by the productive, nearshore seagrass communities. The rich, organic sediments, which accumulate within the fringe forest, are often strongly anaerobic. In these soils, Black Mangroves tend to dominate probably because their pneumatophores or air roots allow access by underground portions of the tree to atmospheric grases. These root systems enable mangroves to withstand the wind and wave energies of tropical storms and provide substrate for marine algae and invertebrates and sanctuary for small fish. In fringe forests, population of succulent, salt tolerant plants often form a dense ground cover. The two most common species are Saltwort and Glasswort (<u>Salicornia spp.</u>). Here, the soil is elevated above mean sea level so that these plants are only wetted by high tides. The soils are often a mixture of organic sediments and coarse, calcareous sand. The trees are usually medium to large and widely spaces; there is no mid-story . There is apparently enough light on the forest floor to support the prolific growth of these succulents. This dense association of low-growing plants, in combination with pneumatophores of the Black Mangroves, acts to entrap sediments and litter, thus accelerating the elevation of this zone above the influence of the tide. In this case, one can perceive the future succession to an upland seral stage. This association has recently been recognized as habitat for the endangered (Florida) Silver Rice Rat (<u>Oryzomys argentatus</u>).

The best developed riverine forests occur along creeks and rivers on the mainland. In the Keys, this forest occurs only along tidal creeks. All three species of mangroves may occur, but the dominant form is usually Red Mangrove. On the mainland, this forest contains the largest trees of all the forest types, with canopy heights in excess of 60 feet but in the Keys, the structure is similar to that of the fringe forest. High rates of productivity and nutrient export are attributable to the daily tidal flushing. Mangroves growing along tidal creeks are well protected from storms and other external influences.

Basin forests also are not well represented in the Keys. On South Peninsular Florida, these forests occur inland along drainage depressions where upland runoff is channeled toward the coast. In the Keys, they are where large,shallow depressions in the caprock fosters the accumulation of soil and channelize tidal flow. Forest structure is similar to overwash forests but the Red Mangrove does not dominate the system to the same extent. Black and White Mangroves occur with greater frequency with increasing soil elevations and diminishing tidal influence.

Scrub or dwarf forest are best developed in the Lower Keys. These communities fail to achieve the tree size and productivity characteristic of the other forest types. Both the scrub and dwarf (known locally as "spider" mangroves) associations are characterized by small trees with an understory of scattered, salt tolerant shrubs, herbs and graminoids. The scrub community generally contains all three species of mangrove but is usually dominated by Black. The trees are widely spaced and often appear stunted; dwarf mangrove associations contain trees less than five feet in height with less distance between trees than in scrub forest. These small trees, usually Red Mangroves, are not juveniles but rather dwarfed forms of this species. Both the scrub and dwarf forests occur in intertidal areas which do not enjoy daily tidal flushing. Dwarf mangroves appear to occur on slightly lower elevations than scrub mangroves.

In many areas of the Lower Keys, where the forests occur, e.g. Sugarloaf, Saddlebunch, and Torch Keys, the oolitic caprock is emergent, providing limited opportunity for soil accumulation. Where soils do occur, they are characteristically thin, saline marls within shallow caprock depressions. Due to lack of regular tidal flushing, soils often become hypersaline during the dry season and dilute during the wet season. Moreover, propagules are less likely to reach these areas since they are dispersed by tide. All of these factors make it difficult for mangroves to colonize and survive in these areas, and a number of researchers believe that the scrub and dwarf forests may also be nutrient limited.

In some rocky, intertidal areas conditions are so severe as to preclude the growth of woody plants. Where soils are thin and hypersaline and tidal impacts minimal, salt marshes or salt flats represent the dominant community. These associations are vegetated by salt tolerant graminoids, shrubs and fleshy succulents. There is usually a mangrove fringe forest waterward of the marsh.

In striking contrast to the scrub and dwarf forests, there occur, within these infrequently flooded areas, occasional small strands of very large Black Mangroves. These isolated pockets are reminscent of cypress domes of bay heads in the Big Cypress Swamp and Everglades. These trees appear to flourish because they are growing within deep solution depressions in the caprock. These sinkhole-like formations accumulate substantial amounts of organic soil or peat and are thus able to retain moisture throughout the year. Although they receive tidal input with the same frequency as the adjacent scrub community, the soil conditions support much higher levels of productivity and tree growth. The fact that these stands are dominated by Black Mangroves may be indicative of anaerobic and saline soil.

Similar, although smaller, solution formations in this zone support stands of Red Mangrove larger than those scrub forms on the adjacent higher grounds. These shallow depressions also accumulate organic soils and thus retain soil moisture better than the thin, marl soils that cover the caprock of the scrub zone.

The importance of mangrove systems both to man and to other natural communities cannot be underestimated. Although the research that has documented this fact has been, for the most part, conducted outside of the Florida Keys, it would certainly be reasonably to extrapolate some of these values to the mangrove systems of this area. Mangroves protect shorelines from erosional damage by tropical storms and hurricanes. This not only protects upland systems but also human communities. Riverine, frining and overwash forests act as "nursery areas" for a variety of finfish and invertebrates. Many of these are of economic importance to the commercial and sport fishing industries of the Keys as well as to the tourist economy. These forests provide both food and sanctuary from predators for larvae and juveniles. Mangroves accelerate the deposition and stablization of particulate sediments thereby maintaining water clarify in adjacent open waters and enhance the ability of marine filter feeding organisms to obtain food by lowering the energy output required to filter out inedible particulates. Marine seagrasses and algae can photosynthesize more efficiently in clear water and snorkelers and divers enjoy a better recreational experience.

A number of food webs are based on primary production of the mangroves and their associated epiflora. Energy flows stemming from mangrove-derived carbon begin their movement through these food webs as detritus or as the products of direct grazing. Other pathways involve bacteria, fungi, macroalgai and phytoplankton associated with mangroves. This energy is often transferred to the human community by the tourist, sport and commercial fishing industries.

Mangroves also provide feeding, nesting and roosting habitat for numerous wading and fishing birds. Not only is the intrinsic value of this avifauna inestimable, but it augments tourism. Further, mangrove forests accumulate various nutrients and pollutants derived from upland sources. Nutrients are converted to plant biomass and exported in particulate or dissolved form. An undetermined portion may be tied up in the sediments or within the living community. Thus, mangrove systems act as natural filters, cycling some nutrients through the environment and storing othes.

Mangrove-dependent Keys reptiles and mammals with "special status" include:

American Crocodile	Crocodylus acutus
Mangrove Terrapin	Malaclemys terrapin rhizophorarum
Key Deer	Odocoileus virginianus clavium
Silver Rice Rat	Oryzomys argentatus
Key's Raccoon	Procyon lotor auspicatus

C. Impacts

Adverse human impacts upon mangrove systems in the Keys have been widespread and destructive. Ever since the period of early colonization of the archipelago by European settlers, mangrove areas have been perceived as pestilential, mosquito-breeding swamps which represented a barrier to settlement. Moreover, fringing mangrove forests are located on those portions of the Keys which are most valuable as homesites--open, breezy, waterfront locations. Thus, the history of development in the Keys has been one of dredge and fill in mangrove areas. These activities by developers clear waterfront lots and provide navigational access via dredged channels. The fill is utilized to elevate lots above tidal influence and to create access roads. These activities totally destroy mangrove forests.

The construction or roads in and adjacent to mangrove areas has both direct and indirect impacts upon the coastal ecosystem. Clearing and filling of roadways devastates the on-site community while impoundment may isolate tidal wetlands from tidal sheet flow, drastically altering the physio-chemical character of their enviornment. Salinity regimes change, nutrient exchange is blocked, export of organic is prevented and fish and invertebrates lose their avenues of access to the sea. The long term results of impoundment include: 1) loss of biotic divesity; 2) diminished wetlands productivity; 3) loss of wildlife habitat; and 4) diminished secondary productivity of nearshore marine systems. In cases where roads do not toally impound wetlands, these adverse impacts do not occur until a storm washes huge quantities of seawater into the impoundment and man-made constraints on flushing prevent the release of this stormwater back to sea. Subsequent evaporation of the freshwater component leaves the impoundment with a hypersaline condition resulting in death of some populations.

Hurricanes are the greatest impact of any natural force on all of the Keys' terrestrial communities. Severe storms may completely destroy a mangrove community and, in some cases, (Craighead, 1971), the subsequent successional sequence may generate a different community type.

The effects of human settlement adjacent to mangrove areas is most profound on wildlife populations. Birds, such as White-crowned Pigeons, are easiliy disturbed by human activity and will not nest near urbanized areas. Secondary impacts include predation on wildlife, such as lizards and birds, by domestic animals (i.e. cats and chickens), molestation of wildlife by dogs, attraction of edificarian species, such as Black and Norway Rats (which feed on nesting birds), and introduction of exotic plants, such as Brazilian Pepper.

Trimming of mangroves to increase breeze, improve views or eliminate mosquitos is a common practice in the Keys. This diminishes primary productivity, eliminates bird habitat and changes air flows in the immediately upland natural community. This last effect may negatively impact hardwood hammocks by allowing salt spray and drying winds into a forest which is very sensitive to moisture and salt.

(5) TRANSITIONAL HABITATS

In the Florida Keys, the term "zone of transition" is that area which generally lies landward of the mangrove fringe and seaward of an upland community not normally influenced by tides. Within this zone, two basic types of communities are recognized, the salt marshes are transitional wetlands and the buttonwood (Conocarpus erectus) are transitional upland communities. The transitional wetland communities include all tidaly influenced wetlands that are not dominated by large, fringing mangroves or areas of "spider mangroves". The transitional uplands or buttonwood zones include the shrub community between the salt marsh zones and the higher upland habitats such as hammocks and pinelands which are not influenced by tides, not dominated by large, fringing mangroves or areas of "spider mangrove" and the buttonwood-hardwood transition."

In transitional habitats several of the most important environmental factors that control species distribution occur along a gradient or "cline". These are functions of tidal influence and are linearly related to distance from mean high water. They include a) duration of submergence, b) duration of exposure, and c) frequency of submergence. Thus, the position of an individual plant or invertebrate population within the transitional zone is an adaptive response to this complex of environmental gradients. In the case of animal populations, the availability of food and cover also influence distribution.

The Florida Keys experience mixed, semidiurnal tides of low amplitude (3 feet), with two unequal high and low tides each tidal day. Because of the low amplitude of Keys' tides, the inundation of the transition zone may be affected by several other factors including wind direction and velocity as well as shoreline exposure and slope. Microrelief is another determinant of vegetation patterns in the transitional zone since areas of exposed caprock do not accumulate soils as do shallow, eroded depressions in the rock. These depressions may be acres in size or only large enough to support a single plant. Elevation of the substrate, and thus drainage patterns, may also affect large or very small areas. The resulting vegetation pattern in Keys' transitional zone is a "mosaic" of plant populations.

Biota

Organisms living in the seaward portion of the transition zone are subject to tidal inundation more frequently and of longer duration than those higher up. A species' response to the ratio of submergence/exposure and the salinity regime of its habitat may be morphological, physiological or, in the case of animal populations, behavioral. Some plants, for example, have glands which excrete the salts which enter through the roots, whereas others become succulent thereby diluting the salts. Saltgrass (Distichlis spicata), an exceptionally widespread component of coastal marshes, is extremely salt tolerant and has a fast-growing rhizome system which allows it to colonize and respond to substrate fluctuations rapidly. Crustaceans, such as fiddler crabs (Uca sp.) and molluscs, such as the peanut snail (Cerion sp.), move vertically with the tide.

Tidal marshes are among the world's most productive ecosystems. Southern marshes may annually produce up to ten tons of marsh grass per acre whereas Northeastern U.S. marshes produce biomass in the range of 3 to 7 tons (Niering and Warren, in Clark, 1977). Much of this plant production becomes available as organic detritus which provides the chief food base for the coastal fish and shell-fish populations of commercial importance (Darnell, 1976). Coastal marshes further provide food, shelter and nesting sites for numerous species of waterfowl and wading birds and habitat for a variety of small mammals and reptiles. Marshes act as nutrient traps and pollution filters thereby maintaining high water quality in nearshore waters. Marsh systems also slow down runoff and trap particulates which would otherwise reduce offshore water clarity and create stress for marine filter feeders as well as for large predators.

The transitional habitats of the Keys contain species representative of the adjacent plant communities. Salt marshes and Buttonwood scrub forests are distinguished from adjacent mangrove and upland hammock associations because the "dominant" elements differ from the latter in terms of "frequency of occurrence" and/or coverage. Although Buttonwood occurs quite often in both mangrove and low hammocks, it is not the dominant element. Buttonwood, especially the larger trees, occurs on ground which is slightly higher than that of the fringing mangrove community. Buttonwood scrub usually occurs as an open stand with an understory of salt tolerant succulents and small shrubs, e.g. Saltwort (Batis martima), Sea Daisy (Borrichia frutescens) and Dropseed (Sporobolus virginicus). Upland, the Buttonwood association grades into low hammock, where it also occurs with some frequency, but is not dominant. Olmstead, et al (1981) point out that in the coastal area of Everglades National Park, between Flamingo and Joe Bay, Buttonwood stands and hammocks intergrade and it is difficult to delineate between them.

Salt marshes, distinguished from adjacent associations by their low stature and lack of woody vegetation, are dominated by salt tolerant herbs, shrubs and grasses. Howard's (1950) description of the "salicornia tidal flats" of Bimini closely approximates that of Keys' salt marshes. These marshes are often found in association with areas of bare ground known as "barrens" that are devoid of macrophytic vegetation and commonly contain only mats of periphyton. Davis (1940) believes that these zones of virtually bare ground are shallow depressions in the substrate wherein high salinities (80 ppt) eliminate plant life. There is little question that Keys' salt marshes are a transitional community wherein soils display highly variable levels of salinity.

The type of transitional association that develops in the Keys is a result of the primary interaction between tide and topography. In the middle and upper Keys, there is a relatively steep slope to the high ground which is elevated above normal tidal influence. In these areas, a hammock is often found within a short distance from the high water mark. On the Florida Bay side of Vaca and Fat Deer Keys, for instance, there is a narrow, rocky, intertidal zone with scattered mangrove, Buttonwood, herbs and grasses which grades into a zone of small shrubs and trees which tolerate sea spray. This "thorn scrub" or "low hammock" protects the upland hammock. On the ocean side of Key Largo, the slope of the intertidal is not as great and one finds a wider zone of transitional, salt tolerant vegetation landward of the mangroves.

In the lower Keys, where the pitch of the intertidal zone is slight, one finds the broadest expanse of transitional zones. On Sugarloaf, Cudjoe, Big Torch, Little Torch, and on a number of other islands, transitional zones occupy areas hundreds of feet in width. On these keys, much of the eroded, oolitic caprock is exposed, creating a "karst-like" substrate with disjunct, shallow depressions containing marl soils. The majority of these areas is wetted only by the highest normal tides and by storm tides.

In the most seaward subzone of these broad, rocky transitional areas, one usually finds "scrub mangrove" communities dominated by small Red and Black Mangroves with an understory of Glasswort (Salicornia spp.). Salt Grass (Distichilis spicata), Key Grass (Monanthochloe littoralis) and Sea Daisy (Borrichia frutescens). Moving upland, there is a change to a more diverse plant community with fewer mangroves. Depending on drainage and soil, this association can be either the Buttonwood scrub association or the salt marsh.

Some salt marshes are mixtures of fleshy halophytes including glasswort (Salicornia virginica and S. bioelovii), Purslane (Sesuvium portulacastrum) and Saltwort with occasional Sea Daisy and small mangrove. Other marshes are dominated by grasses including Salt Grass, Key Grass, Dropseed and occasional (Fimbristylis castanea), Sea Daisy, Saltwort, Buttonwood and small mangrove. These graminoids and herbs occur as small, disjunct populations forming a mosaic.. In some cases a single population will occupy an area of about a half acre, whereas in others, the same species might be represented by only a few individuals. This distributional pattern is probably a function of the area's microrelief which determines drainage and soil salinity.

On slightly higher ground, on Sugarloaf, Big Pine, Water, Crab and several other keys, pure stands of Chestnut Sedge or Cordgrass occur. These areas are somewhat reminiscent of the marshes of the middle Atlantic coast, but on a much smaller scale.

The most landward subzone generally contains the most diverse flora because of its proximity to the upland hammock forest. Here Buttonwood becomes abundant, generally associated with an understory of Sea Daisy, Dropseed, Sea Oxeye (Borrichia arborescens), Cordgrass, Chestnut Sedge, Christmas Berry (Lycium carolinanum) and other small shrubs, herbs and graminoids. The open aspect of this association resulting from the widespread branching habit of the Buttonwoods allows much sunlight into the lower story and generates abundant vegetation beneath these trees in areas with adequate soil accumulations. A frequent epiphyte on these trees is the bromeliad Tillandsia circinnata which actually requires high exposure and is very resistant to desiccation. The yellow-flowered Wild Allamanda (Urechites lutea) and White-flowered Rubber Vine (Rhabdadenia biflora) are also often found on Buttonwoods in this association.

Moving upland the transitional uplands grade into hammock with its dense association of trees and shrubs, closed canopy, vertical structure and absence of graminoids and fleshy halophytes. The landward extent of the tides is marked by the accumulation of litter on the forest floor which generally corresponds to the hammock boundary. Often, there are small islets of low hammock within the transitional zone vegetated by small, salt tolerant trees and shrubs, e.g. Joewood (Jacquinia keyensis), Wild Dilly (Manilkara bahamensis), mayten (Maytenus phyllanthoides), Black Torch (Erithalis fruticosa), Saffron Plum (Blumelia celastrina), and Poisonwood (Metopium toxiferum). These plants are common elements of the low hammock association.

Plants occurring in transitional zone that have been categorized by state and/or federal agencies as endangered or threatened include:

Golden Leather Fern	Acrostichum avieum
Leather Fern	Acrostichum danaeifolium
Geiger Tree	Cordia sebestena
Dollar Orchid	Encyclia boothiana
Butterfly Orchid	Encyclia tempensis
Joeweed	Jacquinia Kenensis
Pride of Big Pine	Strumpfia maritimn
Bay Cedar	Suriana maritima
Twisted Airplant	Tillandsia circinata
Banded Wild Pine Airplant	Tillandsia utriculata
Worm Vine Orchard	Vanilla barbellatus

While not presently so designated, the Tamarindillo (Acacia choriophylla) should similarly be afforded endangered status in the Keys as its population is comprised of a single mature specimen and several seedlings in a transitional wetland on Sugarloaf Key.

The transitional zone support a fauna somewhat different from that of the mangrove systems but there are a number of animals that feed in both tidal areas. The most frequently observed invertebrates are various species of insects, molluscs and crustanceans. Of the latter, the fiddler crab (Uca spp). is often found in the salt marshes and barrens where there is adequate woil for burrowing. The white peanut snail (Cerion spp.) is often found in large numbers on the marsh floor or climbing through the low-lying vegetation, and Ram's horn snails, and the gastropods Cerithidea and Melampus are also very common in the marsh. The herpetofauna of Keys transitional wetlands include:

Green Anole	Anolis carolinensis
Key West Anole	Anolis sagrei stejnegeri
Six-lined Racerunner	Cnemidophorous s. sexlineatus
Black Racer	Coluber constrictor
Diamondback Rattlesnake	Crotalus adamanteus
Cuban Treefrog	Hyla septentroinalis
Rough (Keeled) Green Snake	Opheodrys aestivus

A number of mammals utilize transitional wetlands as habitat. The endangered Key deer (Odocoileus virginianus clavium), and the endemic Key Vaca Raccoon (Procyon lotor auspicatus), listed as threatened by the state, feed in salt marshes and Buttonwood scrub. The habitat of the recently described (Spitzer and Lazall, 1978) Silver Rice Rat (Oryzomys argentatus, state endangered) has been redefined to include the low intertidal zone, salt marshes, and the Buttonwood transitional community (Spitzer, unpublished M.S.). Results obtained from Spitzer's recent (1984) trapping studies indicate that this rodent forages and nests in transitional wetlands, as does the endemic Keys' marsh rabbit, Sylvilagus palustris Lefner (Lazell, 1984).

The importance of Keys' wetlands to wading bird populations has long been recognized by wildlife biologists. Virtually every wading bird species resident in the archipelago forages in tidal wetlands. Scientists from the National Audobon Society have been studying Keys' birds for over 40 years and are presently continuing a three year study on Florida wading bird ecology. This study is providing documentation for the importance of transitional wetlands to these birds. The unpublished results (Sprunt and Powell, Pers. Comm.) demonstrates that:

> ". . . water cycles characteristic of Florida Bay place an exceptionally high level of importance on transition zone habitats throughout the Keys for the survival of wading birds. The topography of Florida Bay and extreme South Florida in general restricts water flow between the Keys, the Atlantic Ocean and the Gulf of Mexico. As a result, water levels in Florida Bay fluctuate seasonally and the Bay remains continually flooded for several weeks and even months of the year. During these periods, most wading birds

are unable to feed in their usual feeding areas because the water is too deep for them to wade. Consequently, they are forced to seek alternative feeding sites and therefore, move into the high marsh and transition zone habitats which are generally covered by shallow water at that time. During these periods, the existence of undisturbed transition habitat is critical to the survival of birds that at other times feed on seagrass meadows adjacent to the Keys. This seasonal dependence on habitats that are available primarily on the main line keys is illustrated in the data we have collected on wading bird abundance in Florida Bay. During the months of September and November, when Florida Bay water levels were high, the birds were absent fromthe Bay and were feeding instead in transitional zone habitats."

Wading birds of "special status" that feed in transitional wetlands include:

Roseate Spoonbill	Ajaia ajaja
Great White Heron	Ardea herodias accidentalis
Great Egret	Casmerodius albus
Little Blue Heron	Egretta eaerulea
Snowy Egret	Egretta thula
Reddish Egret	Egretta rufexens
Tricoloned Heron	Egretta tricolor
White Ibis	Eudocimus albus
Black-crowed Night Heron	Nycticorzx nycticorax
Yellow-crowned Night Heron	Nyctanassa violacea
Glossy Ibis	Plegadis falcinellus

Impacts

The ecological history of Keys' wetlands is often a reflection of disturbance and the biota's collective response to these extreme environmental pulses. Salt marshes are often formed by the action of storms and hurricanes which create natural impoundments on the periphery of these islands. The impounded wetlands contain saline, marl soils which are subsequently wetted by storm overwash or seasonal rains. The most destructive disturbance is that of hurricanes. Hurricanes often reset the time line of ecological succession as in the case of the 1960 hurricane Donna. According to Craighead (1971), who reported the effects of Donna on Everglades National Park:

"...the seed of batis immediately germinated and formed an almost continuous ground cover throughout the entire saline zone on low tidal lands where the mangrove stands had been killed and sunlight reached the new soil left by the storm tide. Batis is a light-demanding plant that was relatively scarce before Hurricane Donna in all well stocked mangrove forest areas. The seeds float and were widely distributed in the fresh mud deposits. By the end ofthe second summary following this storm, pratically the entire area of destruction could be distinguished from the air by the yellowish-green ground cover of this scrubby plant.

The stems of batis loop over and intertwine to reach a height of 2 to 3 feet, making a tangle that is very difficult to penetrate. This mat is an effective hindrance to the growth of mangrove seedlings.

A similar phenomenon occurs when mangroves are removed or impounded by man. The fleshy halophytes suppress mangrove development but are eventually "shaded out" once the mangroves become re-established. If, on the other hand, the soils of the impounded area remain hypersaline, mangroves will not survive and a salt marsh or barren will result. Buttonwood areas of the Keys and Everglades National Park, which had been cleared for charcoal production, now contain a flora dominated by graminoids, herbs and small shrubs. The Buttonwoods are now recolonizing and the pre-existing sere will return.

A less dramatic disturbance occurs in salt marshes as a result of compacting of the vegetation and soils by heavy equipment or off-road vehicles. Salt marsh plants have shallow root systems which form a rhizosphere only a few inches below the soil surface. This confines the feeding rootlets to the zone wherein salinities are less than that of the deeper soil. This stratification results from the leaching action of rainwater which percolates downward, or drains off, carrying with it the accumulated salt load. Moreover, the shallow marl soils tend to compress under loan, diminishing the interstitial speace between soil particles, which is important for gas, water and nutrient exchange. Thus, one finds persistent tracks or scars in salt marshes which are the impact marks of vehicles which have killed the vegetation and created conditions inimical for recolonization, a situation quite similar to the "prop-scarring" of marine seagrass beds by power boats.

Filling areas adjacent to transitional wetlands can produce adverse impacts by interrupting tidal flow and possibly changing salmity. Impoundments in adjacent areas may have similar effects. Examples include construction of roads and subdivision between transitional wetlands and the source of tidal sheet flow for these areas.

(6) SALT PONDS

Salt ponds occur throughout the Florida Keys created both naturally and as byproducts of human activity. Some, like the famous Key West salt ponds, are remnants of former open water areas that have not been completely filled. Salt ponds are cut off from surface tidal action by storm-built berms and/or fill structures such as roads. In a topographic sense, they are actually shallow impoundments, receiving seawater during intense storm events and rainwater on a regular, seasonal basis. The Florida Coastal Coordinating Council, in their 1974 report on the Florida Keys, identified salt ponds as:

> "Shallow, enclosed basins with very restricted tidal influence and generally having extremely variable salinity and temperature. This characteristic is directly related to the season of the year and the rainfall/evaporation budger. Due to these extremes in salinity and temperature, conditions are adversse for most organisms found in coastal wetlands. For these reasons such areas have populations restricted to specialized organisms able to tolerate the rigorous environment. Such populations tend to change with salinity fluctuations caused by alternating periods of rainfall and drought."

In the Keys, salt ponds range in size from less than one acre to tens of acres. The best known are located in Key West, Cudjoe, Little Torch and Long Keys. Seasonally variable water depths range from 2 feet to occasionally dry in the late spring. Salinity of pond waters has been measured at 6 ppt to 66.3 ppt and sediment salinities in some ponds probably exceed this latter figure and at the end of the dry season. Temperatures of the small volumes of water contained in these ponds approach those of the ambient air, which are reported to range from 69.4 to 84.9 F (monthly mean, Key West). In the smaller ponds, and in the larger ponds during periods of dry-down, water temperatures probably experience a daily range considerably different from these reported monthly averages. In these cases, peak summer values undoubtedly exceed 90 F.

Salt ponds sediments are generally a mixture of organic mud marl (a mud precipitated by plants, consisting of mostly calcium carbonate), and coarser-grained, calcereous skeletal elements derived from marine organisms. These sediments often have a reddish color. Their composition reflects a history of both in situ deposition and storm deposition. In some ponds, there is only a thin (1-2 inches) marl layer over the caprock, wehreas in others, sediment depths exceed a foot and are often anaerobic.

Biota.

The extremes of temperature, salinity, exposure and edaphic conditions, provide an explanation for the depauperate flora and low plant biomasss of these ponds. Vascular plants and marcoalgae are most frequently represented by the green algae Bataphora aerstedii and Acetabularia crenulata on coarse substrates and Widgeon Grass (Ruppia maritima) and Spike Rush (Eleocharis cellulosa) rooted in the sediments. Occasional Black Mangrove (Avicennia germinans) and, less frequently, Red Mangrove (Rhizophora mangle) are to be found in the ponds, especially on their periphery. The smaller ponds often contain little or no macroscopic vegetation whatsoever. In larger ponds the Spike Rush and occasional mangroves are restricted to the pond margins and the central area usually contains no emergent vegetation. It appears, therefore, that these ponds may be filling in from the perimeter.

The seasonal fluctuations and extremes of temperature, salinity and exposure characteristic of these salt ponds are inimical to the seagrasses which normally occur in shallow water bodies in the Keys. Seagrasses are usually abundant in similar areas which are regularly influenced by surface tidal flow. Turtle Grass (Thalassia testundinum) withstands temperatures of 91-95 F, but growth falls off rapidly if these temperatures are sustained. Shoal Grass (Halodule wrightii) prefers 68-86 F, but is somewhat more eurythermal than Turtle Grass. Turtle Grass can survive salinites of 3.5-60 ppt but can tolerate these extremes for only short periods; below 20 ppt this species loses leaves. Shoal Grass is the most euryhaline (Zieman, 1982).

Exposure of normally submerged aquatic plants to the desiccating influences of atmospheric air represents an extreme stress, especially when the duration of exposure is greater than a tidal cycle. According to Zieman (1982):

> "The seagrasses of south Florida are all subtidal plants that do not tolerate exposure well. Exposed leaf surfaces will lose water constantly until dry, and there is not constraint to water loss that would limit drying. Although exposure to the air definitely occurs at certain low tides on shallow turtle grass or shoal grass flats, unless it is extremely brief, the exposed leaf surfaces will be killed."

Probably the best adapted biotic element of the salt ponds is the periphyton, an association of microalgae, primarily blue-greens, which form mat-like structures composed of fine, algal filaments. In wetland areas which periodically dry out, these mats appear as black crusts on the surface of the caprock or sediment. These seemingly dead algal mats come to life when wetted in a manner similar to that of the epiphytic Resurrection

Fern (Polypodium polypodioides). The periphyton is now believed to be a significant component of shallow, wetlands areas. On the Florida mainland, the periphyton is found abundantly in all three of the Water Conservation Areas, Everglades National Park, the Big Cypress Swamp and inland prairies of the southeast coast. It is a food source for caddisflies, mayflies, stoneflies, scurds, zooplankton and fish (Gleason and Spackman, in Gleason, 1974). The blue-grass algal constituent of the periphyton is believed to be important to the percipitation of the calcitic mud (marl) which forms much of the sediment in salt ponds.

The synergistic effects of periodic exposure, hypersalinity, high water temperature and sub-optimal edaphic conditions severely limits or excludes seagrasses and mangroves from salt ponds. Those forms which have evolved the adaptations which enable them to withstand these stresses, for example, Widgeon Grass and blue-grass algas, are among the few survivors. Salt tolerant seeds and seedlings of mangroves are herbaceous plants, for example, Saltwort, Glasswort, and others, accompany the storm surge into the ponds. The seasonal occurrence of hurricanes coincides with the fruiting period of mangroves, thus ensuring a large seed/seedling supply for dispersal. If the ponds receive enough mud to elevate their buttoms above standing water, and if soil salinities are not excessive, a saltmarsh or mangrove system may result. If soil salinities exceed the tolerance of marsh plants or mangroves, then "salt flats" or "salt pans" develop. These areas generally contain a sparse association of halophytes and a ground cover of periphyton. In the long term absense of a storm event, the ponds will fill in, from their periphery inward, as a result of the in situ deposition of plant detritus, that is eutrophication. The subsequent seral stages would then progress through a marsh or mangrove system and possibly climax in a hardwood hammock. A severe drought would undoubtedly delay this progression for an indeterminate period of time.

Although the flora of salt ponds is depauperate, especially when compared to other Keys' wetlands, the fauna is diverse. Raccoons, insects, snakes and a great diversity of migratory and resident birds utilize the food resources of salt ponds. Within the ponds are found a variety of small fish, crustaceans and mollusks. Mollusks found in considerable abundance include the genera Cerithium and Modulus. Fish species frequently reported to occur include the Sheepshead Minnow (Cyprinodon variegatus), killifish (Fundulus spp.), Rainwater Killifish (Lucania parva), Mosquitofish (Gambusia affinis), and Sailfin Molly (Poecilia latipinna).

Birds know to utilize Keys salt ponds as feeding habitat include:

Great Blue Heron	Great White Heron
Great Egret	Snowy Egret
Tricolored Heron	Little Blue Heron
White Ibis	Roseate Spoonbill

Reddish Egert	Green Heron
Willet	Greater Yellowlegs
Lesser Yellowlegs	Dowitcher
Dunlin	Blue-winged Teal
Brown Pelican	Herring Gull
Laughing Gull	Ring-billed Gull
Royal Tern	Common Tern
Forster's Tern	Semipalmated Plover
Western Sandpiper	Black-bellied Plover
Semiplamated Sandpiper	Yellow-crowned Night Heron

Those listed by the Florida Committee on Rare and Endangered Plants and Animals are underlined in the above list. Species of *Fundulus*, *Cyprinodon*, and *Poecilia* are the primary food fishes of the rare Roseate Spoonbill (Ogden, in Pritchard, v. 2, 1978) and the White Ibis (Kushlan, 1979). Similarly, the rare Reddish Egret is reported by R.T. Paul (Pers. Comm.) to feed primarily on Killifish.

Impacts

The most direct human impact upon salt ponds is that of filling for development, an activity that destroys the entire system. Development adjacent to a pond, although not affecting the pond's structure, diminishes its functional integrity through adverse impacts upon resident wildlife. Feral and domestic animals, which invariably accompany residential developments, harass wildlife, especially birds and the close proximity of human activity often discourages birds from foraging, roosting and/or nesting, thereby limiting reproductive success and ultimately diminishing populations.

(7) BEACHES AND BERMS

A. Introduction

Beaches, or beach-like systems, are not especially common in the Florida Keys. Their frequency increases from the upper to the lower region of the archipelago. Keys with a large percentage of land mass composed of beach are to be found in the Marquesas, Tortugas and Sand Keys. In the lower Keys, beaches occur on Key West, lower Sugarloaf, Big Pine, the Newfound Harbor Keys and Bahia Honda Key. On these islands the beaches front the waters of Hawk Channel and the channels that flow into it. On the Gulf side of the lower keys, noteworthy beaches can be found on the Content and Sawyer Keys. Moving up the Keys, beaches occur on Boot Key, Key Colony Beach, Grassy Key, Long Key and on the Atlantic side of the Matecumbes. There are no natural beaches in the upper Keys.

Beach systems in the Keys are generally composed of two components. The most seaward component is the "beach" which is defined as "the unvegetated part of the shoreline formed of loose material, usually sand, that extends from the upper berm to the low water mark" (Clark, 1977). The "berm", as defined by this author, is "a ridge or ridges on the backshore of the beach, formed by the deposit of material by wave action, that marks the upper limit of ordinary high tides and wave wash; berms have sharply sloping leading edges." The Florida Natural Areas Inventory abstracts state that "many dune-like sites in the Keys and along the Gulf coast of the peninsula are actually storm-deposit ridges classified as 'coastal berm'."

Beaches form when the proper combination of source material, topography, wave energy and currents coincide. In the Keys, this harmony of physical factors does not occur nearly as often as on the Florida mainland. Here, there are no streams bearing sediments generated by the erosion of upland areas, nor are there strong longshore currents importing sands from upshore sources. Moreover, the shallow, gently sloping bottoms adjacent to these islands reduce the effectiveness of waves carrying sand landward. Further offshore, the coral reefs of the Florida Reef Tract dissipate the energies of large oceanic waves and swells by causing them to break miles from the beaches. In most areas of the Keys, wave energies are so low that beaches never form; instead, if water depths are shallow, mangrove systems or mud flats develop. As a result of the normally low wave energies which impact Keys' beaches, the active beach zone is quite narrow, standing in sharp contrast to the wide beaches of Daytona Beach or Fort Lauderdale.

The width, slope and zonation of a beach system are functions of wave energy, direction, and near-shore current as well as the characteristics of the sand itself. Waves impacting the shore contribute sand to the beach, whereas waves which break at an angle cause sand to be transported offshore. The slope of a beach represents the topographic response to wave energy and direction. Large storm waves erode a beach, thereby increasing the slope angle, while gentle waves generate an accumulation of sand which decreases beach slope. The broad surface of a gently sloping beach absorbs wave energies preventing their impact further inland. When winter storms remove sand from a beach, it is replaced by material from the berm. "It is the capacity of the berm-and dune system to store sand and yield it to the adjacent submerged bottom that gives this system its outstanding ability to protect the shorelands." (Clark, 1977)

Immediately seaward of the beaches of several Keys (e.g. Long Beach, Big Pine Key, Content Keys) there is a broad, shallow sloping, rocky ledge that parallels the entire shoreline. This intertidal area separates these beaches from deeper waters offshore and acts as a buffer to waves in a manner similar to thatof wide, shallow sloping beaches found in other areas of the Keys such as Bahia Honda and Smathers Beach, Key West. It is very likely that gently sloping sand beaches covered these rocky, intertidal areas. This sand was probably deposited in the berm by storms, leaving the exposed rock.

The sands which form Keys beaches and berms are composed primarily of the calcareous remains of the marine organisms which live in shallow offshore waters. Foremost of the contributors to these sands are mollusks, stony corals, echinoids and green algae such as Halimeda and Penicillus. The framentary remains of these organisms are generally coarse and angular in constrast to the fine particles of silica which form the sands of most northern beaches. This coarse fraction of sediments is sorted from the fine by the action of wave and current. Coarse material is deposited in the higher energy areas such as beaches and slope tops of channels, whereas the fine muds end up in quiescent areas such as mud banks, shallow embayments and mangrove fringes.

Subsequent to the deposition of this material on the beach, it is either carried upward to the berm by stormwaves or transported offshore by nearshore currents. Because of its relatively large size and angularity, this sand is not readily transported by the wind as are the siliceous sands of mainland beaches. This explains the absence in the Keys of the shifting or high dunes characteristic of beaches in the middle Atlantic seashore. Thus the narrow beaches characteristic of the Keys are created by an interaction of low wave energy and coarse sand. The berms or sand ridges result from storm waves which transport sand from the shallow submerged bottoms and beach zones landward.

The physical environment of beaches is one of extremes. Beaches are subject to high soil temperatures, persistent wind, occasional severe storms, intense sunlight, salt spray and periodic inundation by seawater. The coarse, calcareous sands of Keys beaches have little capability for moisture-retention. Excellent drainage, high temperatures and constant air movement result in high rates of percolation and evaporation of soil moisture. During the numerous cloudless days, light levels are intense due to both direct sunlight and light reflected from the sand and surf. Storms and high winds have erosive effects on the substrate occasionally causing "blow-outs" of sections of beach. All of these factors combine to make the beach a harsh environment for both plants and animals. Soil salinity is also an important limiting factor to plants since sale represents a physiological stress. A transect study of Barbados beaches has shown that soil water increases landward and soil salts decrease (Gooding, 1947) and this would presumably be true for Keys beaches as well.

B. Biota

In spite of these conditions, beaches support a rich biota which is specifically adapted to this environment. Moreover, these animals and plants not only tolerate this harsh environment, but also stablize and maintain its physical structure. Plants which become established on loose sand and are able to grow upward at a rate exceeding deposition, stabilize it by preventing wind and water erosion. Roots easily penetrate these coarse calcareous sands so that fast-growing plants with deep root systems can reach below the dry top soils. In addition, the lants add an organic component to the calcareous sand by contributing leaves and other plant parts (humus). Thus, both the amount and distribution of berm soils and their ability to retain moisture are directly related to the amount and type of resident vegetation.

According to Furley and Newey (1979), "the distribution of plant communities appears to show a very close relationship to the character of soils which in turn strongly reflect the nature of the topography. Soil moisture appears to play a significant part in the composition of the vegetation..." Soil factors have a controlling influence on the kinds of plants that occur on the strand, their zonation and the successional sequence leading from bare substrate to a mature climax community.

Wind affects beach vegetation both mechanically and physiologically. High wind causes direct injury to plants through defoliation and breakage of woody parts. Plants exposed to excessive and/or constant wind tend to lose water from their tissues (evapotranspiration) at a rate faster than it can be replaced. These plants become desiccated and either die entirely or in part. This results in assymetric growth since new growth is protected on the leeward side and new windward growth is subject to desiccation and death (windpruning). This is thought to explain the "shearing" effect observed on dunes and mangrove islands. Emergent vegetation that would rise otherwise above the canopy, or protrude seaward, is sheared off by wind effect resulting in a flat-topped canopy with a landward slope to the vertical aspect of the woody vegetation. It has been hypothesized that this streamlined profile deflects the force of hurricanes and prevents uprooting of trees.

The biota characteristic of beach systems throughout the world occurs in generalized zones or associations. Each zone is a band running parallel to the shoreline occupied by a distinct assemblage of plants and animals that are adapted morphologically, physiologically and behaviorally to the environmental conditions of that zone. The boundary between zones may be well-defined or obscure. The physicochemical factors which interact with the biota to create these zones include:

1. TOPOGRAPHY
   a. Vertical elevation of the berm.
   b. Slope
   c. Distance from shore
   d. Orientation to prevailing winds.
2. SOILS
   a. Moisture
   b. PH
   c. Nutrients
   d. Salinity
3. LIGHT and TEMPERATURE
   a. Angle and duration of exposure to sunlight
   b. Shading effects
4. RAINFALL

Precipitation decreases linearly from the upper Keys to the Tortugas. Because Keys beaches are xeric (dry habitats), many plants show "xeromorphic" adaptations to this condition. These include succulence, rapid growth, deep roots, cutinized, and/or involuted leaves, reduced leave size, epidermal hairs, etc. Sea Oats (Uniola paniculata), a common beach grass, is quite important to their stability and possess a number of these adaptations. Oosting and Billings (1942) described Uniola as "a fast growing, rhizomatous pioneer which can grow and reach optimum development under constant influence of wind and salt spray at a maximum distance from the water table. It dominates the ocean side of the force dune and crest of the rear dune." Other xeromorphic plants commonly found on Keys shores include Cordgrass (Spartina Paten), Sea Purclane (Sesuvium portulacastrum) and Sea Lavender (Tournefortia gnapholodes.

Four distinct zones on Keys beaches are generally recognized (Davis, 1942). These are:

1. A strand-beach association of pioneer halophytic (salt tolerant) species.

2. An essentially herbaceous strand-dune association, on the fore part of the low dunes.

3. A strand-scrub association.

4. A strand-hammock association.

This generalized zonation scheme is typically found only on the most highly developed beach systems such as on the keys between Key West and the Tortugas. For the remaining islands, this distinct zonation, with some variation, occurs on Bahia Honda, lower Sugarloaf, Big Pine, the Newfound Harbor Keys and the Conte Keys. On other keys, this zonation complex is not as well developed.

The strand-beach association is dominated by plants which are salt tolerant, root quickly, germinate from seed rapidly and can withstand wave wash and shifting sand. Commonly found species include Sea Purslane (Sesuvium portulacastrum), Railroad Vine (Ipomoea pes-caprae), Beach Grass (Panicum amarulum), Sea Oats (Uniola paniculata), Sea Lavender (Tournefortia gnapholodes), Coastal Ragweed (Ambrosia hispida), Bay Cedar (Suriana maritma), Cenchrus and Chamaesyce. On most Keys beaches this association occurs only at the base of the berm since the beach zone is very narrow. These plants also occupy the most seaward portion of the berm and continue some distance landward. On a number of Keys beaches, mangroves and Buttonwood (Conocarpus erectus) have become established in this zone. In the Content Keys, for instance, there is a narrow band of Red (Rhizophora mangle) and Black (Avicennia germinans) Mangroves just landward of the intertidal, bare, caprock bottom. This mangrove fringe, which is only 1-3 trees in width, grades into the sandy, foreshore zone of the beach.

This zone of the beach is especially important to shorebirds since it accumulates vast amounts of decomposing organic material which supports a myriad of small invertebrates such as amphipods, isopods, crabs, mollusks, worms and others. Frequently observed birds in this zone include sandpipers, plovers, Ruddy Turnstones, Sanderlings, Killdeer, Dowitchers, Willets, Dunlins, and gulls. These birds feed on these small invertebrates.

The next zone, Davis' "strand-dune" association, begins with a steep and distinct increase in slope upward from the beach. This sloping portion fo the berm receives the effects of the highest spring tides as well as storm-generated wave wash. The berm may be elevated only several inches or as much as several feet above the level of the beach and may extend landward hundreds of feet as flat-topped plateau or beach ridge. On sections of the Bahia Honda and Marquesas beaches, there are series of parallel ridges separated by shallow swales.

The foreslope of the berm is vegetated primarily by the above-listed species of the beach association. Grasses and herbaceous plants, which stabilize this area, are most common. As one proceeds landward, these pioneer species are joined by other species such as Chaff Flower (Alternanthera maritima), Sea Daisy (Borrichia frutescens), Cordgrass (Spartina patens), Beach Orach (Atriplex arenaris), Spider Lily (Hymenocallis latifolia), and Sea Rocket (Cakile lanceolata). On a number of Keys beaches, Australian Pines (Casuarina equisetifolia) have become established in this zone effectively competing with the native vegetation. It is quite possible that the extensive root systems of these trees interferes with marine turtle nesting. Another exotic, Leatherleaf (Colubrina asiatica), has also become established on Keys beaches forming dense thickets in the seaward portion of the berm.

If the berm is narrow, as on Content and Sawyer Keys, the grass and herb-dominated association covers the majority of the zone. If, however, the berm is a wide feature, as on Long Beach and Bahia Honda, both "strand-scrub" and "strand-hammock" associations develop. Davis (1942) states that a minimum width of 75 yards is required for the simultaneous occurrence of all three stages of this succession. However, on a number of Keys' beach systems these two associations occur on berms that are not this wide. In these cases, either the scrub has developed without a hammock or both communities develop as narrow zones. An additional exception to Davis' scheme occurs in areas where a mangrove fringe fronts a narrow dune ridge. In such cases, as on No Name Key, a scrub or hammock association develops without a beach.

The strand-scrub association is generally considered a transition zone between strand-dune and hammock forest. Shrubs and occasional trees occur more frequently here and become more abundant as one proceeds landward. Species often found include Seagrape (Coccoloba uvifera), Wild Sage (Lantana involucrata), Seven-year Apple (Casasia clusiifolia), Blolly (Guapira discolor), Gray Nicker (Caesalpina crista), Blackbeac (Pithecellobium guadalupense), Nightshade (Solanum bahamense), and the Prickly Pear Cactus (Opuntia stricta). Occasional larger trees include Buttonwood, large Seagrape, Blolly, Gumbo Limbo (Bursear simaruba), and Jamaica Dogwood (Piscidia piscipula). Vegetation occurring as an understory or in open areas includes many of the previously-mentioned graminoids and herbs as well as Natal Grass (Rhynchelytrum repens), Spanish Needles (Bidens alba) and Yellowtop (Flaveria linearis). This transitional association is the seral stage which preceeds the succession to climax hammock forest. The most landward zone on the berm is occupied by tropical hardwood hammocks, which are described elsewhere.

Animals inhabiting Keys beach systems include species which are endemic to the archipelago and/or listed as "endangered," "threatened," "rare" or of "special conern." Endangered marine turtles have been reported to nest on Keys beaches with the most recent sightings on Long Beach, Big Pine Key and Lower Matecumbe Key. Urbanization and the establishment of Australian Pines on nesting beaches are factors resulting in the loss of this critical habitat.

The Marsh Rabbit (Sylvilagus palustris) has been observed on the berm on Long Beach apparently utilizing the open, grassy areas. This endemic subspecies (Lazell, 1984) is also found in Chestnut Sedge (Fimbristylis castanea) dominated marshes. It is apparently present only on the Lower Keys.

The Red Rat Snake (Elaphe guttata guttata) and the Eastern Indigo Snake (Drymarchon corais couperi) are threatened species that have been frequently observed on Keys beach systems. These snakes feed on small rodents and on the abundant Anolis lizards (A. carolinensis and A. sagrei stejnegeri) found in both the open areas of the berm and in the hammocks.

A number of endangered/threatened plants occur on Keys beaches including:

Silver Plam	Coccothrinax argentata
Geiger Tree	Cordia sebestena
Golden Creeper	Ernodea littoralis
Joewood	Jacquinia keyensis
Sea Lavender	Tournefortia gnapholodes
Scaevola	Scaevola plumieri
Pride of Big Pine	Strumpfia maritima
Bay Cedar	Sunriana maritima
Key Thatch Palm	Thrinax morrisii
Yellowwood	Zanthoxylum flavum

C. Impacts

Disturbances which affect beach systems may be natural or manmade. The most obvious of the former are hurricanes, the effects of which can be most dramatic. According to Craighead (1971), many miles of beach shoreline on the southern tip of Florida were once a mangrove fringe. This deforestation was caused by hurricanes of 1935 and 1960. Craighead believes that the mangroves did not become re-established because of tide and wrack accumulations.

The establishment of exotic vegetation on beach systems in the Keys is a widespread phenomenon. Australian pines and leatherleaf are found on most beaches. In some dune hammocks, Brazilian Pepper (Schinus terebinthefolius) has also become established, often forming dense thickets. All of these plants are invasive and displace native vegetation, especially following clearing or other disturbances. Australian Pine is believed by Austin (1978) to be both an effective competitor and an impediment to the nesting of sea turtles and the American Crocodile (Crocodylus acutus). He also believes that it opens beaches and dunes to erosion because it inhibits the growth of native plants which stabilize the sand.

Disturbance of indigenous beach vegetation either selectively or by total removal, has disasterous consequence for the entire system. The most obvious result is the destabilization of the substrate which then is subject to rapid erosional loss leading to "blow outs" of entire sections of beach under storm conditions. If, in fact, the structure of the system is diminished, natural and/or man-made systems which depend upon the beach for protection may be in jeopardy from storm effects. Elimination of shrubs and trees changes the wind regime thereby increasing the drying of soils and the degree of desication suffered by the remaining plants. All of these factors impede the successional sequence. Further, the removal of plants diminishes the amount of food and cover for animal inhabitants. Consequently, only smaller populations can be supported -- a major concern in cases where species are endangered, threatened and/or rare.

(8) TROPICAL HARDWOOD HAMMOCK

Tropical hardwood hammocks represent the climax community of South Florida and the Keys. These forest systems occur as isolated stands of hardwoods amid freshwater or saltwater wetlands. The flora of these communities is largely derived from tropical species from the West Indies rather than the temperate forms that characterize the plant communities of the Florida peninsula generally.

In the Everglades, these tree islands may be seasonally flooded but elsewhere they tend to remain above water except after severe storms or hurricanes. The "soil" of these hammocks, consists mostly of a layer of partially decomposed organic matter resting directly on a porous limestone substrate. This thin film of organics is the principal physical resource that enables hammocks to accommodate a flora that is adapted to mesic -- and not xeric -- conditions. The maintenance of this organic layer is therefore critical to the existence of tropical hardwood hammocks. The closed canopy of hammocks is insulative, moderating thermal extremes (Olmstead and Loope, 1984) and reducing the loss of soil moisture. Key hammocks are also characterized by a heterogeneity that is indirectly attributable to periodic fire and hurricanes. These natural impacts interrupt succession in all or a portion of the hammock to produce a mosaic or seral stages within or among hammocks.

Within the hammocks, most plant species occur as "clumps" rather than being characterized by random or uniform distribution. There is a positive correlation between degree of clumping and rarity (Hubbell, 1979) which means that very rare forms may occur only in one or two places and thus are inordinately susceptible to elimination.

Biota

South Florida's tropical hardwood hammocks have been subcategorized as high hammocks and low hammocks (Davis, 1943; Alexander, 1958) on the basis of their elevation. In the Keys, low hammocks occur approximately plus or minus 1-2 meters above sea level and high hammocks approximately plus or minus 2-5 meters. Thus one hammock type may grade into the other at their common edge.

In Monroe County, high hammocks occur primarily in the upper Keys and are rare elsewhere. Mature high hammocks are extremely rare, with the most mature apparently being limited to North Key Largo and Lignum Vitae Key. A typical high hammock canopy ranges from 4-10 meters high with taller canopy species such as Mahogany (Swietenia mahagoni) protruding 3-7 meters above the canopy. Other canopy emergents include Poisonwood (Metopium Piscidia piscipula), Shortleaf Fig (Ficus citrifolia), and Wild Tamarina (Lysiloma latisiliguum). Shorter canopy species include

Pigeon Plum (Coccoloba diversifolia), Willow Bustle (Sumelia salicifolia) and Black Ironwood (Krugiodendron Ferreum). Smaller trees like White Stopper (Eugenia axillaris) and Crabwood (Ateramnus lucidus) may be part of the canopy or a discontinuous shrub layer. The sparse ground cover includes Snowberry (Chiococca parvifolia), Passionflower (Passiflora suberosa) and other herbaceous forms. Various bromeliads, orchids, and ferns occur as epiphytic forms.

Low hammock species tend to be smaller than those of high hammocks and the canopy is correspondingly lower. The canopy may be so low (2-3 m), in fact, that there is little distinction between canopy and subcanopy. Beard (1955) attributees this and also the high occurrence of thorny species and/or forms with small, simple, stiff leaves to decreased soil moisture. In low hammocks, Buttonwood (Conocarpus erecta) joins the canopy and species such as Wild Dilly (Manikara bahamensis), Jamaica Caper (Caparis cynophallophora), and Saffron Plum (Bumelia celastrina) are usually found only in low hammock systems. Species such as Prickly Pear Cactus (Opuntia stricta) Sea Grape (Coccoloba uvifera) and Cabbage Palm (Sabal palmetto) are restricted primarily to low hammocks but can occur in the upper edge of transitional wetlands.

Low hammocks may be further subcategorized on the basis of plant composition and substrate. Cactus hammocks are low hammocks with understories dominated by cacti of the genera Opuntia and Cereus. While some species such as Barbed Wire Cactus (Cereus pentagonus), Prickly Pear Cactus (Opuntia stricta var. dillenii), and Prickly Apple Cactus (Cereus gracilis) are common in cactus hammocks, others are extremely rare. Tree Cactus (Cereus robinii) for instance is known from fewer than a half dozen sites in the Keys. Examples of cactus hammocks are L5/5* on Long Key and "The Cactus Hammock" on the southern extension of Big Pine Key.

Palm Hammocks are another type of low hammock. These are dominated by palms such as Florida Thatch Palm (Thrinax radiata), Cabbage Palm, Silver Palm (Coccothrinax argentata), or Keys Thatch Palm (Thrinax morrissii). Palm hammocks occur in the middle keys. Examples are L7/2 and L7/3 which are visible from U.S. 1 just north of Marathon.

The third type of low hammock is the dune hammock. As the name implies, these are low hammocks which develop on dunes and they may be dominated by hardwoods or palms. Dune hammocks are found on Sugarloaf Key and a few others.

* Unnamed hammocks are labeled with the numbering system used by Weiner (1979).

Of the many plant species native to the tropical hardwood hammocks of the Keys, 37 are classified by state and/or federal agencies as endangered or threatened. These are shown on Table 1. Two species that are apparently endemic to Keys hammocks are Blodgett's Sage (Salvia blodgettii) and Cyperus blodgettii (Avery and Loope, 1980). Cyperus was originally found on Upper Matecumbe and in the Lower Keys; Boldgett's Sage was recorded from Key West. Both are inconspicuous plants, and no recent sightings are known.

The environment provided by the flora of tropical hardwood hammocks is a major determinant of the assemblage of animal species that inhabitat these ecosystems. Because of their uniqueness and restricted occurrence, tropical hardwood hammocks harbor many endemic or very restricted forms including several of the Keys threatened or endangered species.

While amphibians are not abundant in Keys hammocks, many reptiles may be found. These include the Box Turtle (Terrapene carolina lauri), Key Mud Turtle (Kinosternon bauri bauri), the endemic Keys Mole Skink (Eumeces egregius egregius), Coral Snake (Micrurus fulvius fulvius), Eastern Diamondback Rattlesnake (Crotalus adamanteus), Big Pine Key Ringneck Snake (Diadophis punetatus acricus), Eastern Indigo Snake (Drymarchon corais couperi), Florida Brown Snake (Storeria dekayi victa), Miami Black-headed Snake (Tantilla politica), and the Florida Ribbon Snake (Thamnophis sauritus sackeni). While some of these reptiles apparently occur throughout the Keys, others are restricted to only a portion of the archipelago. The coral snake, for instance, is apparently limited to upper Keys hammocks.

Many species of birds utilize tropical hardwood hammocks. Those known to nest in Keys hammocks are:

Swallow-tailed Kite	Elanoides forficatus
Red-shouldered Hawk	Buteo lineatus
Osprey	Pandion haliaetus
Mourning Dove	Zenaidura macroura
Ground Dove	Columbigallina passerina
Mangrove Cuckoo	Coccyzus minor
Yellow-billed Cuckoo	Coccyzus americanus
Screech Owl	Otus asio
Chuck Will'w Widow	Caprimulgus carolinensis
Pileated Woodpecker	Dryocopus pileatus
Common Flicker	Colaptes auratus
Red-bellied Woodpecker	Centurus carolinus
Gray Kingbird	Tyrannus dominicensis
Great-crested Flycatcher	Myiarchus crinitus
Carolina Wren	Thryothorus ludavicianus
Mockingbird	Mimus polyglottus
Brown Thrasher	Toxostoma rufum
White-eyed Vireo	Vireo griseus
Black-whiskered Vireo	Vireo altiloguus
Red-winged Blackbird	Agelaius phonicius

Common Grackle	Quiscalus guiscula
Cardinal	Richmondena cardinalis

Within the Keys, the range of some species is quite limited. The Pileated Woodpecker and Carolina Wren, for instance, are known only from Key Largo.

Endangered or threatened bird species using tropical hardwood hammocks include the Peregrine Falcon (Falco peregrinus), which hunts along the hammock edge or treetops and the White-crowned Pigeon (Columba leucocephala). The latter is a spring and summer resident of the Keys that is not found elsewhere in the United States. They nest in mangroves but feed in hammocks.

Mammals that utilize Keys tropical hardwood hammocks include the Opossum (Dildelphis marsupialis), Gray Squirrel (Sciurus carolinensis matecumbei), Raccoon (Procyon lotor), Marsh Rabbit (Sylvilagus palustris), Hispid Cotton Rat (Sigmodon hispidus), Least Shrew (Cryptotis parva), the Bobcat (Lynx rufus). Four species of subspecies of mammals that inhabit Keys hammocks are classified by state and/or federal agencies or endangered or threatened. These are:

Key Largo Woodrat	Neotoma floriana smalli
Key Largo Cotton Mouse	Peromyscus gossypinus allapaticola
Key Vaca Raccoon	Procyon lotor auspicatus
Key Deer	Odocoileus virginianus davium

Originally the Key Largo Woodrat and Key Largo Cotton Mouse were apparently limited to hardwood hammocks in North Key Largo. Both were introduced to Lignum Vitae Key in 1970 where they appear to be prospering.

The Key Vaca Raccoon is known from Grassy Key to Key West. The Key Deer is found only on the lower Keys at present. Key Deer utilize several communities for feeding but show a preference for open hammocks and pinelands (Layne, 1974).

Of the many invertebrates inhabiting Keys hammocks, two are endangered forms. These are the Stock Island Tree Snail (Orthalicus reses reses) and the Schaus Swallowtail Butterfly (Heraclides aristodemus ponceanus). The former was originally restricted to Stock Island and Key West while the latter is known only from North Key Largo and Elliott Key where it deposits its eggs primarily on Torchwood. Some color forms of the Florida Tree Snail (Liquus fasciatus) are restricted to specific hammocks, and it appears that collectors have eliminated some forms.

Impacts

Impacts which affect hammocks on the Keys are varied and include natural activities such as hurricanes and fires. Man-induced impacts include activities such as land clearing, dredging, ditching, filling and the introduction of exotic plants. The nature of these impacts depends on the integrity and size of the hammock and its wildlife. Recovery from the impacts depends on the condition, size and amount of surrounding hammocks and wetlands or the type of development in adjacent land.

Due to the intricate relationships of hammock species, seemingly insignificant impacts can result in extensive repercussions. For instance, loss of a large Mahogany adversely affects the Mahogany Mistletoe (Phoradendron rubrum) which grows only on the tops of mature Mahogany trees.

Hurricanes are probably the most important natural force that impacts terrestrial ecosystems in the Florida Keys. The degree of disturbance, of course, varies with hurricane intensity but severe hurricanes can devastate hardwood hammocks and many years or even decades may be required for recovery. The sloping outline of a mature hammock canopy may deflect winds (Craighead, 1974). Thus, hurricane impact is more severe if the hammock edge is not intact. Fires, too, can alter hammocks for long periods since they may destroy the shallow organic "soil" that is essential for the structure and function of these ecosystems. Eventually, however, successional changes will reestablish the species assemblage characteristic of the original system. This is attributable largely to the fact that such natural catastrophes are recurring phenomena to which target species have evolved a genetic accomodation. The cummulative impact of these adaptations generates a regular and orderly successional recovery following such events.

Alterations mediated by humanity are usually more enduring and sometimes permanent. By 1974, over 50% of South Florida's tropical hardwood hammocks had been destroyed (Robertson & Kushlan, 1974). Land clearing, dredging, ditching, and filling modify the edaphic conditions that are essential to hammock restoration. Further, these activities remove the propagules that constitute the gene base for successional recovery. The extensive introduction of exotic plants further complicates the prospects of recovery from natural or human-caused impacts since some of these tend to out-compete and eventually replace some native species that are links in the seral recovery sequence that would otherwise generate a hammock climax. Brazilian Pepper (Schinus terebinthifolius) is one such troublesome weed. While it seems incapable of establishing a toehold in unmodified hammocks, it rapidly invades altered hammock areas and may delay or even prevent recovery depending on the severity of disturbance. In part, the vulnerability of hammocks is attributable, as mentioned, to the easily destroyed meager soil resource that is the edaphic foundation of its fragile trophic structure. But this vulnerability is further attributable to their isolation and discontinuity which can make recruitment of successional forms difficult and thereby retard or prevent reestablishment of a hammock climax. The speed and likelihood of recovery are inversely proportional to distance separating the altered area from an unaltered system from which recruitment can occur.

The incidence of filling uplands appears to be increasing. It is likely that recolonization of abandoned fill sites will result in a species assemblage that differs from the biota of the original hammock because of differences in substrate.

Mosquito control activities also result in the degradation of hammocks. Mosquito ditches provide avenues for saltwater intrusion and invasion by exotics. Mosquito spraying may affect pollinators as well as mosquitoes.

Road construction has seriously affected hammocks both directly and indirectly. In addition to the direct destruction of hammock acreage, road construction dissects and thereby fragments these systems. On North Key Largo for example all hammocks are dissected by U.S. 1 or C-905, most through (or close to) the center. The increased access thus provided to hammocks results in further indirect environmental damage by increasing storm damage, invasion of exotics, soil dessication, collecting, illegal dumping, fire vandalism, and wildlife mortality.

Removing the understory and ground cover from hammocks is becoming a common practice in the Keys. This practice, locally called "grubbing out," provides visual access, increased airflow and space for planted colorful exotics. This severely degrades hammocks by direct elimination of smaller plants (including the young of canopy species), reduction of wildlife habitat and increased exposure to the dessicating influences of wind and light.

Table 1:

Species of Keys hammocks that are presently listed as Endangered or Threatened on state or federal lists* include:

Scientific Name	Common Name
Acrostichum aureum	Golden Leather Fern
Acrostichum danaeifolium	Leather fern
Chrysophyllum oliviforme	Satinleaf
Cereus gracilis	Prickly apple cactus
Cereus pentagonus	Barbed-wire cactus
Cereus robinii	Tree cactus
Clusia rosea	Balsalm apple
Coccothrinax argentata	Silver Palm
Cordia sebenstena	Geiger tree
Cupania glabra	Cupania
Encyclia boothiana	Dollar Orchid
Encyclia tampensis	Butterfly orchid
Eugenia confusa	Redberry stopper
Guaiacum sanctum	Lignum vitae
Hippomane mancinella	Manchineel
Jacquinia keyensis	Joeweed
Opuntia stricta	Prickly pear cactus
Polypodium heterophyllum	Vine Fern
Polypodium phyllitides (Campyloneuron)	Strap fern
Pteris longifolia var. bahamensis	Ladder brake
Salvia blodgettii	Blodgett's sage
Swietenia mahagoni	Mahogany
Thrinax morrissii	Keys thatch palm
Thrinax radiata	Florida thatch palm
Tillandsia balbisiana	Reflexed wild pine
Tillandsia circinata	Twisted air plant
Tillandsia fasciculata	Wild pine
Tillandsia flexuosa	Banded wild pine
Tillandsia setacea	Needle leaved airplant
Tillandsia utriculata	Giant wild pine
Tillandsia valenzuela	Soft-leaved wild pine
Vanilla barbellata	Vanilla orchid
Vittaria lineata	Shoestring fern

*Endangered status is shown in the Table on "Threatened and Endangered Plants of the Florida Keys."

(9) PINELANDS

Pinelands are fire-climax systems dominated by pines. In the absence of fire, pinelands ultimately are transformed into hardwood hammocks--a process that may require several decades (Alexander and Dickson, 1970). Although pinelands formerly existed in the Upper Keys (Alexander, 1953), their occurrence in Monroe County is presently limited to the Lower Keys, primarily on Little Pine Key, Big Pine Key, No Name Key, Cudjoe Key, Sugarloaf Key and on neighboring Keys (Weiner, 1979; Robertson, 1955).

Biota

Pinelands are seral systems that are less easily characterized biotically than climax hardwood hammock. Caribbean Pine (Pinus elliottii var. densa) is the canopy dominant and Silver-palm (Coccothrinas argentata), Black-bead (Pithecellobium keyense) and the Keys Thatch Palm (Thrinax morrisiia) are the primary midstory forms. Species composition of the understory is less easily characterized since it changes as succession progresses. Understory plants of rather general occurrence in pinelands are Long-stalked Stopper (Psidium longipes), Pisonia (Pisonia rotundata), and Locustberry (Byrsonima lucida). In the absence of fire, Poisonwood (Metopium taxiferum) and other hardwood hammock forms invade pineland understory.

The ground cover consists of a large number of species (Alexander & Dickson, 1970); the most important are Golden Creeper (Eonodea littonalis), Sand Flax (Linum arenicola), Pine Pik (Bletia purpurea), Pine Fern (Anemia adiantifolia), Star Rush (Dichromena floridensis) and Andropogon virginicus.

As a consequence of frequent fires, the leaf litter of pinelands is shallow and discontinuous. This, and the open nature of the canaopy, generates a drier environment with more thermal extremes than occurs in the hardwood hammocks of Everglades National Park (Robertson, 1955; Olmsted, 1984) and apparently in the Keys).

In the absence of fire, pinelands understories tend to develop a subcanopy of hardwood species that eventually expands to replace the pine canopy. Nonetheless, the successional sequence is prolonged enough and fires frequent enough to allow continuous presence of Keys pinelands for periods long enough to generate several endemic plants species (Table 1). Examples are the Keys Senna (Cassia keyensis), two spurges (Chamaesyce deltoidea var. serpylludm and C. porteriana var. keyensis), Gerardis keyensis, and Schizachyrium sericatum. At least 11 keys pinelands plants are presently listed as threatened or endangered by state or federal agencies. These are:

Golden Leather Fern	Acrostichum aureum
Leather Fern	Acrostichum danaefolium
Pine Fern	Anemia adiantifolia
Keys Senna	Cassia keyensis
Small-flowered Lily Thorn	Catesbaea parviflora
Silver Palm	Coccothrinax argentata
Michaux Orchid	Habenaria quinquesta
Ladder Brake Fern	Pteris longifolia var. bahamensis
Pride of Big Pine	Strumpfia maritima
Keys Thatch Palm	Thrinax morrisii
Vanilla Orchid	Vanilla barbellata

In the absence of fire, a pineland in the southern peninsula of Florida may be replaced by hardwood hammock after about 25 years (Alexander, 1967); in the lower Keys, 50 years (Alexander & Dickson, 1970). The pinelands of some of the lower Keys presently have almost succeeded to hardwood hammock. In the Pinelands of Cudjoe Key, for example, there exists a hardwood understory 6 meters or more high and ground cover species typical of pinelands are absent.

Pinelands are the home of many animal species including several forms endemic to the Keys. Endemic reptiles that utilize the pinelands include the Keys Mole Skink (Eumeces egrigius egrigius), the Big Pine Key Ringneck Snake (Diadophis punctatus acricus) and Florida Brown Sanke (Storeria dekayi victa). Another endemic snake, the Florida Ribbon Snake (TThamnophis sauritus sackeni), is a denizen of wetlands that is sometimes found in pinelands, especially at points on interface with wetlands. The Eastern Indigo Snake (Drymarchon corais couperi) is a threatened form that regularaly utilizes pinelands and another threatened form, the American Alligator (Alligator mississippiensis) utilizes pinelands as corridors from one freshwater hole to another (Don Kosin, pers. comm.).

While there are no bird species endemic to the Florida Keys, many threatened or endangered forms occur here and a species are known to rest here. Species that utilize pinelands include the Bald Eagle (Haliaeetus leucocephalus Peregrine Falcon (Falco peregrinus tundrius), and White-crowned pigeon (Columba leucocephala).

With the exception of the West Indian Manatee (Trichechus manatus latoristris) all endangered/threatened mammals of the Florida Keys are endemic (mostly subspecific) forms. Two of these that regularly utilize pinelands are the Key Deer (Odocoileus virginianus caluium) and Key Vaca Raccoon (Procyon lotor auspicatus). While Key Vaca Raccoons are versatile animals that adapt well to moderate environmental modification, Key Deer populations have been severely diminished by human impacts. Development has reduced to discontinuance patches the open hammocks and pinelands they prefer and has thereby generated increased contact with traffic, dogs and humans.

Impacts

The most significant natural phenomena that disturb all terrestrial ecosystems in the Keys are hurricanes and fires. As a consequence of recurring exposure, pinelands have become adapted to these disturbances and fully recover from such impacts. Fires, in fact, are essential to the maintenance of pinelands since, as mentioned, these are seral and not climax communities. Consequently, fire exclusion in pinelands eventually generates a proliferation of hardwood species that culminates in a tropical hardwood hammock climax. Since humans discourage fire in the vicinity of habitations, development tends to secondarily reduce the extent of pinelands whose perpetuation entails periodic burning.

Disturbances caused by humans are more varied and frequently more enduring. By far the most damaging impacts are those associated with building and farming. Clearing destroys pinelands outright and subsequent construction on the site precludes their reestablishment indefinitely, perhaps permanently. Indirect effects associated with development may similarly damage pinelands. The establishment of roadways, for instance, directly destroys pinelands and indirectly may reduce populations of its animal inhabitants (Key Deer for example) via road kills. Similarly, dogs harass and kill Key Deer and other pinelands fauna.

Impoundments within pinelands can drastically change the local soil moisture regime and cause the suffocation of roots and the corresponding death or dieback of plants. Following a hurricane, these impoundments may hold saltwater for periods long enough to cause damage to plants.

Another secondary impact of development is the introduction of exotic plants and animals. In some cases, as with landscape plants for instance, introductions are purposeful. The major offenders, however, are exotic species that prefer disturbed sites and consequently tend to characterize the environs of developed features. Brazilian Pepper (*Schinus terebinthifolius*), and Australian Pine (*Casuarina equisetifolia*) are the most invasive forms in Monroe County. Unfortunately, exotic species that populate disturbed sites constitute a reservois from which these invasive forms can colonize unmodified pinelands when natural forces (such as fire or hurricane) rekindle the successional sequence.

Another adverse impact associated with development is the excavation of wells, canals and mosquito control ditches. Here the potential damage is more subtle and less easily quantified. On the larger keys a freshwater "lens" -- a subterranean reservoir of rainwater that has percolated through the overlying soil and limestone -- rests above the denser saltwater that has seeped in laterally. The principal impact of wells is to diminish these lenses through the direct withdrawal of fresh water. Canals and mosquito control ditches carry away fresh water that would otherwise provide recharge and also provide an avenue whereby saltwater can reach and contaminate these lenses. It is reasonable to assume that such reductions of groundwater availability will adversely affect overlying ecosystems, including pinelands, although this has not been demonstrated.

Mosquito spraying in pinelands can severely reduce the population of their insect inhabitants including species essential to pollination. The damage attributable to such spraying is compounded by the openness of the pineland canopies that allows extensive penetration.

There exists another dimension to the extent of damage inflicted by humans on pinelands and other terrestrial ecosystems in the Florida Keys. This is the reduction of large natural expanses to small isolated patches of habitat. This destabilizes the habitat type by complicating recovery from disturbance (since source areas for floral or faunal repopulation may be distant) and reducing the populations of wid ranging forms. Key Deer, for instance, may move between the remnants of a formerly contiguous ecosystem and thereby be exposed to traffic (the primary source of mortality), dogs, hunters and other limiting influences.

TABLE 1

ENDEMIC PLANTS OF SOUTH FLORIDA PINELANDS
Species found in the Florida Keys*

Species	Habitat	Range
Argythamniablodgettii	pinelands	Keys and mainland
Cassia keyensis	pinelands	Keys**
Chamaesyce deltoidea var. serpyllum	pinelands	Keys**
C. garberi	pinelands, hammocks sand dunes	Keys and mainland
C. porteriana var. keyensis	pinelands, dunes	Keys**
C. porteriana var scoparia	pinelands	Keys, possibly Big Cypress
Croton arenicola	pinelands, dunes	Keys and mainland
Evolvulus sericeus var averyi	pinelands	Keys and mainland
Gerardia keyensis (Agalinis)	pinelands	Keys**
Linum arenicola	pinelands	Keys and mainland
Melanthera parvifolia	pinelands	Keys and mainland
Phyllanthus pentaphyllys var floridanus	pinelands	Keys and mainland
Schizachyrium sericatum	pinelands	Keys**
Tragia saxicola	pinelands	Keys and mainland

* according to Avery and Loope (1980)
** endemic to the Keys only

(10) FRESHWATER WETLANDS

Small expanses of freshwater wetlands occur, primarily in the Lower Keys, as vestiges of the more expansive systems that existed prior to the 1950's. The diminution of these wetlands has resulted from filling for development and draining for mosquito control.

Biota

Both Cowardin (1979) and Clark (1977) characterize freshwater wetlands by the presence of erect, graminoid vegetation rooted in poorly drained, saturated soils which are rich in organics. Wetlands are flooded either permanently or for a sufficient period each year to support communities of waterdependent plants. Two types of freshwater wetlands occur in the Keys. The most extensive is the Sawgrass (Cladium jamaicense) - dominated marsh. Keys' sawgrass marshes are quite different from the vast sawgrass marshes of the Everglades where a tall (6-10 foot) dense monoculture of sawgrass occurs on deep (2 feet), peaty soils which are covered by water for most of the year. In the Keys, small, disjunct, sawgrass-dominated associations occur on much shallower soils are individual plants are much smaller. Other species common to Keys' sawgrass marshes include: Saw Sedge (Cyperus ligularis), White-top Sedge (Dichromena floridensis), Leather Fern (Acrostichum sp.), False Foxglove (Agalinis spp.), Aster (Aster tenuifolius), Broom Sedge (Andropogvon glomeratus) and Buttonwood (Concocarpus erectus). Two vines--Mangrove Rubber Vine (Rhabdadenia biflora) and Wild Allamanda (Urechites lutea) -- as well as a variety of bromeliads, occasionally occur on the Buttonwoods.

Sawgrass occurs ubiquitously in both fresh and brackish wetlands. In areas which contain brackish water or slightly saline soils, the association often includes other salt tolerant forms including the sedges Fimbristylis castanea and F. spathacea, and the grasses Sporobolus virginicus and S. domingensis. In these areas, Buttonwood and mangroves frequently occur. In small, shallow solution depressions on Big Pine, No Name, Cudjoe and Sugarloaf Keys, dense stands of Saw Palmetto (Serenoa repens) are found closely associated with sawgrass.

The other type of freshwater wetland found in the Keys is the Cattail marsh. This marsh occurs much less frequently than the Sawgrass association but occurs on Knockemdown, Big Pine, Little Torch, Middle Torch, Sugarloaf and Cudjoe Keys. Narrow, linear stands of Cattail (Typha sp.), established in mosquito ditches, occur throughout the Lower Keys. These marshes are flooded by freshwater during the wet season and contain wet to moist soils throughout the year since their deep, organic layer has a high water-holding capacity.

It appears that the portions of this habitat which have the deepest, organic soils support almost pure stands of Cattail. On the higher periphery of the marsh, Spike Rush (Eleocharis cellulosa) and Sawgrass occur. The Spike Rush often occurs in pure stands just a few inches below the Sawgrass and is also found in brackish salt ponds. Buttonwoods and occasional mangroves occur on the borders of the marsh supporting mixed populations of bromeliads, i.e. Tillandsia spp. and, at one time orchids, e.g. Encyclia teampensis, which require a high relative humidity. Because cattail marshes naturally occur well within the confines of hammocks protected from the xeric atmospheric conditions characteristic of more open areas of the Keys, they are probably subjected to saline influences only during hurricanes.

Freshwater marshes normally support a highly diverse and abundant fauna which includes fish, invertebrates, amphibians, reptiles, birds and mammals. On the mainland of South Florida, they are critical to the reproductive success of animal populations which bear young during the dry season. Here, they are habitat for the threatened American Alligator (Alligator mississippiensis) and the endangered (state) endemic Key Mud Turtle (Kinosternon bauri bauri). The recently described Silver Rice Rat (Oryzomys arentatus) was originally discovered in a Cattail marsh on Cudjoe Key (Spitzer & Lazell, 1978).

According to Jacobsen (1983), the small, isolated population of alligators in the lower Keys (Big Pine, Little Pine and No Name Keys) is dependent upon preservation of freshwater habitats in this area. Lazell (Pers. Comm.) believes that the optimal habitats of the mud turtle are small fresh or slightly brackish ponds in or at the edges of hardwood hammocks. The various frog species of the Keys as well as the Florida Ribbon Snake (Thamnophis sauritus sackeni) require freshwater habitats during at least a portion of their life history.

The federally-endangered Key Deer (Odocoileus virginianus clavium) is only found on those islands which contain both food and fresh water. Although this animal moves out from Big Pine/No Name Keys (population center) during the wet season, it returns here during the drier months. Maintenance of aboveground, freshwater resources in undeveloped areas is therefore critical to its survival.

Freshwater marshes are important to both resident and migratory bird populations. During the dry season, freshwater wetlands are the only natural sources of water for the Key Deer.

Impacts

The impact of hurricanes on freshwater wetlands can be devastating. In addition to the outright destruction of the system's biota, the deposition of salt water can have an indirect adverse effect on its flora. Hurricane impact is discussed more fully in the section dealing with tropical hardwood hammocks.

Human impacts which most affect freshwater wetlands include filling, mosquito ditching and the dredging of upland canals and borrow pits. While filling directly eliminates this habitat, dredging is believed to diminish surface freshwater resources. The blasting and dredging, which accompanies canal and borrow pit construction, exposes shallow, water-containing strata of bedrock to salt water intrusion and evaporation. This lowers freshwater levels in ponds and marshes thereby decreasing the size of this habitat and diminishing, or making unpalatable, drinking water supplies available for wildlife. This problem is especially important to the Key deer populations on No Name and Big Pine Keys, islands with the archipelago's largest fresh, groundwater resources.

Mosquito ditches, which are widespread in the lower Keys, have had disastrous consequences for freshwater wetlands. The ditches were intended to drain or bring in tidewater to upland areas which contained standing water, which were believed to be mosquito breeding areas. As a consequence, numerous freshwater wetlands were drained or subjected to saltwater intrusion, thereby creating a brackish mixture in what was historically a freshwater habitat. Ultimately, salt tolerant vegetation displaced freshwater-dependent species and much freshwater wildlife habitat was lost. Ironically, many of these ditches, since they are not maintained, have become cut off from surface tidal influence, and therefore contain freshwater during the wet season--the period of maximum mosquito activity. These ditches also tend to trap deer fawns. The ditches do, however, provide limited habitat for Cattails and Leather Fern as well as alligators and small fish.

(11) PLANTS AND ANIMAL SPECIES OF SPECIAL STATUS

Table 1: PLANT SPECIES OF THE FLORIDA KEYS WITH SPECIAL STATUS

SCIENTIFIC NAME	COMMON NAME	STATUS: STATE	FEDERAL	FCREPA
Acrostichum aureum	Golden Feather Fern	THR	None	Rare
Acrostichum danaeifolium	Leathern Fern	THR	None	None
Anemia adiantifolia	Pine Fern	THR	None	None
Campyloneurum phyllistidis	Strap Fern	THR	None	None
* Cassia Keyensis	Big Pine Partridge Pea (Key Cassia)	END	UR	THR
Catesbaea parviflora	Small Flowered Lily Thorn	END	END	END
Cereus gracilis	Prickly Apple Cactus	END	UR	THR
Cereus pentagonus	Barbed Wire Cactus	THR	None	None
Cereus robinii	Tree Cactus	END	END	END
Chrysophyllum oliviforme	Satin Leaf	THR	None	None
Clusia rosea	Balsam Apple (USA)	END	None	EXTINCT
Coccothrinax argentata	Silver Palm	END	None	THR
Cordia sebestena	Geiger Tree	THR	None	None
Cupania glabra	Cupania	END	None	END
Enclyclia boothiana	Dollar Orchid	END	UR	None
Encyclia tampensis	Butterfly Orchid	THR	None	None
Eugenia confusa	Redberry Stopper	THR	None	None
Guaiacum sanctum	Lignum Vitae	END	None	None
Habenaria quinquesta	Michaux's Orchid			
Hippomane mancinella	Manchineel	THR	None	THR
Jacquinia Keyensis	Joewood	THR	None	None
Mallotonia gnapholodes syn: Tournefortia gnaphalodes	Sea Lavendar	END	None	THR
Microgramma heterophylla syn: Polypodium heterphyllum	Vine Fern			
Opuntia spinosissima	Semaphore Cactus			
Pseudophoenix sargentii	Buccaneer Palm	THR	None	END
Pteris longifolia var. bahamensis	Ladder Brake	THR	None	None
Scaevola plumieri	Scaevola	END	None	None
Strumphfia maritima	Pride of Big Pine	END	None	END
Suriana maritima	Bay Cedar	END	None	None
Swietenia mahagoni	Mahognay	THR	None	None
Thrinax morrisii	Florida Thatch Palm	THR	None	THR
Thrinax radiata	Key Thatch Palm	THR	None	THR
Tillandsia balbisiana	Reflexed Wild Pine Airplant	THR	None	None
Tillandsia circinata syn. paucifolia	Twisted Airplant	THR	None	None
Tillandsia fasciculata	Wild Pine Airplant	END	None	None

Tillandsia Flexuosa	Banded Wild Pine Airplant	THR	None	THR
Tillandsia setacea	Needle-leaved Airplant	THR	None	None
Tillandsia utriculata	Giant Airplant	THR	None	None
Tillandsia valenzuelana	Soft-leaved Wild Pine			
Vanilla barbellata	Worm Vine Orchid	THR	None	THR
Vittaria lineata	Shoestring Fern	THR	None	None

KEY:

FCREPA = Florida Committee on Rare and Endangered Plants and Animals
END = Endangered
THR = Threatened
UR = Under Review
* = Endemic to Florida Keys

Table 2: ENDANGERED AND THREATENED FAUNA OF THE FLORIDA KEYS

SCIENTIFIC NAME	COMMON NAME	STATUS: STATE	STATUS: FEDERAL
FISHES:			
*Menidia conchorum	Key Silverside	END	None
AMPHIBIANS AND REPTILES:			
Alligator mississippiensis	American Alligator	(SSC)	THR
Caretta caretta carretta	Atlantic loggerhead turtle	THR	THR
Chelonia mydas mydas	Atlantic green turtle	END	END
Crocodylus acutus	American crocodile	END	END
*Diadophis punctatus acricus	Big Pine Key ringneck snake	THR	UR
Dermochlys coriacea	Leatherback turtle	END	END
Drymarchon corais couperi	Eastern indigo snake	THR	THR
Eretmochelys imbricata imbricata	Atlantic hawksbill turtle	END	END
*Kinosteron bauri bauri	Key mud turtle	END	UR
Lepidochelys kempi	Atlantic ridley turtle	END	END
*Storeria deKayi victa (Lower Keys only)	Florida brown snake	THR	UR
Tantilla oolitica	Miami black-headed snake	THR	UR
*Thamnophis sauritus sackeni	Florida ribbon snake (Lower Keys only)	THR	None
BIRDS:			
Charadrius aleandrinus tenuirostris	Southeastern snowy plover	END	UR
Columba leucocephala	White-crowned pigeon	THR	UR
Falco peregrinus	Peregrine falcon	END	END
Haliaeetus leucocephalus	Bald eagle	THR	END
Mycteria americana	Wood stork	END	UR
Pelecanus occidentalis carolinesis	Eastern brown pelican	THR	END
Sterna dougallii	Roseate tern	THR	UR
Sterna antillarum	Least tern	THR	None
MAMMALS:			
*Neotoma floridana smalli	Key Largo wood rat	END	END

*Odocoileus virginianus clavium	Key deer	THR	END
*Oryzomys argentatus	Silver rice rat	END	UR
*Peromyscus gossyupinus allipaticola	Key Largo cotton mouse	END	END
*Procyon lotor auspicatus	Key Vaca raccoon	THR	UR
Trichechus manatus latoristris	West Indian Manatee	END	END

INVERTEBRATES:

*Heraclides aristodemus ponceanus	Schaus' swallowtail butterfly	END	END
*Orthalicus reses	Stock Island tree snail	THR	THR

KEY:

END = Endangered
THR = Threatened
UR = Under Review
SSC = Species of Special Concern
* = Endemic to Florida Keys

(12) EVALUATION AND RANKING OF FLORIDA KEYS HABITATS

The Florida Keys Habitats were broken down into ten groups for the purposes of evaluation of impacts. Three matrices were developed. The first (Table A) is an impact matrix on habitat structure and function which categorizes the activities within and adjacent to the particular type habitat types which exist on the Keys. The second and third matrices (Tables B and C) are sensitivity matrices involving habitat type and an evaluation of the potential for impacts for each system. The impact matrix on habitat structure and function presents the detailed level of evaluation of impacts while the sensitivity matrices provide an evaluation of a variety of parameters which may affect each habitat type.

Impact Matrix on Habitat Structure and Function

Habitat types in this matrix (Table A) were broken down into eight groups with mangroves treated as a single type and freshwater wetlands also classed as a single type. Activities which were deemed important to these systems were listed and numerical levels assigned to each. The numerical ratings were as follows: 3 = high impacts, 2 = moderate impacts, 1 = low impacts, 0 = not applicable. This numerical arrangement provides the opportunity for ranking the particular habitats according to the specific impacts of all possible activities which occur within or adjacent to these sites. A general discussion of each activity or impact is presented below along with a discussion of individual impacts in each habitat characterization.

Impact Activities in Florida Keys Habitats

Dredging Dredging activities or the excavation of materials from all habitat types produce significant impacts. Once removed, habitats which have been dredged out become very difficult to reestablish. In the Keys most of the habitats are very fragile and any significant dredging within these sites produces effects which are often deleterious. Adjacent activities are generally less destructive to habitat types, however, in the case of habitats such as freshwater wetlands and pinelands, the impacts can be very severe due to lowering of the water table.

Filling. Filling of habitats within the Keys basically destroys all existing plant communities. Also, most fill material does not match the soil type of the area which is being filled resulting in the production of an unsuitable substrate for any restoration potential of the particular type of habitat.

In the case of mangroves, elevational increases due to filling often lead to other habitat types such as uplands. In most cases fill materials serve as substrates for exotic plants such as Brazilian Pepper. After colonization by exotic species, succession to endemic communities generally does not occur on the Keys.

Impoundment. Impounding water on upland habitats such as pinelands and hammocks generally results in severe impacts due to the increased water regime on these sites. This is also true for the impounding of water on mangroves and transitional habitats and by disruption of the food web in these systems. Impacts are generally less in the transitional habitats and mangroves due to less reliance of the plant species in these areas on insect pollenators and tidal pulses which generally dilute the pesticides.

Road Construction. Road construction involves both the movement of dirt and filling operations in all types of habitats. Some grading and ditching operations may also result in either impoundment or drainage of habitat types. Road construction is generally more servere in freshwater wetlands, salt ponds and beaches and berms since these activities can seriously disrupt these habitats.

In the case of hammocks and transitional habitats, road construction can result in the removal of the existing vegetation and, where deposition or grading occurs, lead to invasion by exotic species. In general, an opening of the hammock habitat upsets the delicate climatological regime within these areas, thus leading to the general demise of the system. In the case of mangroves, some impacts may occur on these areas either from the filling or deposition of materials. Road construction activities generally result in a change in grade or elevation of these sites which either increases or reduces the intertidal regime for these sites. This action can lead to different community types depending on final elevations.

Utilities. Utility construction in wetland areas generally results in little impacts. Some clearing may be necessary for the initial right-of-way construction; however, the vegetative communities which dominate in both the fresh and saltwater wetlands are usually not high enough to interfere with powerlines. Digging and refilling for underground utilities should result in littlg longterm impacts if elevations are restored to preconstruction levels in these habitats.

In the case of pinelands and hammocks, utility construction results in severe impacts in these areas due to removal of the canopy trees to prevent interference with powerlines and root growth over pipelines.

Utility construction in adjacent areas generally leads to little impacts except for moderate impacts in hammocks. Agains, any changes brought about such as opening of the canopy can produce significant impacts away from the actual construction site.

Land Clearing.Land clearing in any type of habitat results in immediate destruction of the vegetative communities and subsequent loss of habitat for faunal species which occupy these areas. In many cases, the amount of time for revegetation of cleared sites is extremely long due to the successional seres through which many of the communities have to undergo to reach a climax state. In the case of clearing of pines and hammocks it is likely that heavy invasion by exotics would preclude any revegetation of the sites by many endemic species.

Land clearing in adjacent sites generally has little impact on the habitats in surrounding areas, however, fragile beach and berm overstories and hammock overstories may be significantly affected by microclimate changes in surrounding sites.

Sewage disposal. In general, sewage disposal would have little effect on the plant communities in wetland areas except for salt ponds. In these areas the fragile balance of hypersaline conditions can be upset by the introduction of water from sewage disposal. This activity can result in the decreased salinities leading to more freshwater systems. Some impacts would also be serious in areas such as hammocks and possibly pinelands where increased fresh water into these systems can change the soil moisture regimes and lead to succession to a wetter habitat such as a freshwater marsh.

Sewage disposal in adjacent areas generally would have little impact on any of the communities or habitat types found in the Florida Keys.

Landfill operations. Landfill operations in any habitat results in the obliteration of existing communities and also generally provides higher elevations. Any increase in elevation obviously completely wetland areas to nonwetland sites. In the Keys, disposal is generally by landfill buildup with some material placement over the site. If allowed to revegetate, any of these areas would generally succeed to upland communities; however, the invasion of exotics into these sites should be significant and upset any normal successional regime which would naturally occur on these sites.

Disposal operations in adjacent areas should result in little impact to any of the habitat types in the Keys.

Debris-Solid waste disposal. In many parts of the Keys a significant amount of debris can be found from haphazard disposal operations which have occurred in the past and are still continuing today. Disposal within hammocks generally would result in the addition of combustible materials which could increase fire hazards in these areas and areas such as pinelands and beaches and berms.

In the case of freshwater wetlands and salt ponds, any addition to these sites could cause significant impacts. Also, disposal operations in many of the habitat types could open up the canopy or cover the existing vegetation and introduce seed stock of exotic species which often outcompete endemic plants.

Consumptive water use - Domestic. Consumptive water use in all habitats found on the Keys should generally result in insignificant impacts except for those particular areas such as pinelands which depend upon the fragile balance of water for maintaining plant succession. Usually removal of freshwater for septic tank systems results in return flows back into the ground producing little net change in water balance for a particular site.

The impacts of consumptive use of water in adjacent areas would probably be low for most habitats, however, if very small freshwater systems are impacted, animals in adjacent areas may be deprived of water sources. For example, many animals such as the Key deer may travel fairly long distances to a particular freshwater area for water. Moderate impacts could generally be expected from disposal of water in adjacent areas to habitats such as pinelands which could suffer from higher water tables.

For individuals utilizing water from the pipeline and subsequently disposing in septic tanks, the impacts could be more significant in drier habitats such as pinelands and hammocks due to the net increase in freshwater to these sites.

Consumptive water use - Commercial. Any significant amount of water which would be utilized from freshwater wetlands on a commercial basis could severely impact these areas, whether the water is taken from within the site or from adjacent sites. Net losses of water from freshwater wetlands could quickly reduce these areas to dry habitats; however, the likelihood of any significant commercial use from any of these areas is very small.

In adjacent areas, the impacts of consumptive use of water would probably be low; however, if very small freshwater systems are impacted, animals in adjacent areas could be deprived of water sources.

Settlement. Settlement activities generally involve both the direct loss of habitat and the introduction of people and pets to these sites. Direct loss of habitat from settlement is generally severe since structures placed over the existing habitat, if not permanent, result in long-term loss. Settlement in adjacent areas may often result in significant impact due to the introduction of domestic pets, especially dogs, which can severely deplete or have an impact on deer populations and other species such as rabbits.

Vehicular traffic (on road). Activities from vehicular traffic on roads are related to the increased encounter of both people and automobile with animal species in the areas. In general, the most significant impacts would be related to vehicular traffic through pinelands where species such as the endangered Key deer may be impacted both within its habitat range and within adjacent areas due to encounters with automobiles.

Freshwater wetlands may also be significantly impacted by vehicular traffic due to the possible close proximity to these sites and possible impacts on faunal species which travel to these sites for water. Areas such as transitional habitats and uplands and mangroves would be least impacted by these areas. Salt ponds would also suffer little impact except for disturbance to wading birds which utilize these sites.

Recreation. Recreation impacts can be generally severe in those areas for which there are small acreages of habitat remaining on the Keys. Any kind of recreational activity such as the use of all terrain vehicles, and even hiking, plant collecting, and other activities can result in the significant degradation of habitats. When man enters these areas, his movement through these sites can change community succession and result in an upset in the successional sere for these sites. Animal populations which occupy these areas can also be significantly impacted such as the impact on the Key Largo woodrat in transitional habitats.

Recreational activities in adjacent areas generally would provide little impact except for areas such as freshwater wetlands and salt ponds of which the faunal constituency could be impacted by greatly increased contact with recreationists.

Toxic wastes. Toxic waste disposal activities in areas such as freshwater wetlands, salt ponds and beaches and berms could be very significant due to the small amount of habitat which exists of these areas. Also any toxic waste which would be introduced into freshwater wetlands, the source of drinking water for many endangered species and other faunal components, would greatly affect these areas.

In general, toxic waste disposal in areas away from sites or adjacent to habitat types would result in minimal impacts unless some transport of the toxic waste occurred through overland flow or other means into surrounding communities. In the case of freshwater wetlands and salt ponds any small amount of toxic waste which could be transported or would flow into these areas could result in significant environmental impacts.

Ranking of Impacts on Habitat Structure and Function. The bottom of Table A shows the ranking of the particular habitats found on the Florida Keys according to the within/adjacent activities which may affect these sites. The sites which could potentially suffer the most serious impacts or be most sensitive to most impacts include pinelands, freshwater wetlands and hammocks. These fall into the category of high impact. Those in the moderate category include salt ponds and beaches and berms. Those ranked according to the least potential for impact activities include transitional habitats and mangrove communities.

Sensitivity of Florida Keys habitats to impacts. Tables B and C are primary sensitivity matrices for Florica Keys habitats. In Table B the ten habitat types are presented according to rarity of the systems, resilience, restoration potential and the number of threatened and endangered plant and animal species which are found in these areas. Freshwater wetlands were divided into typha marshes and cladium marshes in the sensitivity matrices due to the dissimilarities and general functions of these sites. Typha marshes make up only a very small percentage of the communities in the Florida Keys. Mangroves were also divided into scrub mangroves and fringing mangroves in the sensitivity matrix. As for freshwater wetlands, significant differences exist between the scrub and fringing mangrove communities. Also, some of the impacts for these sites can vary due to differences in tidal amplitudes and differences in primary producitivities of these communities.

The resilience factor is based on the impact matrix in Table A on habitat structure and function. The ratings for habitats are broken down into very rare, rare, moderately rare and common for the rarity index; low, moderate and high for resilience index; and low, moderate and high for restoration potential of these sites. The total number of threatened and endangered species is given for each habitat unit.

Rarity. The rarity of the habitat types within the Keys was ranked according to very rare, rare, moderately rare and common or on the basis of acreages of the habitats which occur on the Keys. The rarest community types consist of the typha marshes and the beach and berm communities. Only a very small acreage of typha marsh exists on the Florida Keys and should likely be considered in a category of its own, however, beaches and berms are also very rare and fragile systems which occur on the Keys. Those types falling into the rare category are the cladium marshes, saltponds and pinelands. Transitional wetlands and hammocks are considered to be moderately rare or basically in between the common or frequently occurring mangroves and communities such as pinelands.

Resilience. The resilience of communities to impact activities both within and adjacent was ranked according to the impact matrix on habitat structure and function in Table A. Those areas with the lowest resilience or ability to withstand impacts include pinelands, hammocks, and typha and cladium marshes. Those with the highest resilience or the potential to withstand impacts were transitional uplands and the mangrove communities.

Restoration potential. The restoration potential for the habitats which are found on the Keys relates to the ability to restore these areas to their original or natural conditions after impact activities have occurred. In the case of areas such as pinelands, beaches and berms, hammocks and typha marshes, restoration would be very difficult. For example, pinelands would be difficult to restore to their successional sere due to the potential for invasion of sites by exotics. It is very unlikely that any pineland community could ever be restored from a prisere situation again in the Keys due to exotic. Hammocks would also be difficult to restore due to exotic invasion and the difficulty of obtaining propagule sources for replanting sites of this type.

Typha marsh communities on the Keys would also very likely be difficult to restore due to the fragile nature and the very rare occurrence of these areas on the Keys. On the other hand, cladium marshes occur in much greater numbers and different physical settings on the Keys; therefore, restoration should be easier for these sites.

Salt ponds and transitional habitats also have some restoration potential, however, it is difficult to judge the potential for salt pond restoration. Any inability of the soil or substrate to hold water would prevent restoration of a salt pond. Also, the physical features and elevations surrounding these sites would likely be difficult to duplicate.

Transitional uplands or buttonwood communities are often invaded by exotics are disturbance. This factor would likely preclude succession back to transitional habitats. Transitional habitats or salt marsh communities could be established given enough time and money which could be devoted to the effort; however, exacting requirements of final elevations within the tidal regime make reestablishment of these areas more difficult than mangrove systems which occupy greater tidal ranges than Key salt marshes.

Mangroves have the highest restoration potential for the Keys due to the physical setting for these sites. In the case of mangroves, it is very likely that restoration could be complete in many cases where final elevations and tidal exchange could be accomplished. Propagule sources are readily available for these areas and a significant amount of research on establishment has been conducted for these habitats.

Threatened and endangered species. Plant and animal species which were listed as either threatened or endangered by either the State of Florida or the U. S. Department of Interior are also shown in Table B. Hammocks rank much higher than the other habitat types due to the large number of threatened and endangered plants which occur in these areas. Thirty eight species occur in this habitat type. Other areas which ranked high are transitional uplands and pinelands. These are followed by beaches and berms which the other habitat types ranking down to salt ponds which have no endangered plants and only three endangered animals which utilize these areas.

Sensitivity ranking of Florida Keys habitats. Table C is a numerical rating for all of the factors which were considered in Table B. The numerical system is based on a ranking of totals of the rarity, resilience, restoration potential and threatened and endangered species. The habitats with the highest potential and threatened and endangered species. The habitats with the highest potential for impacts are the hammocks and pinelands. These sites would be very difficult to restore and have low resilience to the classes of impacts which were considered in this study. As previously discussed, restoration or natural succession to mature habitats of these two types would be very difficult if not impossible under most settings in the Keys.

Beaches and berms ranked second in the potential for impacts, again due to their rarity and low restoration potential. These areas are often dependent upon a single storm event for either creation and/or nourishment. Many years would elapse before these sites would be restored, if ever.

Typha marshes also rank high in the potential for impacts. As was previously noted only a very small acreage of these wetlands exist on the Keys and any significant activity could completely eliminate these sites. These sites also serve as the only substantial sources of freshwater for species such as the endangered Key deer during extremely dry periods. This factor adds greatly to their importance.

Those habitats ranking intermediate in potential for impacts include freshwater cladium marshes, transitional uplands and salt ponds. These areas generally rank intermediate in resilience and in threatened and endangered species (except for transitional uplands). Restoration potential of these sites is also moderate. In the case of salt ponds and cladium marshes, these areas are quite rare; however, they also can be restored if engineering techniques for restoration can be developed in the future.

Those habitats ranking lowest on the impact scale include transitional wetlands and fringing and scrub mangrove communities. As for the impact matrix on habitat structure and function (Table A) these sites generally rank lower in all categories for potential for impacts. These areas are generally low in number of endangered and threatened species and have high restoration potential and resilience to impacts.

In the case of the mangrove communities, the acreage of these habitats on the Florida Keys is much greater than any of the other habitat types. A great deal is known about these sites from the standpoint of productivity and functional capacity; however, when viewed solely on the potential for sensitivity and from an overall environmental viewpoint, these sites rank highest for development potential of the Keys habitats.

Table A. Impact matrix on habitat structure and function, Florida Keys (NOTE - The two numbers in each space correspond to impacts as follows: Activity occurring within habitat/Activity occurring adjacent to habitat).

Activities Within/ Adjacent	Habitat Types: FW Wetlands	Salt Ponds	Beaches & Berms	Pine-lands	Hammock	Trans. Wetlands	Trans. Uplands	Mangroves
Dredge	3/3	3/1	3/1	3/3	3/2	3/1	3/1	3/1
Fill	3/1	3/1	3/1	3/1	3/1	3/2	3/1	3/2
Impoundment	1/1	2/1	0/0	3/2	3/2	3/2	3/2	3/1
Mosquito Ditching	3/3	3/1	3/1	3/2	3/1	2/1	2/1	1/1
Mosquito Spraying	3/2	3/2	2/2	3/1	2/1	1/1	2/1	1/1
Road Construction	3/1	3/1	3/1	2/1	3/2	3/1	2/1	3/2
Utilities	1/1	1/1	1/1	3/1	3/2	1/1	1/1	1/1
Land Clearing	3/1	0/2	3/2	3/1	3/2	3/1	3/1	3/1
Sewage	1/1	3/1	1/1	2/1	3/1	1/1	1/1	1/1
Landfill	3/1	3/1	3/1	3/1	3/1	3/1	3/1	3/1
Debris-Solid Waste	2/1	2/1	2/1	2/1	2/1	1/1	1/1	1/1
Consumptive Water Use. Domestic	1/1	0/0	0/0	2/2	1/1	0/0	0/0	0/0
Consumptive Water Use. Commercial	3/3	0/0	0/0	2/2	1/1	0/0	0/0	0/0

Table A. Impact matrix on habitat structure and function, Florida Keys (concluded)

Activities Within/ Adjacent	Habitat Types FW Wetlands	Salt Ponds	Beaches & Berms	Pine-lands	Hammock	Trans. Wetlands	Trans. Uplands	Mangroves
Settlement	3/2	3/2	3/2	3/3	3/2	3/2	3/2	2/1
Vehicular Traffic (on-road)	3/2	1/1	2/1	3/3	2/1	1/1	1/1	1/1
Recreation	3/2	3/2	3/1	3/1	2/1	3/1	3/1	1/1
Toxic Waste	3/2	3/2	3/1	1/1	1/1	1/1	1/1	1/1
Totals:	42/28	36/20	35/17	44/27	41/23	32/18	32/17	28/17
Rank*	2	4	5	1	3	6	7	8

3 = High; 2 = Moderate; 1 = Low; 0 = Not Applicable

* Ranked according to sensitivity to impacts

Table B. Primary sensitivity matrix of Florida Keys habitats

	Potential for Impacts			Threatened & Endangered spp.				
			Restoration	Plants		Animals		
Habitat Type	Rarity	Resilience*	Potential	E	T	E	T	Totals
FW wetlands Typha marsh	very rare	low	low	0	2	2	1	5
FW wetlands Cladium marsh	rare	low	moderate	0	2	2	1	5
Beaches and Berms	very rare	low	low	3	0	2	3	8
Salt Ponds	rare	moderate	moderate	0	0	3	0	3
Pinelands	rare	low	low	3	3	4	3	13
Hammocks	mod. rare	low	low	7	20	5	6	38
Trans. Uplands	mod. rare	moderate	moderate	1	8	2	1	12
Trans. Wetlands	mod. rare	moderate	moderate	1	0	3	1	5
Scrub Mangroves	common	high	high	0	0	5	0	5
Fringing Mangroves	common	high	high	0	0	5	1	6

* Based on impact matrix on habitat structure and function
High=44/27-41/23; Moderate=40/22-33/19; Low=32/18-28/17

Table C. Primary sensitivity numerical matrix of Florida Keys habitats

	Potential for Impacts/Rank					
Habitat Type	Rarity	Resilience*	Restoration Potential	Threat. & Endangered Species	Totals	Rank**
Pinelands	3	3	3	3	12	1
Beaches & Berms	4	2	3	2	11	2
Hammocks	2	3	3	4	12	1
FW wetlands Typha marsh	4	3	3	1	10	3
FW wetlands Cladium marsh	3	3	2	1	9	4
Salt Ponds	3	2	2	1	8	5
Trans. Uplands	2	1	2	3	8	5
Trans. Wetlands	2	2	2	1	7	6
Fringing Mangroves	1	1	1	2	5	7
Scrub Mangroves	1	1	1	1	4	8
	Very Rare=4 Rare=3 Mod. Rare=2 Common=1	Low=3 Moderate=2 High=1	Low=3 Moderate=2 High=1	16-38=4 11-15=3 6-10=2 0-5=1		

* Based upon impact matrix on habitat structure and function
High=44/27-41/23; Moderate=40/22-33/19; Low=32/18-28/17

** 1=Most sensitive; 8=least sensitive

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