

4.0 SCENARIO EVALUATION AND RESULTS

4.1 SCENARIOS

The evaluation of scenarios for the Florida Keys Carrying Capacity Study (FKCCS) involved both the interpretation of existing information and the analysis of future scenario conditions using the Carrying Capacity/Impact Assessment Model (CCIAM). The Government Study Team formulated six scenarios, which represent potential futures for the Florida Keys. In addition, the study addressed current conditions primarily through the interpretation of existing information, as well as by executing model analyses.

The first scenario, termed “Smart Growth,” provided by the local planners, was translated for input into the CCIAM. The scenario represents a moderate development scheme, in which future growth and development are intended to redevelop blighted commercial and residential areas, reduce sprawl, and direct future growth to appropriate infill areas. The Smart Growth Scenario, as provided by the Local Planners Working Group, is transcribed below:

“A Smart Growth initiative will be implemented in Monroe County to preserve the natural environment, redevelop blighted commercial and residential areas, remove barriers to innovative design concepts, reduce sprawl and direct future growth to appropriate infill areas.

All Conservation and Recreational Lands (CARLs) and any adjacent habitat areas will be closed to future development and purchased in an accelerated acquisition program. In sparsely developed areas, any land within 1,000 feet of the CARL/Habitat areas will also be designated for purchase.

Infill will only be permitted on suitable parcel subdivisions, which are at least 50 percent developed. A maximum of 3,000 scarified lots in these subdivisions will be permitted in a lottery system over the next 20 years. Scattered lands within subdivisions that contain habitat or “redflag” wetlands will be purchased and a conservation easement placed on the lots to prevent future development. Ocean Reef and other subdivisions, which are vested will continue to build out on lots with habitat, but red flag wetland lots will not be filled and developed.

In the Urban Residential District and the Suburban Commercial District in Key Largo/Tavernier, and from Stock Island to Big Coppit an additional 500 multi-family, affordable housing units will be developed on scarified lands at a density of 15 to 20 units per acre. Redevelopment of trailer parks and other substandard housing throughout the Keys will be at the existing density, above base flood, and with sanitary sewer.

Twenty-five percent of the existing commercial stock will be redeveloped, resulting in improved stormwater management and landscaping. Infill sites for commercial development will be within 200 feet of existing commercially developed areas. A total of 700,000 square feet of commercial will be permitted over the next 20 years either in expansion of existing uses or in infill sites.

Institutional uses will be deducted from the 700,000 square feet, although they will not have to compete for square footage.

Fifty percent of the existing Industrial and Marine Industrial sites will be cleaned up and redeveloped with stormwater management and landscaping. Future uses will be of a lighter industrial nature. All County owned buildings would be landscaped and retrofitted for stormwater management.

Two additional parks of 5-10 acres each will be developed in the Lower Keys: one on Big Pine Key and one on Sugarloaf Key.

With full implementation of the Overseas Heritage Trail and the Scenic Highway program, the entire U.S. 1 alignment will be landscaped. The stormwater management plan will be implemented on State and County roadways and for all new development. The sewer master plan will be fully implemented with the removal of all cesspits. An active program of water conservation will be instituted for existing development; the building code will assure new development conserves water.”

To exemplify the interpretation of scenarios in terms of model parameters, the choices made on the CCIAM Graphic User Interface (GUI) for the Smart Growth Scenario are summarized below (Table 4.1).

TABLE 4.1
CCIAM GUI CHOICES FOR SMART GROWTH SCENARIO

Vacant Land
Keys-Wide Except Ocean Reef
<ul style="list-style-type: none"> • Change vacant land parcels proposed for conservation by CARL and adjacent (300 ft distance) habitat to “Open Space.” • Change sparsely developed (<25 percent) subdivision Vacant Land lots containing habitat polygons within 1,000 feet of CARL to Open Space. • Change 3,000 scarified Vacant Land parcels, in moderately or densely developed (≥ 75 percent) subdivisions, with no wetland or habitat polygons to Residential at the existing density level of the subdivision. Apply default stormwater and wastewater treatment parameters. • Change Vacant Land and/or Commercial land within 200 feet of existing Commercial land to Commercial, with existing zoning to produce 700,000 square feet of commercial GFA.
Ocean Reef (Ocean Reef/PAED 21 (North Key Largo) Planning Area):
<ul style="list-style-type: none"> • Change all vacant land parcels with “red flag” wetlands to open space. • Change all other vacant land parcels to developed at the existing zoning and density for the area. Apply default stormwater treatment; apply existing wastewater treatment.
<ul style="list-style-type: none"> • Key Largo/Tavernier and Stock Island to Big Coppitt (PAED 15 (Tavernier), PAED 16 (Rodriguez Key), PAED 17 (Rock Harbor), PAED 18 (John Pennecamp State Park), PAED 19 and 20 (Garden Cove), PAED 21 (North Key Largo), Stock Island, and Boca Chica Planning Areas):
<ul style="list-style-type: none"> • Change scarified vacant land parcels zoned Urban Residential (UR) and Suburban Commercial (SC) to provide 500 multifamily units at a density of 15 units per acre (HDR classification). Apply default stormwater and wastewater treatment.

TABLE 4.1 (CONTINUED)
CCIAM GUI CHOICES FOR SMART GROWTH SCENARIO

Redevelopment
Keys-Wide
<ul style="list-style-type: none"> Query for Trailer Parks and “substandard lots” (residential, <5,000 ft² parcel, structure < 1,200 ft² and >25 years old); “Change From” existing residential density to same residential density, but apply base flood elevation and current zoning restriction. Apply default wastewater and stormwater treatment. Query for “blighted” commercial parcels (<19 percent FAR, structure assessed value < 33 percent of land value, structure < 1,200 ft² and >20 years old); “Change From” existing commercial density, but apply default stormwater and wastewater treatment for 25 percent of the parcels. Query for “blighted” industrial/marine industrial parcels (<19 percent FAR, structure assessed value < 33 percent of land value, structure < 1,200 ft² and >20 years old); Change from existing industrial to light industrial land use, and apply default stormwater and wastewater treatment for 50 percent of the parcels.
Retrofitting
<ul style="list-style-type: none"> Apply default stormwater and wastewater treatment to all county-owned lands parcels. Query for all parcels with “cesspit” as wastewater treatment. “Change from” wastewater treatment to default wastewater treatment. Apply default stormwater treatment default to all “Road” parcels on U.S. 1.
<ul style="list-style-type: none"> Water Conservation
<ul style="list-style-type: none"> Apply current building code water conservation defaults for parcels changed from Vacant Land to Residential, Commercial, or Industrial, and all redeveloped parcels.

The Government Study team provided the following five additional scenarios:

Scenario 1: Assume same amount of growth as in the Smart Growth scenario; assume necessary hurricane evacuation improvements (i.e., as recommended by Miller 2001) and potable water improvements (i.e., desalination plant).

The Hurricane Evacuation Study (Miller 2001) recommended the following structural improvements to U.S. 1:

- One additional northbound lane on U.S. 1 in Florida City.
- A three-lane on-ramp from U.S. 1 to northbound Florida’s Turnpike.
- One additional northbound lane with a fixed barrier in the median on the 18-mile stretch of U.S. 1.
- One additional northbound lane between milemarkers (MM) 90 and 106.6.
- A continuous three-lane section between MM 54.5 and MM 90.

- One northbound lane through the signalized intersection of U.S. 1 and Wilder Road in Big Pine Key.
- Redesign the intersection of Card Sound Road (C.R. 905A) and County Road 905 to provide a gentle northbound to westbound curve.
- One additional northbound lane from MM 47.6 to MM 48.

Scenario 2: Same as Scenario 1 but, in addition, assume preservation of all habitat areas and restore areas adjacent to existing similar habitat to create habitats of sufficient size and connectivity to be of ecological use to plants and animals.

In the analysis, the Technical Contractor interpreted “preservation” as the acquisition of vacant land for preservation. Potential restoration areas that would increase patch size and connectivity were evaluated.

Scenario 3: Same as Scenario 1 but assume an additional 500,000 annual visitors.

The additional annual visitors were added to the transient population. Assuming that visitors stay in the Florida Keys an average of 5.2 days, the annual number represents an additional 7,142 people on any given day. This amount was added to the functional population.

Scenario 4: Same as Scenario 2 but assume 1/3, 1/3, 1/3 cost sharing for land acquisition, road improvements, and sewer improvements between local, state and federal governments.

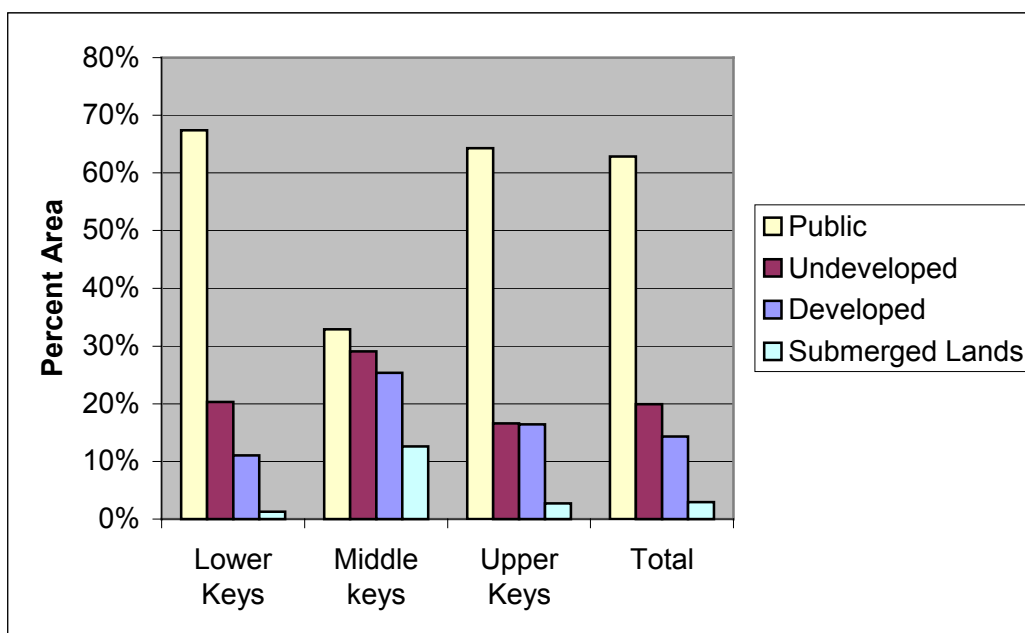
Scenario 5: Scenario 5 calls for a development pattern different from Smart Growth, with the following elements:

- 5,100 additional units over next 20 years (255 units/year x 20 years).
- 2,000 of those units are concentrated in Marathon in an infill pattern (i.e., Grassy Key).
- Full implementation of wastewater and stormwater improvements in Marathon as recommended in master plans.
- Sewering of three hot spots in Upper Keys, sewerage of Bay Point, and sewerage of Stock Island.
- For Key West, assume complete implementation of stormwater improvements and only redevelopment.
- Development throughout remaining area of Keys as with Smart Growth Scenario but with preservation and restoration as described in Scenario 2.
- Necessary potable water and hurricane evacuation improvements, and
- 1/3, 1/3, 1/3 cost sharing for land acquisition, sewerage, and hurricane improvements between local, state, and federal governments.

4.2 LAND USE AND DEVELOPMENT SUITABILITY

Nearly 15 percent of the land area in the Florida Keys is developed (Figure 4.1), and over 60 percent is undeveloped and in public ownership, much of it under conservation. The pattern is similar in the Upper and Lower Keys. The Middle Keys show less public lands and more development. While the majority of the private lands are vacant (Figure 4.2), over 50 percent of the private vacant lands are deemed unsuitable for development (Figure 4.3) based on the developability criteria used in the FKCCS (Section 3.4.2). Approximately 22,600 privately owned parcels remain undeveloped; over 15,000 of them are unsuitable for development. The suitability analysis performed for the FKCCS indicates that less than 10 percent of the acreage of private vacant lands is suitable or moderately suitable for development (Figures 4.4 and 4.5).

FIGURE 4.1
OWNERSHIP AND DEVELOPMENT STATUS OF LANDS IN THE FLORIDA KEYS



The effects of the suitability analysis are reflected in the implementation of the scenarios in the CCIAM. For example, the Smart Growth Scenario calls for 3,000 additional units on subdivisions that are at least 50 percent developed. The scenario also describes other criteria. The CCIAM applied development suitability criteria and generated 2,803 additional units, underscoring the limited availability of suitable land for development in the Florida Keys. Similarly, the CCIAM generated 1,551 additional units in Marathon when it ran Scenario 5.

FIGURE 4.2
SUMMARY OF LAND USE DISTRIBUTION IN THE FLORIDA KEYS

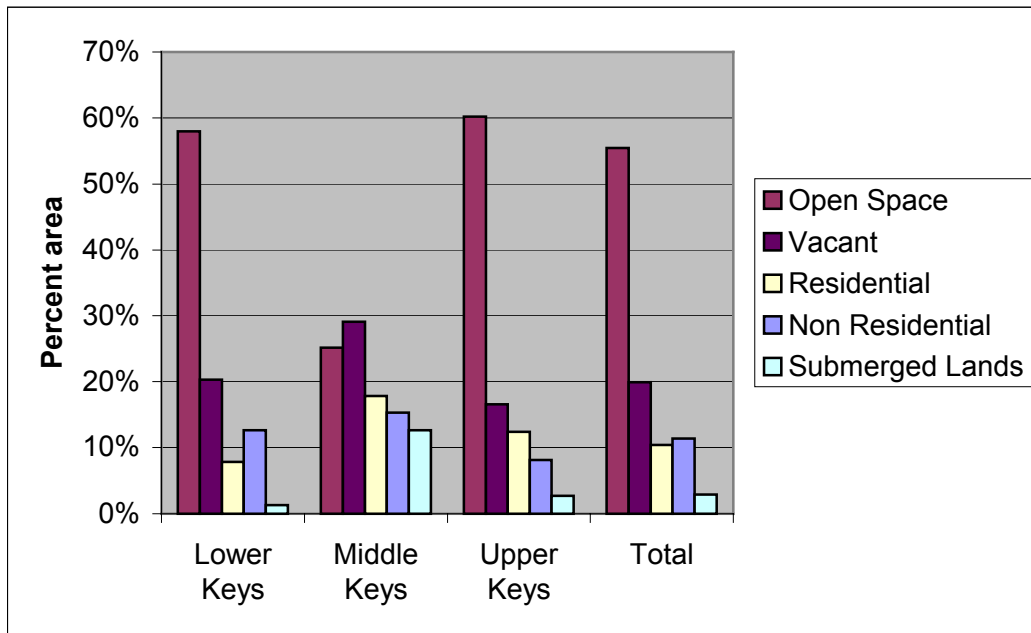


FIGURE 4.3
DISTRIBUTION OF LANDS UNSUITABLE FOR DEVELOPMENT

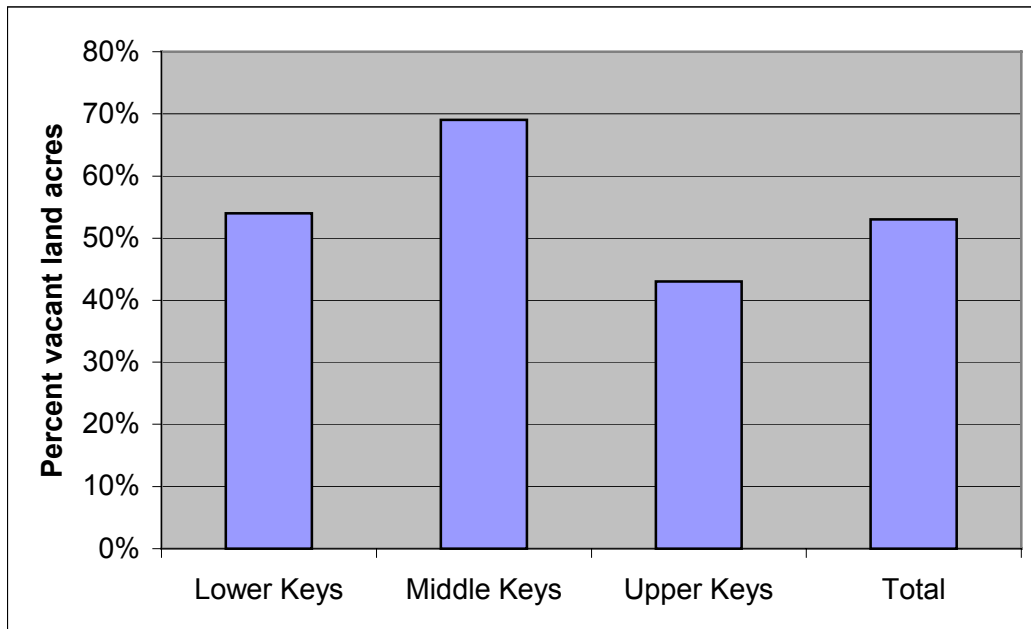


FIGURE 4.4
DEVELOPMENT SUITABILITY OF VACANT RESIDENTIAL LANDS

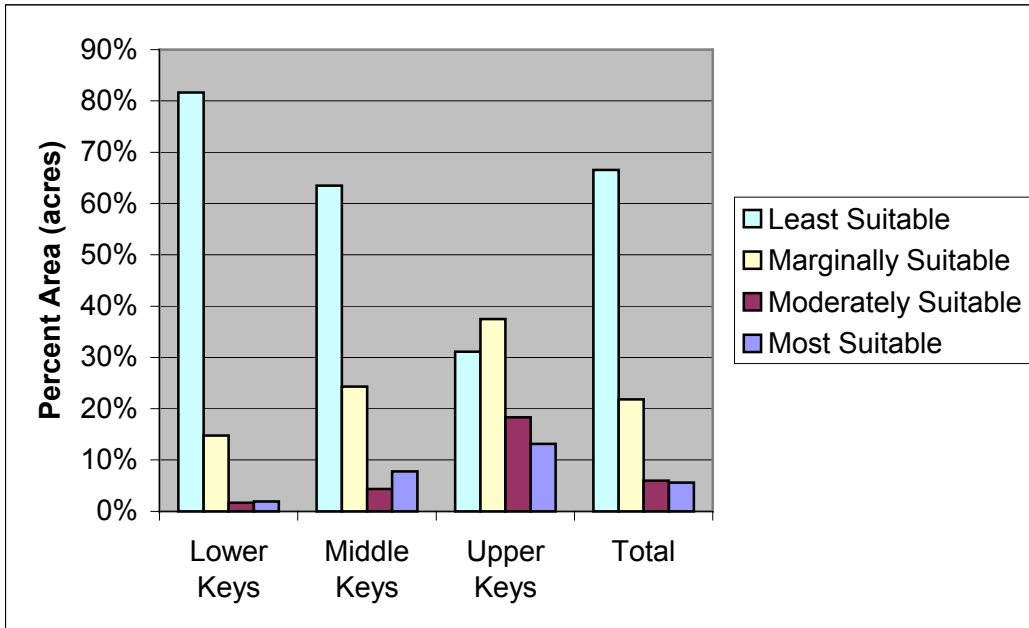
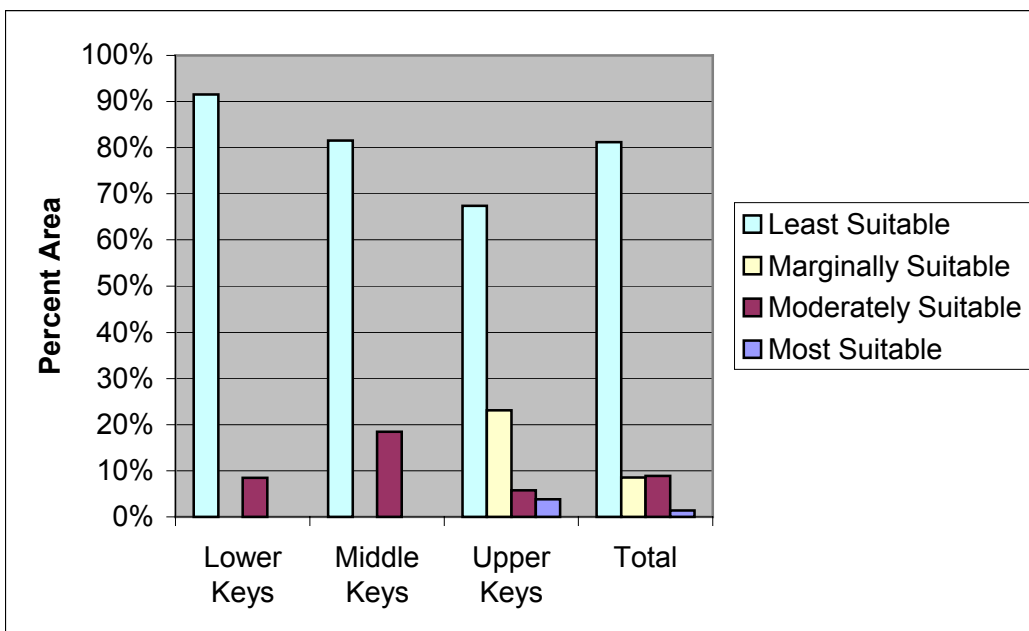


FIGURE 4.5
DEVELOPMENT SUITABILITY OF VACANT NON-RESIDENTIAL LANDS



4.3 SOCIOECONOMIC AND FISCAL ANALYSIS

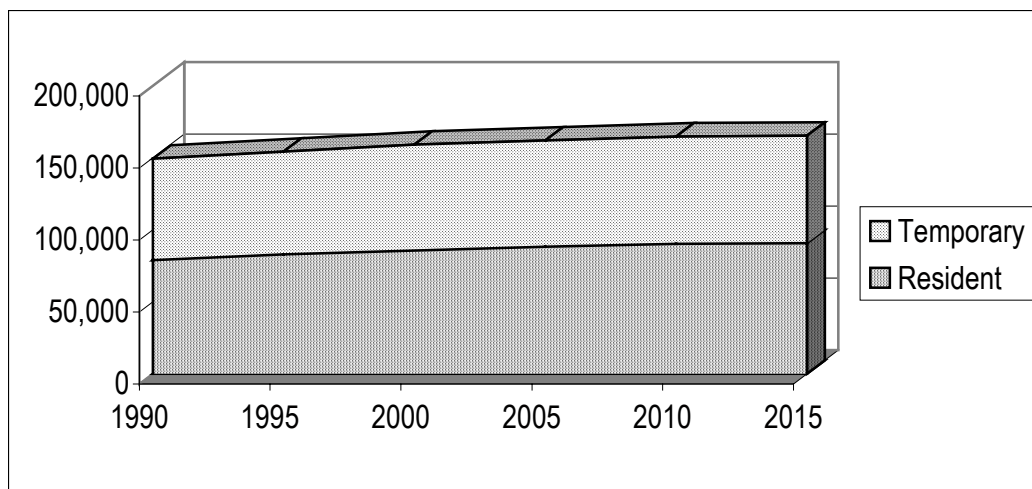
4.3.1 Socioeconomic Impacts

Housing and Population

The permanent population of the Florida Keys in 2000 was 79,589 and the total number of dwelling units was 51,617 (U.S. Census Bureau 2002). Population growth in the Keys slowed significantly in the 1990s, largely because of the implementation of the Rate of Growth Ordinance (ROGO). Between 1970 and 1980, the permanent population of the Florida Keys increased by 20.2 percent; between 1980 and 1990, the permanent population increased by 23.5 percent. In contrast, between 1990 and 2000, the permanent population increased only by 2 percent.

In addition to the permanent population, the Florida Keys host a seasonal population (those who stay in the Keys between 30 and 180 days) and a transient population (those who stay up to 30 days). Monroe County (Monroe County 2001) applies the concept of “functional” population to evaluate facilities demand. The functional population is defined as the number of people likely to be in the Florida Keys on any given evening, and includes the permanent, seasonal, and transient populations. The proportion of temporary population (transient and seasonal combined) relative to permanent population has fluctuated little since 1990 (Figure 4.6), and averages 86 percent of the permanent population.

FIGURE 4.6
TRENDS OF RESIDENT AND TEMPORARY POPULATION



For 2000, the Census Bureau reports 51,617 total housing units. Future scenarios represent 2,803 (Smart Growth) and 4,355 (Scenario 5) additional housing units in 20 years, for a growth of 5.4 and 8.4 percent, respectively. Correspondingly, permanent population growth in the scenarios is less than 10 percent in 20 years (Table 4.2). The Smart Growth Scenario would add

4,049 permanent residents to the Florida Keys; Scenario 5 results in 6,656 additional permanent residents. The additional 500,000 visitors contemplated in Scenario 3 add 7,142 persons to the transient population, therefore increasing the functional population as well.

TABLE 4.2
PROJECTED ADDITIONAL POPULATION¹

	Smart Growth	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Permanent	4,049	4,049	4,049	4,049	4,049	6,656
Functional	7,531	7,531	7,531	14,674	7,531	12,380
Temporary	3,483	3,483	3,483	10,625	3,483	5,726
Seasonal	1,299	1,299	1,299	1,299	1,299	2,133
Transient	2,184	2,184	2,184	9,326	2,184	3,593

¹ Current permanent population: 79,589 (per Census 2000).

Employment and Payrolls

Total employment in the Florida Keys increased by 18.14 percent from 1990 to 1997, while resident population increased by 2.0 percent from 1990 to 2000. Tourist-oriented businesses, such as food establishments, miscellaneous goods (souvenirs and specialty items), hotels/motels, and amusement services, accounted for 34.8 percent of the county's total employment growth.

The Monroe County Comprehensive Development Plan limits new non-residential growth to 239 square feet per each new housing unit. The amount of non-residential growth in the Smart Growth scenario (700,000 square feet) roughly corresponds to the increase in the number of housing units based on the CompPlan relationship. Employment under Smart Growth scenario is, therefore, projected to grow at the same rate as the employee population, and the ratio of employees available to employees required remains nearly 1 (Table 4.3). Scenario 5 results in more permanent residents than Smart Growth, but it does not add non-residential uses; therefore, there is an increase, although small, of employees available with respect to employees required.

TABLE 4.3
EMPLOYMENT AND PAYROLLS^{1,2}

	Smart Growth	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Employees						
Available	33,903	33,903	33,903	33,903	33,903	35,050
Required	34,363	34,363	34,363	34,363	34,363	34,363
Ratio	0.99	0.99	0.99	0.99	0.99	1.02
Payroll						
Total Payroll (in \$ millions)	656.3	656.3	656.3	656.3	656.3	656.3

¹ Current condition employees: 32,508 ("required").

² Current payroll: \$623.1 million.

Total annual payrolls in Monroe County grew by 49 percent during the 1990 to 1997 period. The U.S. Department of Housing and Urban Development estimated a 2000 median household income for Monroe County at \$44,600. Personal income resulting from wages and salaries (labor income) has markedly declined since 1971 (Florida Bureau of Business Research (BEBR) 2000). Personal income resulting from investments (dividends, interest, and rent) increased from 18.9 percent in 1971 to 40.9 percent in 2001. This shift suggests that a larger number of households do not rely on weekly paychecks for their income.

Payrolls are projected to increase less than 10 percent, in line with the projected population growth in the scenarios (Table 4.3).

Cost and Taxable Value of New Construction

Annual housing construction peaked in the mid-1970s and again in the mid-1980s, but has since fallen and leveled off in the mid-1990s (Figure 4.7). In contrast, the price of new houses has steadily increased in the 1990s (Figure 4.8).

**FIGURE 4.7
MONROE COUNTY HOUSING CONSTRUCTION TRENDS**

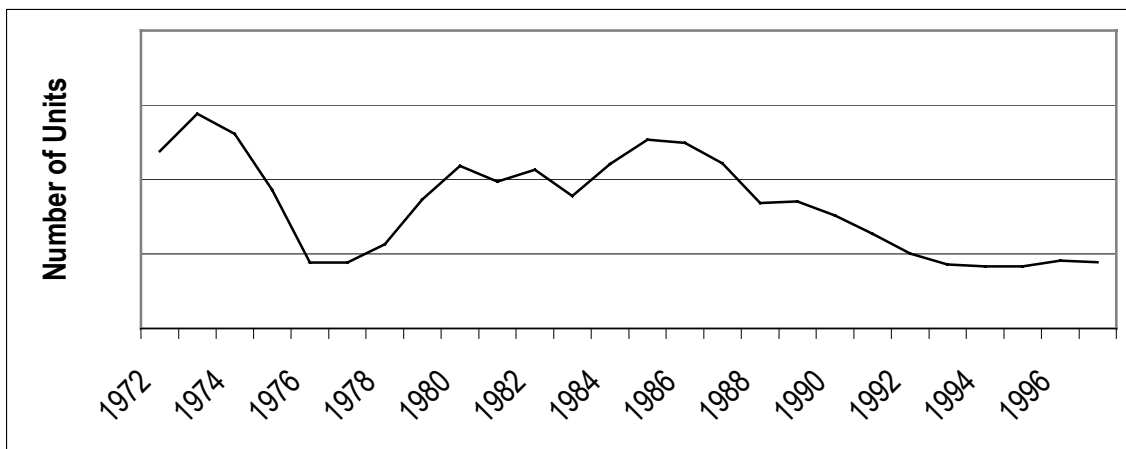
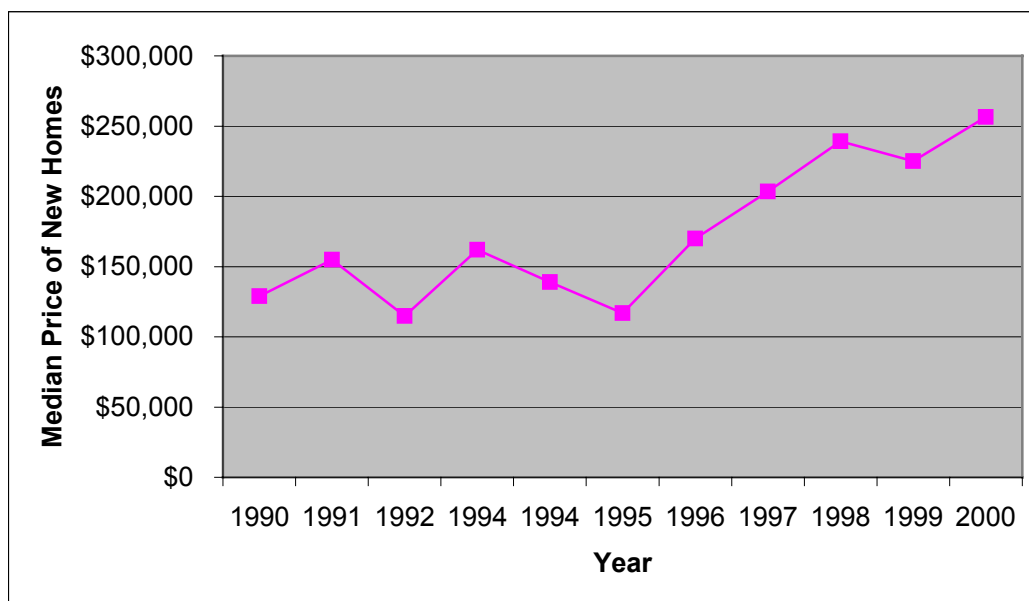


FIGURE 4.8
MEDIAN NEW HOME PRICE IN MONROE COUNTY



Cost of new construction contemplated in the scenarios would exceed \$500 million, and would create \$800 million in taxable value. Scenario 5, results in higher cost of construction and taxable value (Table 4.4).

TABLE 4.4
COST AND TAXABLE VALUE OF NEW CONSTRUCTION
(IN MILLIONS OF DOLLARS)

	Smart Growth	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Cost	536.6	536.6	536.6	536.6	536.6	805.7
Taxable Value	840.9	840.9	840.9	840.9	840.9	1,276.8

Tourism

Tourism is the most important sector of the economy in the Florida Keys. The most consistent source of estimates of tourist activity is the *Florida Visitor Study*, conducted each year by the State of Florida. In 1998 (most recent report available), an estimated 48.7 million tourists visited the state, of which 1,266,000 (2.6 percent) vacationed in the Florida Keys.

The National Oceanic and Atmospheric Administration (NOAA) conducted a study of visitors to the Florida Keys based on a sample survey during June 1995 to May 1996 (Leeworthy 1996). The purpose of the study was to determine activities and economic value of visitors to the

Florida Keys. Over three million people visited the Keys during the study period, of which 2.5 million visited for recreation purposes (Table 4.5). Over 40 percent of the 2.5 million visitors made it to Key West, whereas 27 percent visited the Upper Keys, 21 percent the Middle Keys, and 9 percent visited the Lower Keys.

TABLE 4.5
VISITORS TO THE FLORIDA KEYS 1995-1996

Category	Total Persons	Person-Days
Recreating Visitors	2,540,488	13,298,387
Non-Recreating Visitors	517,093	2,974,738
All Visitors	3,057,581	16,273,125

This survey also investigated the expenditure patterns of the visitors over this 12-month period. The average expenditure per person per day was \$108.98, similar to the value reported in the *Florida Visitor Study* for 1998 (\$117.80). The NOAA study shows that 70 percent of visitors' expenditures cover lodging, food and beverage, and transportation. Boating, fishing, and diving activities account for 12 percent of the expenditures (Table 4.6)

TABLE 4.6
AVERAGE VISITOR EXPENDITURES BY PERSON PER DAY

Expenditure Category	Amount
Lodging	\$36.31
Food and Beverage	\$29.76
Transportation	\$10.56
Boating	\$5.69
Fishing	\$3.30
Diving	\$3.46
Sightseeing	\$4.16
Other Activity	\$1.57
Miscellaneous	\$12.53
Services	\$1.64
Total Expenditure	\$108.98

Source: *Visitor Profiles: Florida Keys & Key West*; NOAA.

While the economic impact of tourism on the Florida Keys is very significant, the land use impact is focused on relatively few activities, and the total demand in acres or floor space is limited. Hotels/motels and restaurants are also important indicators of tourist activity

(Table 4.7). From 1989 to 1998, the number of hotels increased from 17 to 25 and the total number of rooms increased by nearly 800. During the same period, the number of motels increased from 157 to 174 and the total number of rooms increased by more than 400. The number of restaurants decreased, but their total seating capacity and average size increased.

TABLE 4.7
TOURIST-RELATED BUSINESSES IN MONROE COUNTY

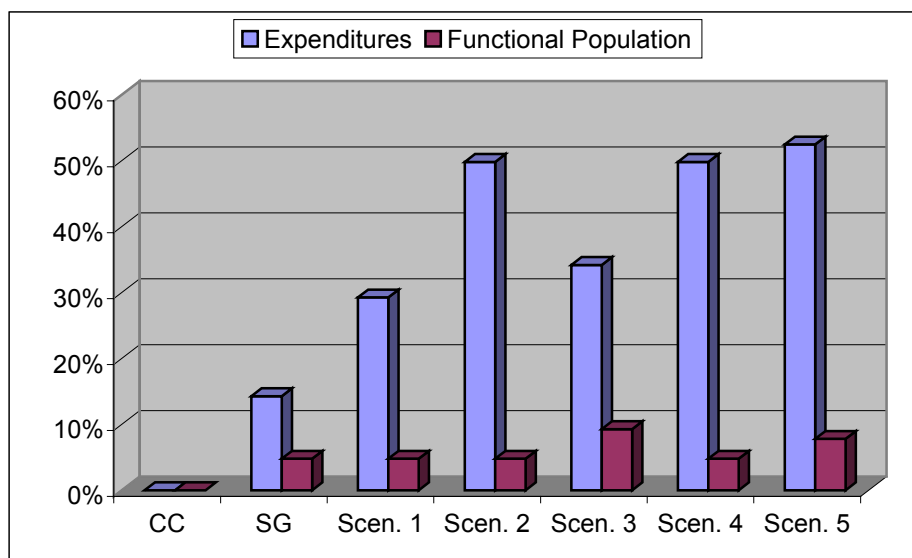
Facilities	1989	1998
Hotels		
Number of Establishments	17	25
Number of Rooms	1,455	2,238
Motels		
Number of Establishments	157	174
Number of Rooms	5,647	6,068
Restaurants		
Number of Establishments	553	524
Seating Capacity	35,591	42,357

The addition of over 7,000 transient persons to the functional population would create a demand for additional tourist-related facilities. Currently, the ratio of transient population to hotel rooms is 0.0197. Should that ratio hold in the future, the additional transient population would require approximately 141 additional hotel rooms.

4.3.2 Fiscal Impacts

Annual government expenditures increase between 13 percent and 51 percent, depending on the scenario (Figure 4.9). In contrast, functional population would grow by less than 10 percent over 20 years in all scenarios

FIGURE 4.9
PERCENT INCREASE IN TOTAL ANNUAL GOVERNMENT EXPENDITURES VERSUS 20-YEAR
INCREASE IN FUNCTIONAL POPULATION WITH RESPECT TO CURRENT CONDITION



Therefore, the results show a sharp increase in per capita government expenditures, which would obligate government to increase revenue. Revenue to cover the increased expenditure may be obtained in many ways, such as cost-sharing arrangements with state and federal agencies, bond issues, and tax increases.

Scenarios 1 through 5 included large expenditures (Table 4.8). For example, improvements to U.S. 1 for hurricane evacuation would cost approximately \$72 million, assuming a cost of \$1.2 million per mile of improvement. Land acquisition for preservation, calculated as the sum of the taxable value of the parcels in the tax roll, would cost approximately \$469 million.

TABLE 4.8
ESTIMATED CAPITAL COST OF SCENARIO IMPROVEMENTS

	Scenario 1	Scenario 2	Scenario 3	Scenario 4*	Scenario 5*
U.S. 1 Improvements	\$0	\$71,800,000	\$0	\$23,933,333	\$29,933,333
Wastewater	\$268,966,789	\$268,966,789	\$268,966,789	\$89,655,596	\$93,160,537
Stormwater	\$191,299,900	\$191,299,900	\$191,299,900	\$63,766,633	\$59,706,633
Land Acquisition	\$23,802,643	\$469,285,169	\$23,802,643	\$156,428,390	\$148,149,505
Restoration	\$0	\$670,000,000	\$0	\$223,333,333	\$223,333,333
Total	\$484,069,332	\$1,671,351,858	\$484,069,335	\$557,117,285	\$554,283,341

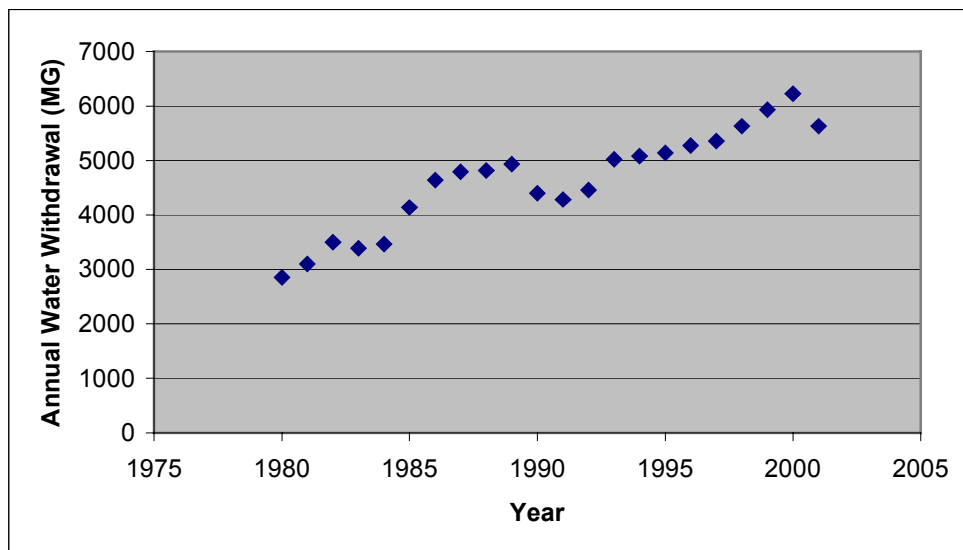
* Cost are divided by 3 to represent shared burden between Federal, state, and local governments.

4.4 INFRASTRUCTURE

4.4.1 Potable Water Supply Impacts

There are no significant water supplies within the Florida Keys. The Florida Keys Aqueduct Authority (FKAA) supplies virtually all of the potable water used in the study area from a wellfield located in southern Miami-Dade County. Key data reviewed with respect to the potable water system include recent consumption records, permitted capacities, plans for expansion, the cost of delivered water, and the operational capabilities of the primary facilities. The facilities include an existing wellfield, water treatment, pumping and transmission facilities, as well as emergency desalination facilities located within the Keys. Annual withdrawals have steadily increased since 1980 (Figure 4.10) and permitted capacity was exceeded in 1999 and 2000 (Monroe County 2001).

FIGURE 4.10
ANNUAL WATER WITHDRAWAL (MG), 1980-2000



The Smart Growth Scenario results in a 0.7 million gallons per day (mgd) increase in withdrawal which, if added to the annual withdrawal recorded in 2000 (6,228 MG; Monroe County 2001) would result in an average of 17.8 mgd, well beyond permitted capacity. Scenario 5 would result in approximately a 1.0 mgd increase in withdrawal. Assuming a per capita daily use of 100 gallons, Scenario 3 could generate 1.4 mgd due to the increase in visitors.

TABLE 4.9
ADDITIONAL POTABLE WATER DEMAND
(IN MILLION OF GALLONS PER DAY)

	Smart Growth	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Demand	0.7	0.7	0.7	1.4	0.7	1.0

Ongoing FCAA regulatory initiatives may help reduce water use. For example, the FCAA recently adopted a formal resolution requesting all municipalities and unincorporated Monroe County to adopt mandatory water conservation and irrigation ordinances in accordance with the South Florida Water Management District's (SFWMD) permit allocation manual. Draft ordinances are being provided (FCAA letter to Ann Lazar, Florida Department of Community Affairs (DCA), February 27, 2002). Scenarios 1 to 5 assume the construction and operation of a desalination plant. A desalination plant contemplated in Scenarios 1-5 would provide sufficient water to meet projected demands.

The 22 mgd capacity of FCAA's existing water treatment plant is sufficient to meet the projected potable water demands for Smart Growth and Scenarios 1-5 for the average day, maximum month day, and maximum day conditions. The anticipated growth under Smart Growth will consume a significant portion of the residual capacity of the existing water treatment system under maximum day conditions. However, the FCAA's water plant expansion program, currently under construction, will increase treatment capacity to 25 mgd, which will provide additional treatment capacity and redundancy for the system.

Comparison of the projected average day demands against the reported capacity of the FCAA pipeline in each segment indicated that the existing pipeline is adequate to handle the scenario potable water conveyance. The projected cumulative maximum day flow in each of the planning units typically required less than 60 percent of the rated aqueduct segment capacity. The highest use of aqueduct capacity occurs at the northern end of the Keys, in the Key Largo Area (Ocean Reef Club + PAED 21 (North Key Largo) + PAED 22 (Cross Key)), where the potable water supply first enters the study area.

4.4.2 Traffic Impacts

Traffic volumes and level of service (LOS) on U.S. 1 are estimated every year based on survey work performed at peak season, between late February and early March (URS 2002). Traffic volume, although with year-to-year fluctuations, has tended to increase slowly since 1993 (Figure 4.10). Median speed, which determines LOS, fluctuates from year to year, with seemingly little connection to changes in land use. For example, while no development has occurred in Big Pine and No Name Keys in the last three years, median speed changed -2.9 mph from 2000 to 2001 and +2.5 mph from 2001 to 2002 (Table 4.10). Traffic volume decreased in both periods (Figure 4.11).

FIGURE 4.11
TRAFFIC VOLUME AT SELECTED LOCATIONS IN THE FLORIDA KEYS

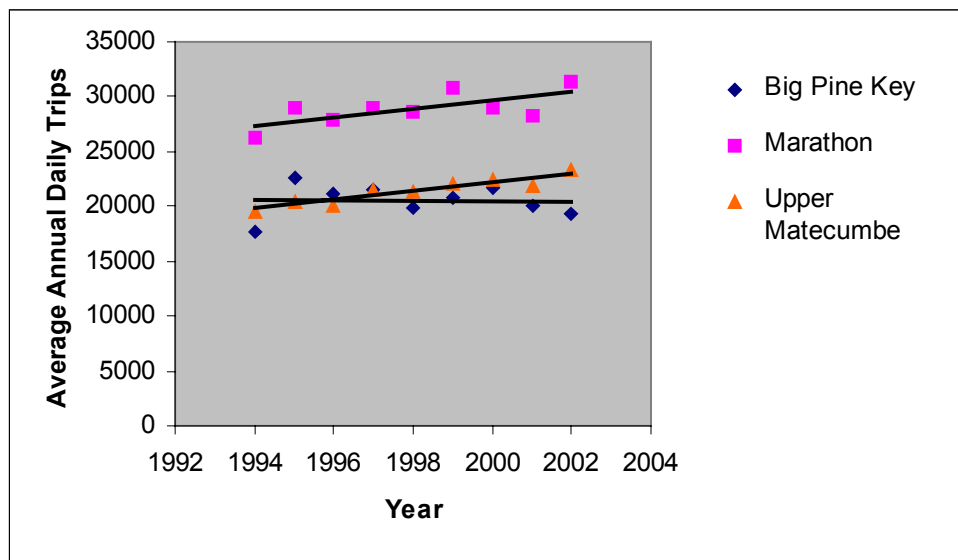


TABLE 4.10
VARIATION IN MEDIAN SPEEDS ON U.S. 1

U.S. 1 Segment	2000-2001	2001-2002
Stock Island	4.1	-1.3
Boca Chica	1.2	-2.5
Big Coppitt	1.7	-2.9
Saddlebunch	-0.5	-1.7
Sugarloaf	-0.2	-1.3
Cudjoe	-1.1	0.6
Summerland	-0.4	0.6
Ramrod	0.4	-0.2
Torch	0.5	-0.9
Big Pine	-2.9	2.5
Bahia Honda	1.7	-1.5
7-Mile Bridge	0.8	-0.9
Marathon	-0.5	-1.8
Grassy	0.5	-0.6
Duck	1.6	-1.1
Long	1.9	-1.9
Lower Matecumbe	0.6	0.2
Tea Table	-0.3	0.0
Upper Matecumbe	0.0	0.0
Windley	0.0	1.6
Plantation	3.5	-0.2
Tavernier	0.9	-1.1
Largo	0.7	0.7
Cross	1.2	2.3

Source: 2002 Arterial and Travel Time/Delay Study, URS Greiner, Inc.

The regression equation that relates acres of residential and tourist-related land uses with median speed predicts a decrease of 1 mph per 62.5 acres/mile of U.S. 1 of new development in the planning unit. Projected changes in land use acreages result in changes in median speed, which are within annual fluctuation. LOS on U.S. 1 will likely continue to fluctuate in the next 20 years, with a tendency to deteriorate. An additional northbound lane on portions of U.S. 1, as proposed, is not intended to improve the LOS on U.S. 1. However, should the additional lane be used continuously as a turn or scramble lane, northbound flow could improve.

The number of additional of housing units is lower than the residential capacity in all future scenarios, suggesting that U.S. 1 may accommodate the additional trips. However, not all segments of U.S. 1 have reserve capacity and the effect of development on the entire U.S. 1 length may be affected by the distribution of development among segments.

4.4.3 Hurricane Evacuation Impacts

Clearance time to Florida City ranges from 24:14 under current conditions to 20:32 in Scenario 1. Under Smart Growth, which does not include improvements to U.S. 1, the clearance time increases by 28 min with respect to current conditions. Under Scenario 5, which includes more dwelling units than Scenario 1, as well as U.S. 1 improvements, the clearance time is 20:56. All runs included a Category 1-3 hurricane.

4.5 POLLUTANT LOADS

4.5.1 Stormwater Loads

Due to the historic lack of flooding in the Florida Keys related to rainfall, little quantitative data exists on the relationship between rainfall and runoff. Few engineered drainage systems have been developed in the Keys, as the soils are highly porous soils and drainage areas are near receiving waters. Similarly, until recent years, there were virtually no stormwater treatment systems in the Keys and stormwater pollutant loads were generally discharged directly to receiving waters.

Stormwater flows and pollutant loads were computed for the seven scenarios using the projected land uses, event mean concentration (EMC) values, and selected load reductions attributable to Best Management Practices (BMPs). The stormwater treatment strategies recommended in the Stormwater Management Master Plan were applied to new development and redevelopment at the parcel level, as well as the retrofitting strategies for identified problem areas. Extensive use of BMPs is required under the Smart Growth strategies, which resulted in implementation of stormwater BMPs that serve 7,086 acres of the Florida Keys. Total loads are only slightly higher in Smart Growth and Scenarios 1-5 than in current conditions (Table 4.11).

**TABLE 4.11
STORMWATER LOADS
(IN LBS. PER DAY)**

	Current Conditions	Smart Growth	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TN	1,333	1,355	1,368	1,368	1,368	1,368	1,377
TP	169	167	169	169	169	169	170

Note: Includes SW-Surface, SW-Ground, and U.S. 1.

4.5.2 Wastewater

With the exception of the Key West Wastewater Treatment Plant (10 mgd), there are no large centralized wastewater collection and treatment systems in the Florida Keys. There are small wastewater treatment plants in Key Colony Beach and Ocean Reef Club (0.34 mgd and 0.55 mgd, respectively). Wastewater treatment for existing residential and commercial/industrial wastewater flows is provided by a wide variety of systems ranging from simple cesspits to small on-site package plants.

Wastewater effluent pollutant loads were computed for the seven scenarios using the total number of EDUs and the effluent characteristics from the U.S. Environmental Protection Agency (EPA)/Florida Department of Environmental Protection (FDEP). The effects of an improvement in treatment technology are significant (Table 4.12). Total nitrogen (TN) and total phosphorous (TP) loads are reduced by 69 percent and 73 percent respectively in Smart Growth and Scenarios 1-4, which considered complete implementation of the Wastewater Master Plan. In Scenario 5, in which only a few hot spots were upgraded to treatment plants, the total loads increased significantly, although they are still lower than under current conditions.

**TABLE 4.12
WASTEWATER LOADS
(IN LBS. PER DAY)**

	Current Conditions	Smart Growth	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TN	2,429	762	762	762	762	762	1,952
TP	238	66	66	66	66	66	198

4.5.3 Pollutant Loads and Water Quality in Canals

A growing body of literature documents the deterioration of water quality in dead-end canals in the Florida Keys (reviewed in Kruczynski and and McManus 2002). The Canal Module explores the effects of stormwater and wastewater pollutant loads and tidal flushing on water quality in dead-end canals. The model was applied to 10 canals, which represent the diversity of lengths, associated land uses, number of turns and splits, and location of canals in the Florida Keys (Table 4.13).

**TABLE 4.13
CHARACTERISTICS OF SELECTED CANALS**

Canal ID	# of Seg.	Total Length of Seg. (ft)	Canal Splits	Longest Distance (ft)	Nearshore Water Quality ¹	
					TN (mg/l)	TP (mg/l)
50 Key Largo	16	2,250	3	1,590	0.334	0.009
69 Rock Harbor	27	4,930	2	1,920	0.429	0.009
70 Rock Harbor	12	1,330	0	1,330	0.419	0.009
117 Plantation Key	14	1,923	0	1,923	0.344	0.009
152 Lower Matecumbe Key	30	6,214	2	3,244	0.197	0.007
204 Marathon	6	795	0	795	0.213	0.010
208 Marathon	12	1,083	0	1,083	0.213	0.010
246 Marathon	8	1,150	1	1,030	0.245	0.009
288 Big Pine Key	12	1,314	0	1,314	0.303	0.010
339 Little Torch Key	44	6,185	6	2,580	0.301	0.010

¹Estimated by interpolating existing water quality data. It estimates concentrations at 250 feet offshore from the mouth of the canal.

For each canal, the model was run to evaluate current conditions and the Smart Growth scenario. The main difference between the runs is that, under Smart Growth, wastewater is assumed to be transported to a treatment plant and disposed away from the canal.

In the two scenarios, stormwater loads remain essentially unchanged. In contrast, wastewater loads are dramatically lower under the Smart Growth scenario (Table 4.14). The average reduction in stormwater pollutants was only about 1 percent on average; for wastewater pollutants, the average reduction was about 90 percent. Wastewater contribution to total TN and TP loads is about 80 percent under current conditions, but only about 10 percent under Smart Growth.

In all cases, model results show pollutant concentrations increase with distance from the canal mouth (Appendix C), and are higher than in the open, nearshore waters. Under current conditions, average concentrations (mg/l) ranged from 0.51 to 2.53 for TN and 0.02 to 0.25 for TP (Table 4.15). Under the Smart Growth scenario, average concentrations (mg/l) ranged from 0.24 to 0.57 for TN and 0.01 to 0.06 for TP. The pollutant discharge from the canal (during ebb tide), which can be interpreted as a point source discharge, ranged from 2.98 to 38.34 pounds/day of TN and 0.21 to 1.25 pounds/day of TP under current conditions and from 1.80 to 34.36 pounds/day of TN and 0.10 to 0.85 pounds of TP under Smart Growth.

**TABLE 4.14
POLLUTANT LOADS INTO CANALS**

Canal	Daily SW Load			Daily WW Load		
	TN (lbs)	TP (lbs)	Flow (cft)	TN (lbs)	TP (lbs)	Flow (cft)
50 Key Largo						
Current Conditions Scenario:	0.19	0.04	2,125	1.09	0.11	698
Smart Growth Scenario:	0.18	0.03	2,314	0.60	0.03	966
Percent Change:	-6%	-5%	9%	-45%	-72%	39%
69 Rock Harbor						
Current Conditions Scenario:	0.38	0.08	4,655	2.68	0.27	1,714
Smart Growth Scenario:	0.38	0.08	4,666	0.00	0.00	0
Percent Change:	0%	0%	0%	-100%	-100%	-100%
70 Rock Harbor						
Current Conditions Scenario:	0.14	0.02	1,362	1.07	0.11	683
Smart Growth Scenario:	0.14	0.02	1,391	0.00	0.00	0
Percent Change:	-1%	-1%	2%	-100%	-100%	-100%
117 Plantation Key						
Current Conditions Scenario:	0.49	0.09	4,582	3.38	0.33	2,024
Smart Growth Scenario:	0.48	0.09	4,715	0.00	0.00	0
Percent Change:	-2%	-1%	3%	-100%	-100%	-100%
152 Lower Matecumbe Key						
Current Conditions Scenario:	0.37	0.07	5,489	3.03	0.30	1,931
Smart Growth Scenario:	0.37	0.07	5,489	0.00	0.00	0
Percent Change:	0%	0%	0%	-100%	-100%	-100%
204 Marathon						
Current Conditions Scenario:	0.12	0.02	1,150	0.83	0.08	469
Smart Growth Scenario:	0.12	0.02	1,166	0.00	0.00	0
Percent Change:	-1%	-1%	1%	-100%	-100%	-100%
208 Marathon						
Current Conditions Scenario:	0.11	0.02	1,025	0.82	0.08	463
Smart Growth Scenario:	0.11	0.02	1,025	0.00	0.00	0
Percent Change:	0%	0%	0%	-100%	-100%	-100%
246 Marathon						
Current Conditions Scenario:	0.16	0.03	1,515	0.56	0.05	282
Smart Growth Scenario:	0.16	0.03	1,515	0.18	0.01	282
Percent Change:	0%	0%	0%	-69%	-82%	0%
288 Big Pine Key						
Current Conditions Scenario:	0.11	0.02	1,118	0.57	0.06	365
Smart Growth Scenario:	0.11	0.02	1,133	0.00	0.00	0
Percent Change:	-1%	-1%	1%	-100%	-100%	-100%
339 Little Torch Key						
Current Conditions Scenario:	0.38	0.08	4,439	2.31	0.23	1,512
Smart Growth Scenario:	0.38	0.08	4,439	0.00	0.00	0
Percent Change:	0%	0%	0%	-100%	-100%	-100%
Minimum % Change:	-6.4%	-5.1%	0.0%	-100%	-100%	-100%
Maximum % Change:	0.1%	0.1%	8.9%	-45%	-72%	39%
Average % Change:	-1.1%	-0.9%	1.7%	-91%	-96%	-76%

**TABLE 4.15
POLLUTANT CONCENTRATION AND CANAL DISCHARGES**

Canal	Average Canal Concentration(mg/l)		Canal Discharge (lbs/day)	
	TN	TP	TN	TSS
50 Key Largo				
Current Conditions Scenario:	0.51	0.030	9.94	133.84
Smart Growth Scenario:	0.45	0.019	9.01	133.50
Percent Change:	-12.4%	-37.3%	-9.3%	-0.3%
69 Rock Harbor				
Current Conditions Scenario:	0.51	0.019	38.34	453.27
Smart Growth Scenario:	0.44	0.011	34.36	451.96
Percent Change:	-14.8%	-40.2%	-10.4%	-0.3%
70 Rock Harbor				
Current Conditions Scenario:	1.28	0.105	5.85	40.77
Smart Growth Scenario:	0.51	0.027	3.00	39.91
Percent Change:	-60.4%	-74.6%	-48.8%	-2.1%
117 Plantation Key				
Current Conditions Scenario:	2.53	0.250	12.76	89.86
Smart Growth Scenario:	0.57	0.059	4.79	77.99
Percent Change:	-77.5%	-76.4%	-62.5%	-13.2%
152 Lower Matecumbe Key				
Current Conditions Scenario:	0.62	0.054	13.2	204.3
Smart Growth Scenario:	0.24	0.016	7.42	202.26
Percent Change:	-62.0%	-71.1%	-43.6%	-1.0%
204 Marathon				
Current Conditions Scenario:	0.55	0.043	3.5	51.6
Smart Growth Scenario:	0.25	0.016	1.85	46.58
Percent Change:	-53.4%	-62.1%	-47.2%	-9.7%
208 Marathon				
Current Conditions Scenario:	0.51	0.040	4.3	73.7
Smart Growth Scenario:	0.25	0.015	2.76	69.80
Percent Change:	-50.8%	-61.4%	-36.2%	-5.2%
246 Marathon				
Current Conditions Scenario:	0.62	0.050	2.98	47.24
Smart Growth Scenario:	0.41	0.028	2.20	42.63
Percent Change:	-33.1%	-44.0%	-26.2%	-9.8%
288 Big Pine Key				
Current Conditions Scenario:	0.86	0.077	3.19	33.11
Smart Growth Scenario:	0.39	0.029	1.80	32.68
Percent Change:	-54.4%	-61.7%	-43.6%	-1.3%
339 Little Torch Key				
Current Conditions Scenario:	0.55	0.040	16.20	226.34
Smart Growth Scenario:	0.33	0.018	12.05	225.07
Percent Change:	-40.3%	-55.2%	-25.6%	-0.6%
Minimum % Change:	-77.5%	-76.4%	-62.5%	-13.2%
Maximum % Change:	-12.4%	-37.3%	-9.3%	-0.3%
Average % Change:	-45.9%	-58.4%	-35.4%	-4.3%

4.6 TERRESTRIAL ECOSYSTEMS AND SPECIES

4.6.1 Habitat Loss and Fragmentation

Since the 1800s, development in the Florida Keys has occurred primarily in upland areas, resulting in the loss of almost half of the upland habitats, from 20,038 acres in pre-development times to 10,353 acres in 1995. Along with habitat loss, upland habitats have been severely fragmented into numerous, smaller patches (Figures 4.12 and 4.13). This is in sharp contrast with pre-colonial conditions, where the average patch size was over 100 acres.

FIGURE 4.12
NUMBER OF UPLAND PATCHES IN THE FLORIDA KEYS, 1800 – 1995

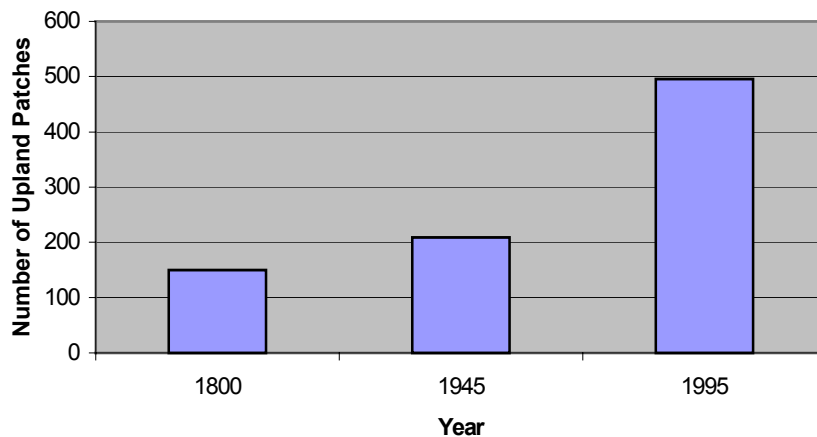
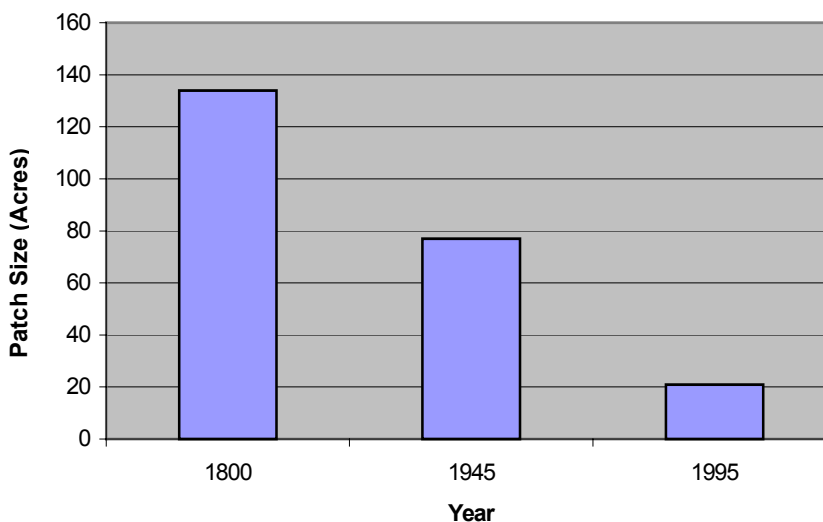


FIGURE 4.13
AVERAGE SIZE OF UPLAND PATCHES IN THE FLORIDA KEYS, 1800 – 1995



Under both current conditions and Smart Growth, approximately 80 percent of all upland habitat patches are less than five acres (Figures 4.14 and 4.15). The frequency of small patches is lowest in the Lower Keys and highest in the Upper Keys. In all scenarios, including current conditions, nearly 90 percent of all the remaining upland occurs as patches of less than 10 acres. Keys hammocks, smaller than 13 acres, are considered “all edge,” with forest interiors lacking the buffering effects of edge vegetation (Strong and Bancroft 1994).

FIGURE 4.14
DISTRIBUTION OF UPLAND PATCH SIZES IN THE FLORIDA KEYS – CURRENT CONDITIONS

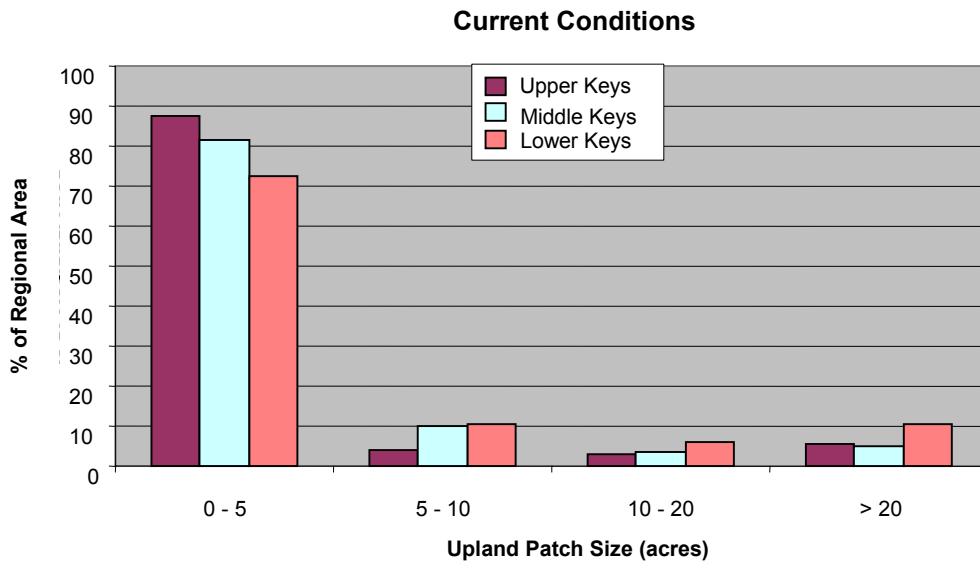
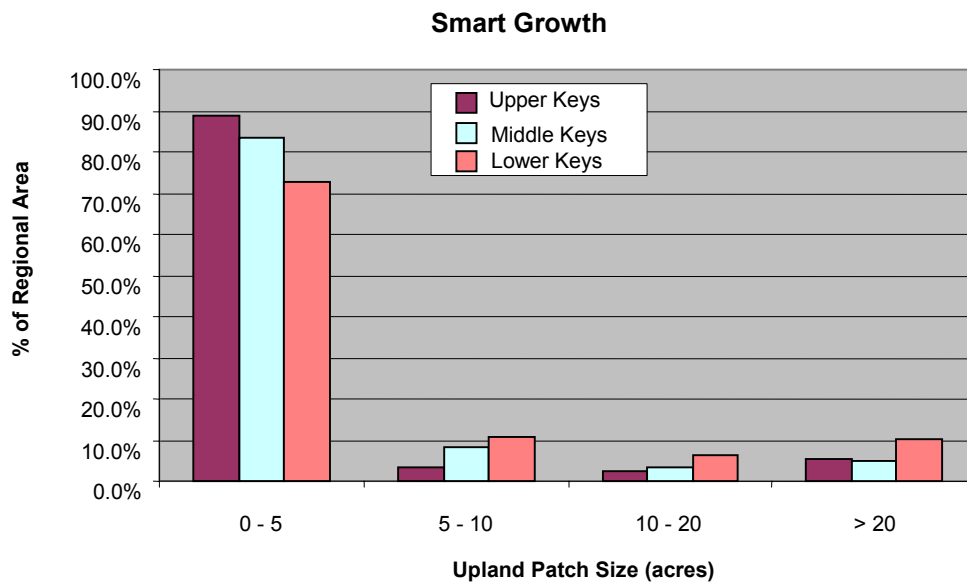


FIGURE 4.15
DISTRIBUTION OF UPLAND PATCH SIZES IN THE FLORIDA KEYS – SMART GROWTH



4.6.2 Species Richness

Species richness, here approximated by the potential occurrence of up to 17 species of concern in 30 x 30 foot cells, is highest in the Lower Keys and lowest in the Middle Keys (see examples in Figures 4.16 and 4.17). The overlay analysis results in a maximum of 10 species per cell in the richest areas. Throughout the Florida Keys, low species richness cells account for the majority of the area. Additional adverse species richness effects are negligible (fourth decimal place) in Smart Growth and Scenarios 1-5 with respect to current conditions; however, virtually any encroachment of development into open areas affects one or more species of concern.

FIGURE 4.16
SPECIES RICHNESS IN THE FLORIDA KEYS – HIGH SPECIES RICHNESS AREA

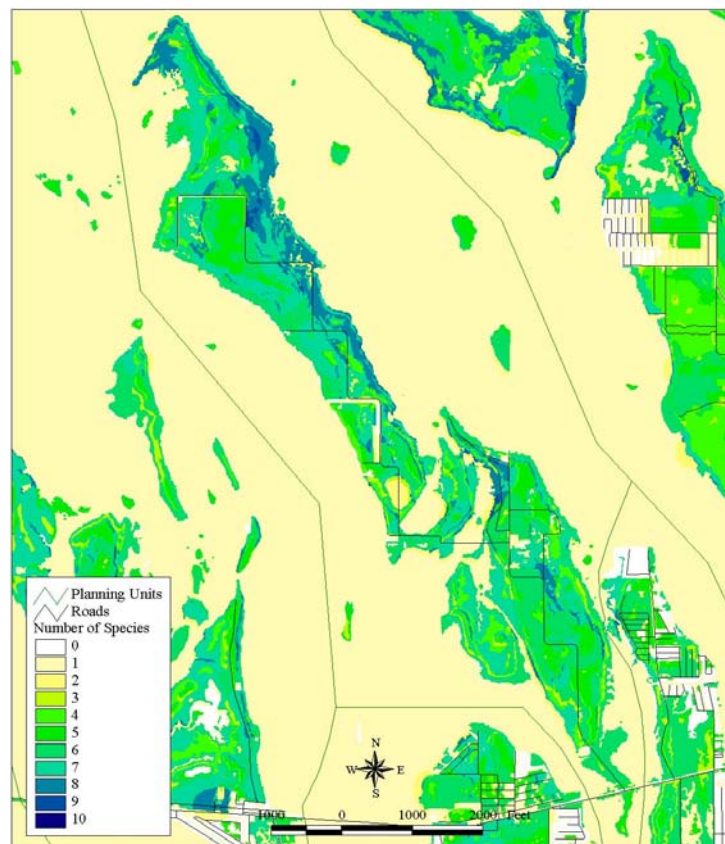
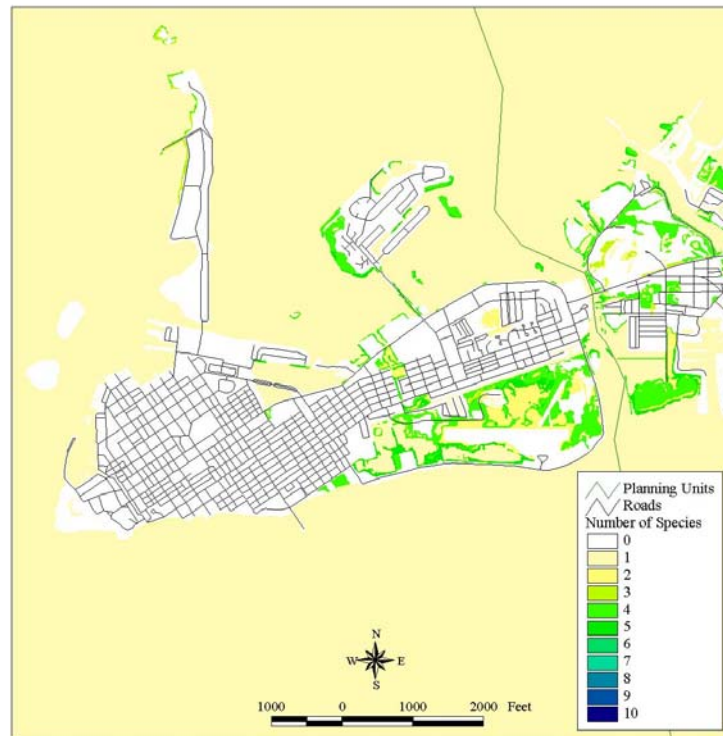


FIGURE 4.17
SPECIES RICHNESS IN THE FLORIDA KEYS – LOW SPECIES RICHNESS AREA



4.6.3 Species-Specific Impacts

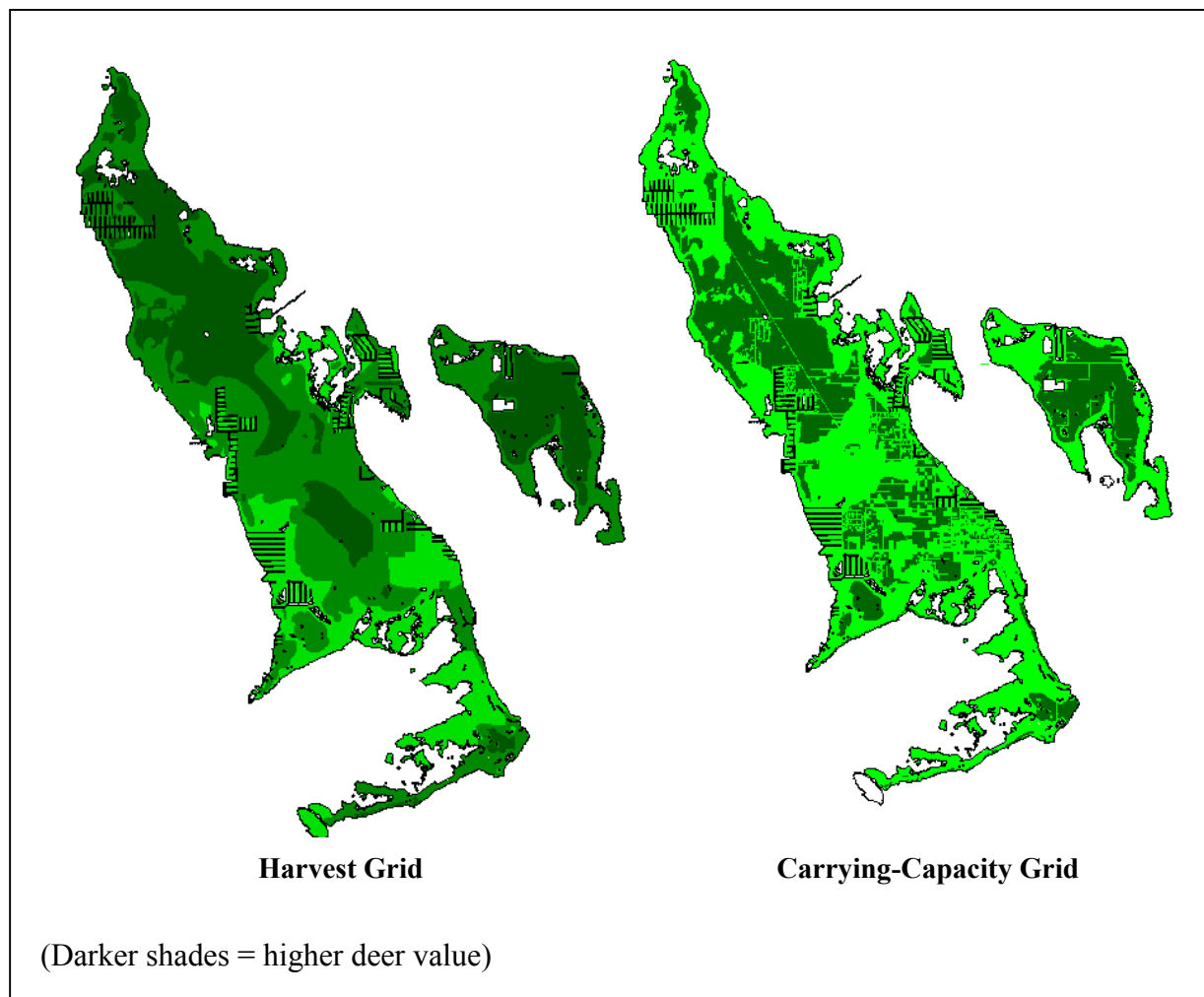
Key Deer

The most studied terrestrial species in the Florida Keys is the Florida Key deer (*Odocoileus virginianus clavium*), yet existing detailed population studies were over 20 years old (e.g., Silvy 1975). Recent population research revealed that the Key deer population has tripled since the 1970s (Lopez 2001). The Key deer is the subject of an ongoing Habitat Conservation Plan (HCP), which addresses the species in detail. As part of the HCP, URS Corporation and Dr. Roel Lopez (Texas A&M University), on behalf of the Florida Department of Transportation (FDOT), DCA, and Monroe County developed a population viability analysis (PVA) for the Key deer. The PVA model included two main components: a matrix model of population dynamics and a spatial habitat model of carrying capacity and secondary impacts.

Lopez (2001) studied the ecology and population dynamics of the Key deer for three years (1998-2000). As part of the HCP studies, the movement, habitat utilization, and fate of over 150 individual deer were followed for the three years of the study. Quantitative information on mortality and fecundity for deer of different ages was used to create a matrix model, which allows for simulating the fate of the population under different scenarios. In the matrix model, changes in mortality or fecundity result in changes in the way the population fluctuates through time.

Coupled with the matrix model, the habitat preferences of the Key deer, and data on Key deer mortality due to vehicle collisions and other human effects, were used to determine the contribution of different habitats to the carrying capacity (i.e., the number of deer the area can support) and the “harvest” (i.e., contribution to mortality due to human impacts) for Big Pine and No Name Keys.

FIGURE 4.18
KEY DEER PVA MODEL GRID LAYERS



The PVA model evaluated twelve development intensities. In each scenario, the model “chooses” parcels to be developed beginning with those of lowest quality for the Key deer. Risk of extinction increases with development intensity. Risk increases faster as higher-quality parcels become developed. The PVA model also provided an estimate of additional mortality, which represents an estimate of “take” due to the level of development.

Additional development in Smart Growth and Scenarios 1-5 occurs outside high-quality Key deer areas.

Lower Keys Marsh Rabbit

Recent literature documents the population biology and population viability of the endangered Lower Keys marsh rabbit, whose distribution is restricted to the Lower Keys. Forsy and Humphrey (1999) developed a PVA for the marsh rabbit in order to estimate the threat of extinction faced by the marsh rabbit and determine the necessity and efficacy of different management strategies. Results of the simulations indicate survival, particularly for adult females, must be increased for the marsh rabbit to persist. Other than development, domestic cats represent the main threat to the Lower Keys marsh rabbit and are the principal cause of mortality. Since the rabbit occurs in small, relatively disjunct populations, has a low population density, and is subject to predation by domestic predators, the species is in danger of extinction.

Smart Growth and Scenarios 1-5 result in small additional habitat loss for the Lower Keys marsh rabbit (Table 4.16, Figure 4.19) with respect to current conditions. In addition to habitat loss, there is an increase in the amount of habitat at risk due to potential secondary effects shown by fewer patches and acres available after including risk.

**TABLE 4.16
REMAINING HABITAT: LOWER KEYS MARSH RABBIT**

		Number of Patches	Total Area	Mean Patch Size
Direct Impacts	Current Conditions	150	1,125	7.5
	Smart Growth	152	1,124	7.4
	Scenario 5	152	1,124	7.4
Secondary Impacts	Current Conditions	123	798	6.5
	Smart Growth	125	797	6.4
	Scenario 5	125	797	6.4

FIGURE 4.19
EXAMPLE OF SMART GROWTH DEVELOPMENT ENCROACHMENT ON
LOWER KEYS MARSH RABBIT HABITAT



Silver Rice Rat

The silver rice rat (*Oryzomys palustris natator*) is a medium-sized, semi-aquatic rat known to occur on 12 islands of the Lower Keys (Forys, et. al. 1996). Viable populations require large, contiguous mangrove and salt marsh habitats for foraging and salt marsh habitats for nesting. Freshwater marshes that lie adjacent to salt marshes are also used along with buttonwood transitional vegetation. The U.S. Fish and Wildlife Service (USFWS) maintains a Geographic Information System (GIS) data layer (provided by Dr. Phil Frank, USFWS), which documents the status of every suitable habitat patch for the silver rice rat. No additional impacts occur under Smart Growth and Scenarios 1-5 with respect to current conditions.

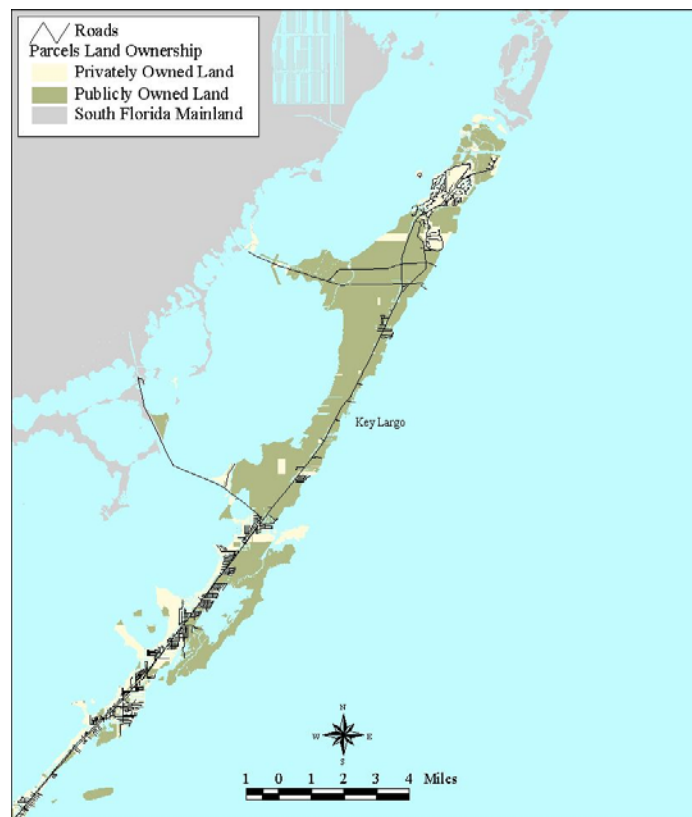
Key Largo Woodrat

The Key Largo woodrat (*Neotoma floridana smalli*) is a small rodent, currently limited to northern Key Largo, but it once ranged over the entire island. The woodrat builds large stick nests for resting, feeding, and breeding. Females are on average much smaller than the males (Hersh 1981). Key Largo woodrats are active climbers (Goodyear 1985) and have overlapping

home ranges. They have defined trails and fallen trees are often used to move through the hammocks. The Key Largo woodrat is capable of reproducing all year although winter peaks are evident (Hersh 1981). They are nocturnal omnivores but feed primarily on plant material (Brown 1978). The primary threat to their survival is habitat loss and fragmentation. Natural and increased levels of predation are a threat including raccoons and domestic and feral cats.

The Multi-Species Recovery Plan for South Florida (USFWS 1999) cites 4,445 acres (91 percent) of suitable Key Largo woodrat habitat is in public ownership and, therefore, protected; the remainder is in private ownership (Figure 4.20). Smart Growth and Scenario 5 result in the loss of about 50 acres of Key Largo woodrat habitat.

FIGURE 4.20
LAND OWNERSHIP IN KEY LARGO



Schaus Swallowtail Butterfly

Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*) is a large blackish-brown and yellow butterfly; antennae are black but males have a yellow knob. Historically they are known from hardwood hammocks from southern Miami to Lower Matecumbe Key in the Middle Keys. Their current range is largely diminished. Two unconfirmed sightings occurred over 20 years ago in the Lower Keys (USFWS 1982, Covell 1976). Males prefer trails and edges of the hammock and females typically fly within the hammocks (Rutkowski 1971). The butterflies are diurnal and short-lived. They have a single annual flight-season from May to June, and there is only one generation per year (Emmel 1985). The Schaus swallowtail butterfly population has been in general decline for many years primarily because of habitat destruction but also from pesticides, road kill, extreme climatic conditions, and collectors.

The vast majority of the Schaus swallowtail butterfly in the Florida Keys is under public ownership and has conservation status. Smart Growth and Scenario 5 result in the additional loss of 26 acres of potential swallowtail habitat.

Other Species Directly Addressed in the CCIAM

The CCIAM incorporates habitat requirements for the white-crowned pigeon (*Columba leucocephala*) and five species of forest-nesting birds. The white-crowned pigeon occurs in several areas of the Florida Keys, and is an important seed disperser in upland forests (Bancroft et al. 1994). White-crowned pigeons nest primarily on mangrove islands (Strong and Bancroft 1994), but must disperse to hardwood hammocks to meet foraging needs. Once they have fledged, young white-crowned pigeons show a strong preference for hardwood hammocks 5.0 hectares or greater within the first 72 hours of fledging (Strong and Bancroft 1994). After this, white-crowned pigeons generally stay within hardwood hammocks, avoiding urban areas (Strong and Bancroft 1994). Viable foraging habitat represents the major limiting factor for the white-crowned pigeon (Strong et al. 1991). Smart Growth and Scenario 5 result in further losses of white-crowned pigeon habitat (Table 4.17)

**TABLE 4.17
WHITE-CROWNED PIGEON**

	Number of Patches	Total Area (ac)	Mean Patch Size (ac)
Adult White-Crowned Pigeon			
Current Conditions	496	7,080	14.3
Smart Growth	504	7,000	13.9
Scenario 5	504	6,979	13.8
Juvenile White-Crowned Pigeon			
Current Conditions	5,833	44,372	7.6
Smart Growth	5,858	44,251	7.6
Scenario 5	5,857	44,193	7.5

Bancroft et al. (1995) determined the minimum patch size below which five forest-nesting bird species were unlikely to be found. The species studied were the white-eyed vireo (*Vireo griseus*), the black-whiskered vireo (*Vireo altiloquus*), the northern flicker (*Colaptes auratus*), the yellow-billed cuckoo (*Coccyzus americanus*), and the mangrove cuckoo (*Coccyzus monor*). The Smart Growth Scenario resulted in a slight additional habitat loss for the five forest nesting species (Table 4.18).

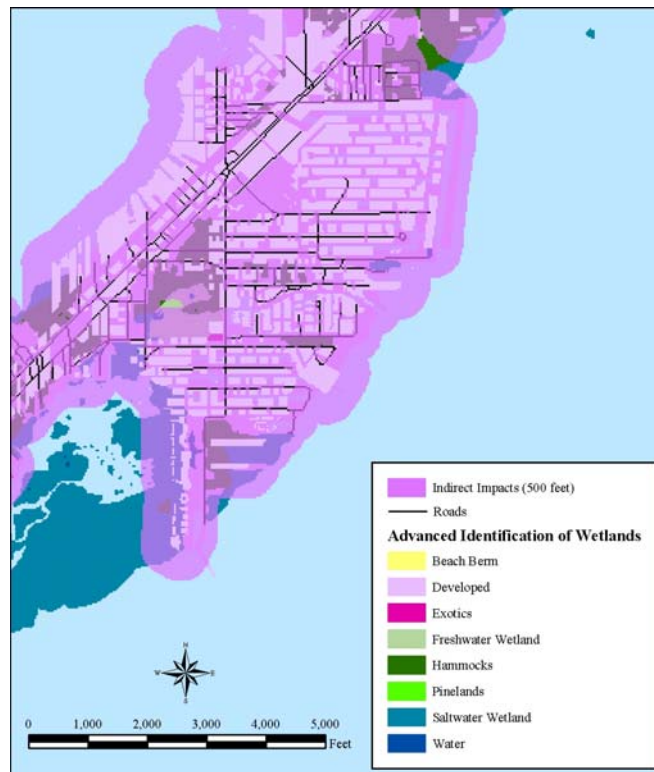
TABLE 4.18
RESULTS OF THE DIRECT IMPACTS TO FOREST INTERIOR BIRD HABITAT

Species	Current Conditions		Smart Growth		Scenario 5	
	Habitat Acreage	Number of Patches	Habitat Acreage	Number of Patches	Habitat Acreage	Number of Patches
Black-whiskered Vireo	7,579	625	7,486	611	7,460	606
White-eyed Vireo	6,778	189	6,703	187	6,683	189
Northern Flicker	6,401	136	6,335	135	6,335	135
Yellow Cuckoo	5,633	74	5,574	73	5,574	73
Mangrove Cuckoo	5,055	50	5,000	49	5,000	49

4.6.4 Secondary Impacts

The secondary effects of development on habitats, such as increased predation pressure due to the introduction of domestic predators, or the effects of increased and sustained noise levels, ripple through the habitat and may affect entire patches of native vegetation. Small patches, which are the rule in the Florida Keys, are often surrounded by development and may receive secondary effects around its entire perimeter. While difficult to quantify, secondary effects are likely to be more significant as patch size decreases. In many areas of the Florida Keys, particularly in the narrower Upper and Middle Keys, indirect effects cover entire patches of habitat (Figure 4.21).

**FIGURE 4.21
INDIRECT EFFECTS**



Over 37 percent of the remaining habitat after direct effect is within 500 feet from a developed area, leaving approximately 32,000 acres of habitat potentially unaffected by development (Table 4.19).

**TABLE 4.19
HABITAT REMAINING**

	After Direct Impacts	After Indirect Impacts
Current Conditions	51,652	32,563
Smart Growth	51,490	32,463
Scenario 5	51,382	32,400

4.6.5 Restoration Potential in the Florida Keys

Development has replaced and fragmented natural habitats throughout the Florida Keys, leaving over 90 percent of the remaining upland areas fragmented into patches of 10 acres or less (Figures 4.22 and 4.23). Restoring connectivity and re-creating large patches of continuous habitat would require the conversion of developed lands (Figures 4.24 and 4.25).

FIGURE 4.22
EXAMPLE OF HABITAT LOSS AND FRAGMENTATION IN THE UPPER KEYS

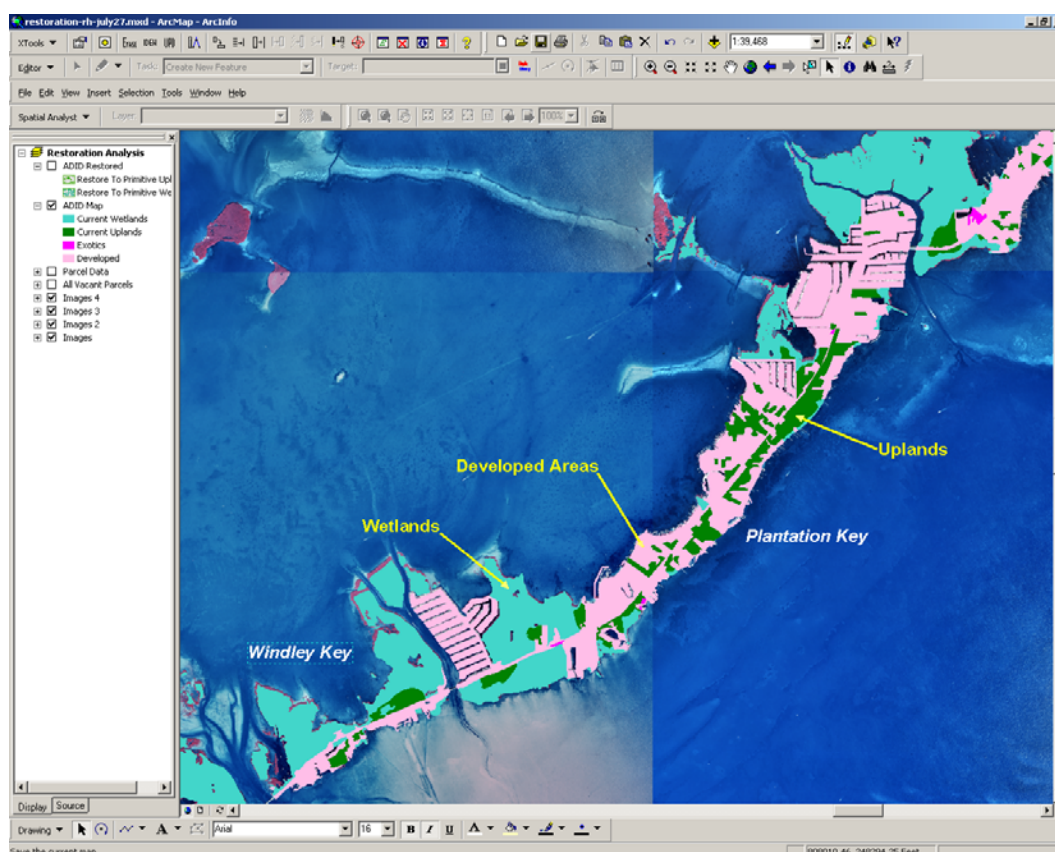
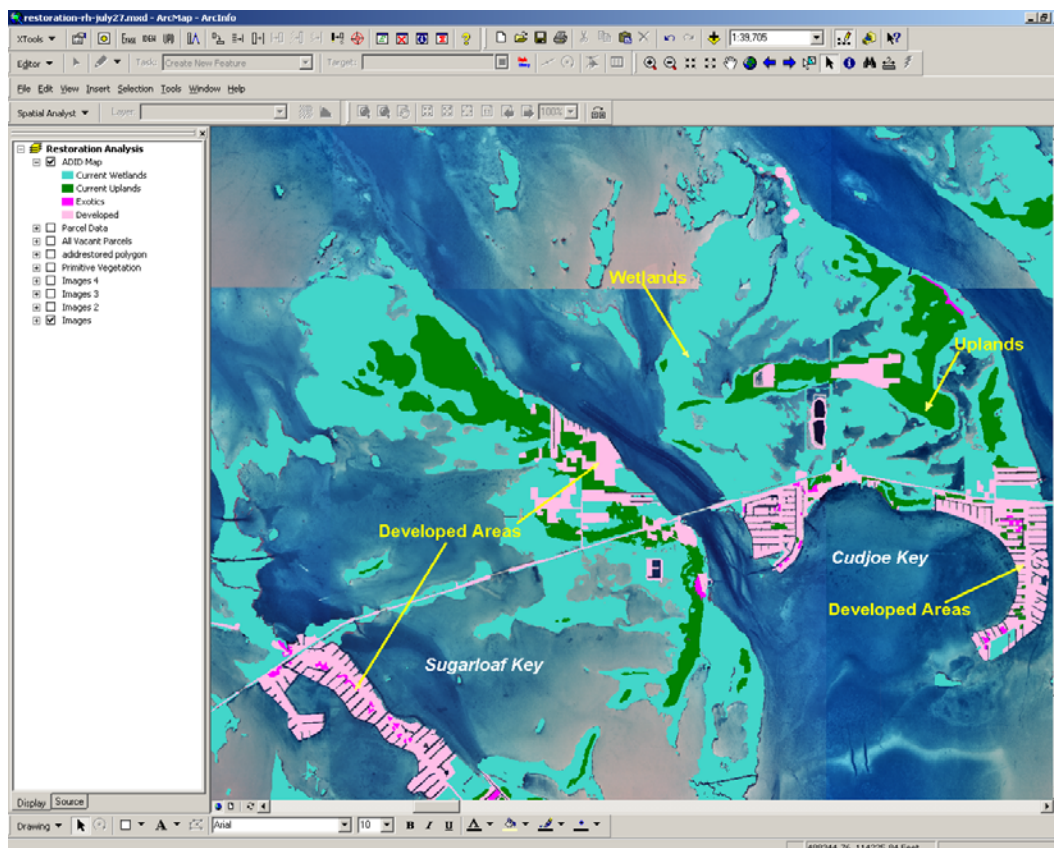


FIGURE 4.23
EXAMPLE OF HABITAT LOSS AND FRAGMENTATION IN THE LOWER KEYS



The Technical Contractor explored the challenges and consequences of restoring habitat through the acquisition and conversion of developed lands using example areas in the Upper Keys and Lower Keys. In pre-development times, upland habitats in the Upper Keys occurred in a long, narrow, continuous patch from northern Key Largo to Tavernier. This long patch was fragmented into many small patches, over 90 percent of which are below the 13-acre threshold. Restoring connectivity in the example area would require the acquisition and conversion of over 3,000 parcels (Figure 4.24), with over 3,200 dwelling units, and a total taxable value of over \$520 million.

A similar exercise for the example area in the Lower Keys suggested that restoration would require the acquisition and conversion of over 1,300 developed parcels (Figure 4.25), including over 740 dwelling units, with a total taxable value of nearly \$150 million. No attempt was made to estimate other cost involved in such a restoration effort, such as permitting, demolition, re-grading, re-planting, monitoring, and closing costs.

FIGURE 4.24
RESTORATION CHALLENGES IN EXAMPLE AREA IN THE UPPER KEYS

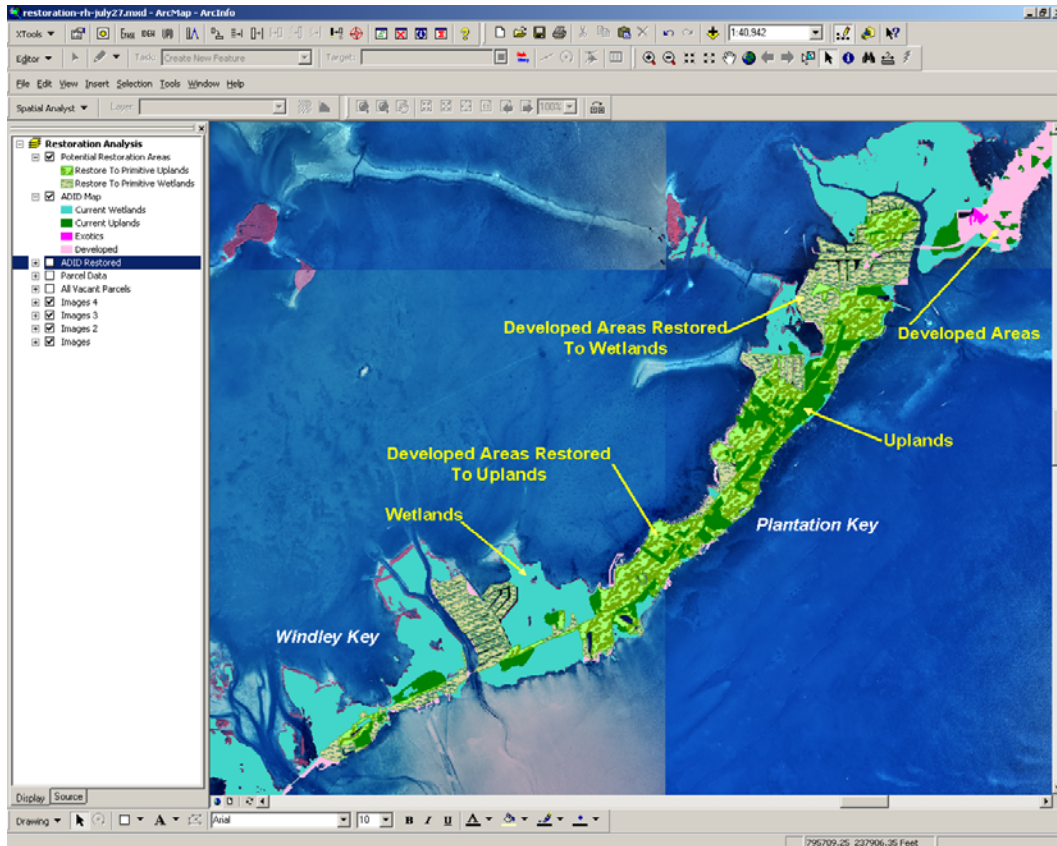
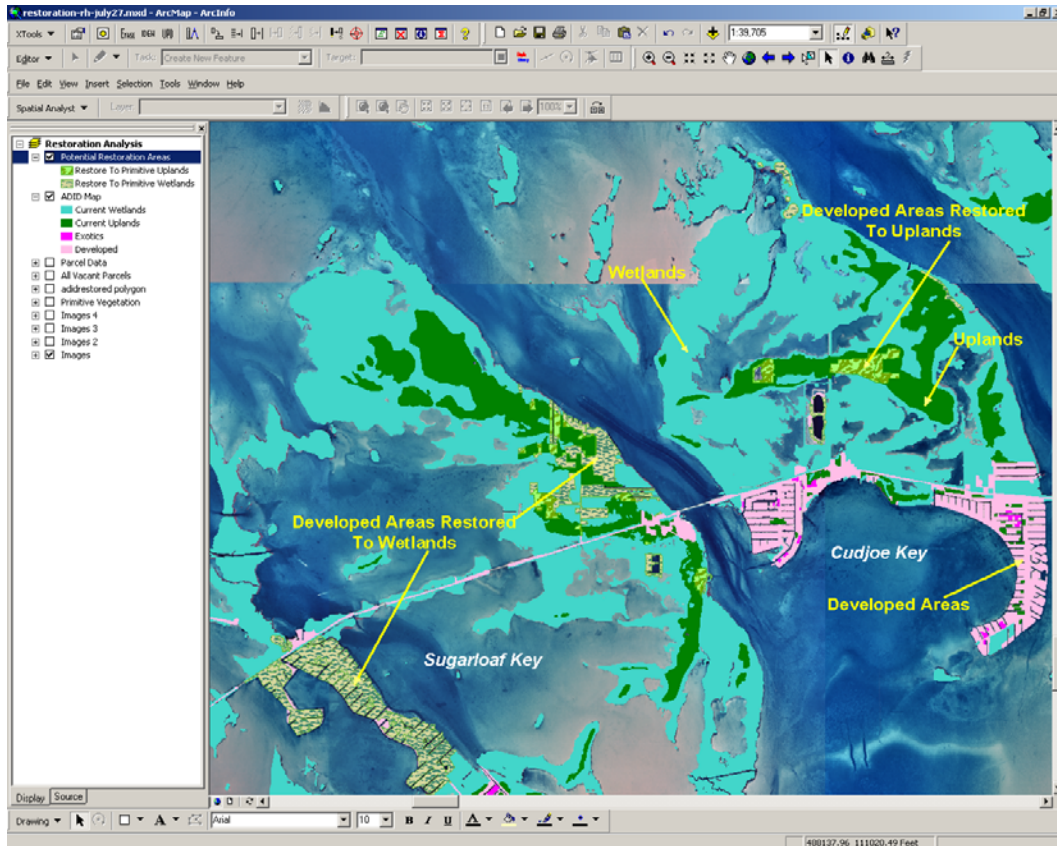


FIGURE 4.25
RESTORATION CHALLENGES IN EXAMPLE AREA IN THE LOWER KEYS



4.7 MARINE ECOSYSTEMS AND SPECIES

The literature search on marine ecosystems and species of the Florida Keys focused on peer-reviewed data on direct impacts caused by human activities on the marine environment, including propeller scarring in seagrass, boat collisions and anchoring impacts of coral, diving and snorkeling impacts, and fishing pressure. The literature search also sought information on the potential effects of nutrient, pollutant, and pathogen discharges from the Florida Keys on the water quality and benthic communities within the Florida Keys National Marine Sanctuary (FKNMS). Despite the existence of an extensive and growing body of literature on the ecological resources and water quality characteristics of the FKNMS (reviewed in Porter and Porter 2002, Sullivan et. al 1996), the available data proved insufficient to establish predictive relationships between land development activities and the impacts listed above. The remainder of this section summarizes current knowledge on water quality, benthic community biological response to nutrients, and direct human impacts to marine resources in the FKNMS.

4.7.1 Water Quality and Benthic Communities of the Florida Keys National Marine Sanctuary

Water Quality in the Florida Keys National Marine Sanctuary

Since 1995, EPA and the State of Florida have been monitoring water quality in the FKNMS. Boyer and Jones (2002) summarized the results of this monitoring program based on sampling from 1995 to 1998. They concluded that, at a Keys-wide scale, the FKNMS exhibited “very good” water quality (Boyer and Jones 2002, page 613). They showed that the Upper Keys generally have lower nutrient concentrations than the Middle or Lower Keys. Concentration of TN generally decreased from inshore to offshore (both bayside and oceanside); the same occurred for TP, with the exception of the Upper Keys, where TP increased offshore, oceanside. Median TP and TN concentrations were 0.17 μm and 10.04 μm respectively, with a median TN:TP ratio of 62.10, indicating a P-limited environment (benthic organisms uptake N and P in relatively constant ratios. A P-limited environment has lower availability of P and benthic organisms may respond rapidly to increases in P). Sampling stations located in channels or passes had significantly higher nutrient concentrations than stations located off land; however, differences were “very small and not likely to be biologically important” (Boyer and Jones, op. cit., page 626).

The Nature Conservancy (TNC) has run a volunteer-based water quality sampling program in canals and other nearshore locations in the Florida Keys since 1994. Keller and Itkin (2002) have reported on the results of this program. Results based on sampling data from November 1996 to October 1997 show that monthly TN values range from 13.6 to 177.0 μm , with the largest annual mean occurring in the Upper Keys, followed by the Lower and Middle Keys. Statistically significant differences occurred only between Upper and Middle Keys values. TN was lower in sampling stations near developed areas (41.3 μm) than in natural shorelines (52.3 μm). Monthly mean values for TP ranged from 0.17 to 5.25 μm . Annual mean was not statistically different between stations with regard to region (Upper, Middle, Lower Keys), shoreline type (developed, undeveloped), side (bayside, oceanside), or season. A significant correlation between TP and Chl a suggested that P-limitation occurs.

Kruczynski and McManus (2002) provide an extensive discussion of water quality issues in the Florida Keys. They reviewed TN and TP data for three canals, and show values between 19.8 and 40.5 μm for TN and between 0.21 and 1.04 for TP; both higher than those observed in open waters. Lapointe et al. (1994) also measured elevated TN and TP levels ($>35 \mu\text{m}$ and $>0.45 \mu\text{m}$, respectively) at sampling stations that received direct nutrient inputs, including a canal in Big Pine Key.

Water Circulation

Circulation patterns influence water quality. Lee et al. (2002) and Smith and Pitts (2002) recently reviewed the current state of knowledge regarding circulation patterns in the Florida Keys. Circulation patterns in the Keys are complex, as they vary in space and time and exhibit influences from regional current, local gyres, tidal movements, and wind patterns. Smith and Pitts (2002) conclude that there is a clear coupling between the Gulf of Mexico and the Atlantic side of the Keys, mainly through Florida Bay and tidal channels. Despite extensive documentation of circulation patterns, no one has attempted to develop a hydrodynamic model for the Florida Keys. For the FKCCS, diligent attempts to adapt existing models or to develop a simple model led to the conclusion that existing models and data are insufficient.

Pathogens in the Marine Environment

High levels of pathogens in recreational waters can increase human exposure through ingestion and body contact; therefore, increasing the risk of human illness. Total and fecal coliform bacteria are frequently used as indicators for waters polluted by human wastes typically through sewage and stormwater runoff. Additionally, other agencies recommend other indicators for use in marine waters, such as Enterococci. A review of federal, state and local datasets revealed that, while several programs are in place, no long-term data were available to establish a relationship between land development and human pathogens in the marine environment in the Florida Keys. However, mounting evidence suggest that human pathogens enter the marine environment from Florida Keys sources. For example, health officials have closed beaches in the Florida Keys several times in the last few years because of fecal coliform contamination. Recent research has shown viral tracers on coral heads within 100 m from shore (Lips et al. 2002), suggesting a potential connection between sewage and coral communities.

Effects of Nutrients on Benthic Communities

The literature review focused on finding peer-reviewed documentation of the relationship of land development activities and the distribution, extent, and ecological conditions of benthic communities in the Florida Keys. In particular, efforts focused on the documentation of the relationship between water quality and benthic communities. An extensive body of literature explores the effects of pollution on seagrasses, but widespread agreement on the appropriate indicator to study is elusive.

Lapointe et al. (1994) determined that TN and TP concentrations decreased with increasing distance from shore. They measured TN and TP concentrations in the water column as well as seagrass productivity parameters. They concluded that the use of TN and TP pools appears to be the best single nutrient index of eutrophication as this measurement includes all nutrient pools and is also a proxy for water transparency (Lapointe and Clark 1992). The FKCCS explored the

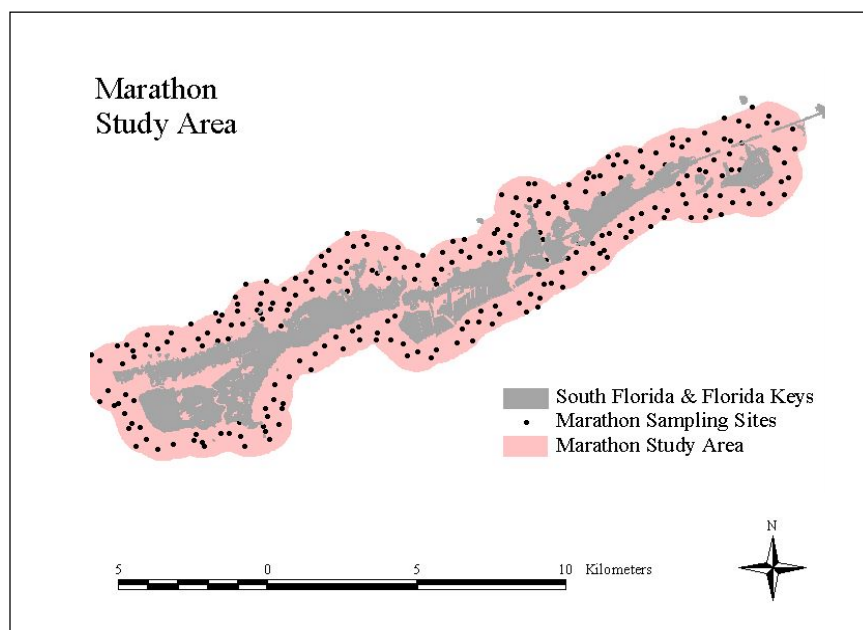
connections between TN and TP loads and their contribution to TN and TP concentrations in the marine environment.

The FKCCS included an investigation by Florida International University (FIU) (Jim Fourqurean and Leanne Miller-Rutten, investigators) of nearshore (<1 km from shore) benthic communities of the Florida Keys (Appendix A). The study tried to identify spatial and temporal variations within nearshore benthic communities and their associated nutrient regimes and to determine if these variations may be associated with human land use activity in the Florida Keys. Working hypotheses included:

- **H₁:** Nearshore benthic communities and their associated nutrient regimes exhibit spatial/temporal variation throughout the Florida Keys.
- **H₂:** There is a significant relationship between human land use activity and spatial/temporal variation of nearshore benthic communities and their associated nutrient regimes throughout the Florida Keys.

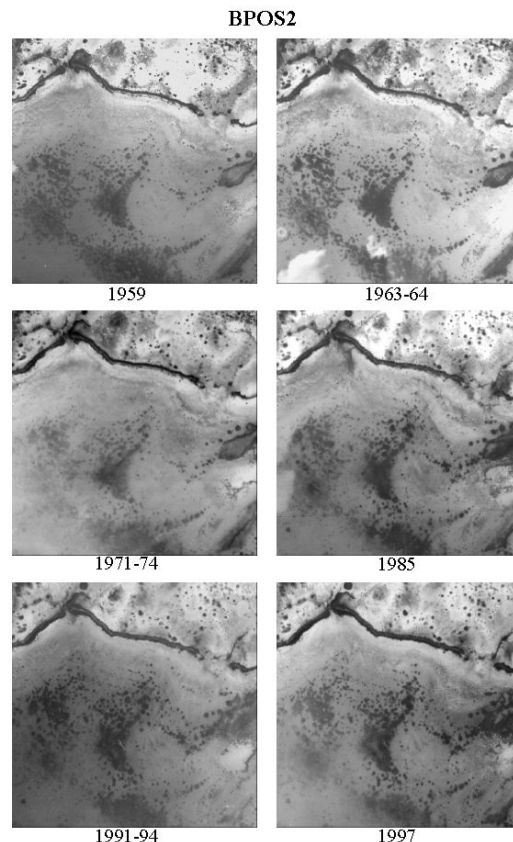
The project began with the creation of maps of the current distribution and composition of nearshore benthic communities using intensive surveys and recent aerial photographs. Next, historic aerial photographs were used to construct a complete time series of maps at multiple sites within the study area. The nature of changes within nearshore benthic communities at those sites was investigated. Nutrient samples were also collected near the time series sites to characterize the nutrient regimes of nearshore benthic communities (Figure 4.26). Finally, all project data and available countywide land use activity data were incorporated into a GIS database. Database queries and spatial analyses were conducted to explore relationships between land use activities, nearshore nutrient regimes, and nearshore benthic communities in the Florida Keys.

FIGURE 4.26
BENTHIC SAMPLING LOCATIONS NEAR MARATHON



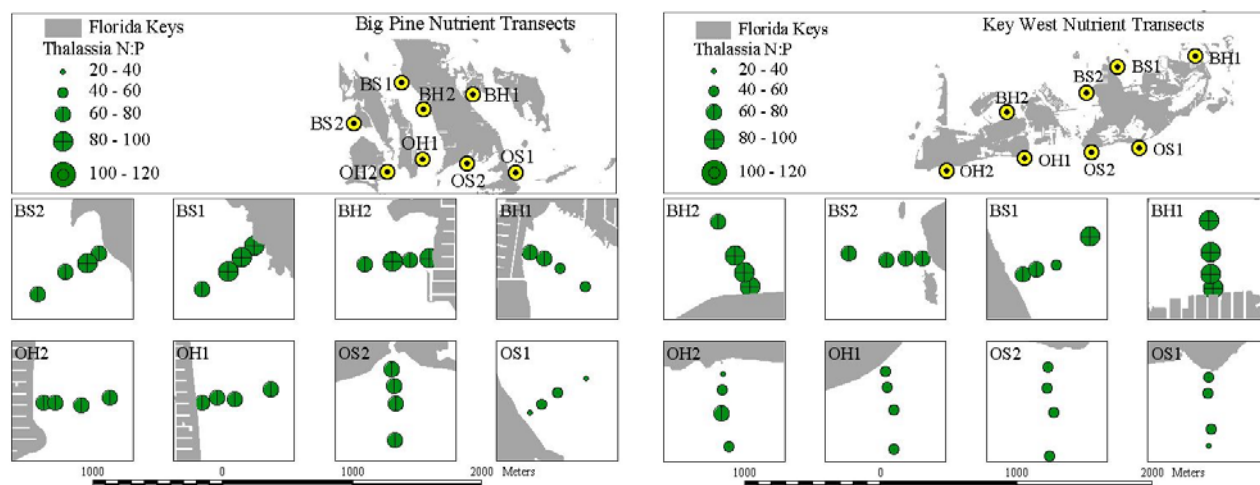
The first working hypothesis, that nearshore benthic communities and their associated nutrient regimes exhibit spatial or temporal variation throughout the Florida Keys, was conclusively proven. Both nearshore benthic communities and their associated nutrient regimes do exhibit spatial variation throughout the Florida Keys. However, nearshore benthic communities exhibited very little temporal variation through the past 40 years, even in the face of tremendous land development in the Florida Keys. FIU's time series analyses of the black and white FDOT aerial photographs reveal very little change in the distribution of nearshore benthic communities in the Florida Keys since 1959 (Figure 4.27). There are no significant differences in the amount of Keys-wide benthic macrophyte cover with respect to time (1959-1997, six time steps), location (oceanside or bayside), or land use (heavily or slightly developed). However, there are clear differences in the magnitude and direction of the minimal changes detected with respect to study area. The mean temporal change at most Key Largo and Marathon sampling sites were positive, reflecting small net increases, while the mean temporal change at most Big Pine and Key West sampling sites were negative, reflecting slight net decreases. The results provided little evidence to support the hypothesis that there is a significant relationship between human land use activity and spatial or temporal variation of nearshore benthic communities and their associated nutrient regimes throughout the Florida Keys.

FIGURE 4.27
EXAMPLE TIME SERIES



Results indicate that substrate, not land use, is the most important factor associated with benthic community distribution and composition. Two modeling approaches identified potential relationships between a few individual taxa, taxa groups, nutrient parameters, and land use, but very few of these relationships are significant throughout the Florida Keys. Preliminary analyses of *Thalassia testudinum*, sediment, and epiphyte samples collected at 32 transects did not reveal any significant Keys-wide trends in nutrient parameters with respect to location (oceanside or bayside), distance from shore (50 meters, 100 meters, 250 meters, or 500 meters), or land use (heavily or slightly developed). However, maps of nutrient data revealed potential significant relationships may exist within study areas (Figure 4.28). Further spatial analyses showed no conclusive relationships. N:P were high in the vast majority of samples, corroborating other reports of a P-limited environment.

FIGURE 4.28
THALASSIA N:P RATIOS IN BIG PINE KEY AND KEY WEST



4.7.2 Direct Human Impacts on Marine Resources

Residents and tourists alike use the expansive waters of the FKNMS for boating, snorkeling, diving, and fishing. Each of these activities put people in direct contact with environmental resources and may significantly affect them. The study team's research focused on four types of direct impacts: propeller scarring, boat groundings, snorkeling and diving impacts, and fishing pressure. The main objective was to determine a quantitative and spatial relationship between land development activities, people, and impacts to the resources.

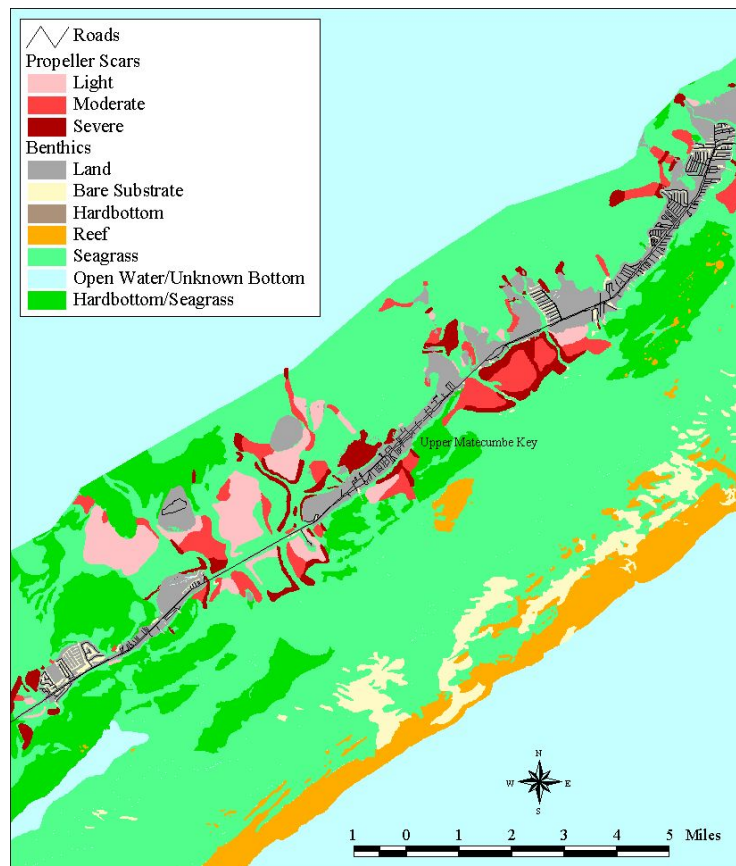
Propeller Scarring in Seagrasses and Boat Groundings on Coral Reefs

Initially, efforts concentrated in quantifying the volumes and sources of boat traffic within the study area. A review of the literature revealed that no comprehensive boat traffic study existed for the Florida Keys (Leeworthy 1998, Stolpe 1998, Matthews and Donovan 1992, FKNMS 1996; Kruer 1993).

Subsequently, the Technical Contractor evaluated aerial survey data for boat usage from both Florida Marine Research Institute (FMRI) and the National Marine Fisheries Service (NMFS). The NMFS Miami Laboratory, in conjunction with the United States Coast Guard Miami Air Station, has monitored vessel activity in the Sanctuary from 1992 to present. FMRI aerial fly-over/surface survey data, collected from June 1992 through August 1993, represents the most rigorous attempt to estimate utilization of the FKNMS to date. However, the FMRI survey includes data for only one year, which prevents any correlation analysis to development in the Florida Keys. In addition, Hurricane Andrew hit south Florida during the FMRI survey period. The NMFS survey data, though collected for nine years, does not measure the total number of boats. Therefore, neither dataset proved appropriate for establishing a connection between population and the number of boats utilizing the FKNMS.

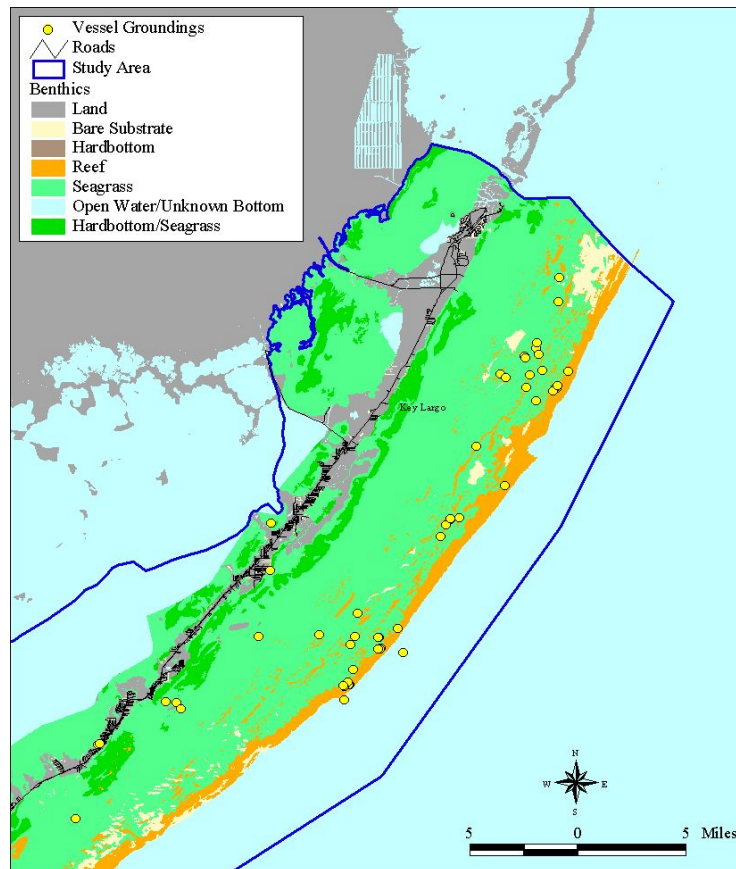
FMRI developed a seagrass scarring map (Sargent et al. 1995, see Figure 4.29) that classifies scars as light, moderate, or severe. Multiple regression analysis showed no significant correlation between the distribution of scars and a series of development surrogates, including development status of the nearest shore, location of marinas and boat ramps, location of navigational aids, and location of channels. The distribution of scarred seagrass areas was correlated with distance from shore (independently of shoreline type) and water depth. The conclusion was that, as expected, seagrass scarring occurs mainly in nearshore, shallow water.

FIGURE 4.29
PROPELLER SCARS MAPPED IN THE UPPER MATECUMBE AREA



In addition, FMRI maintains a spatial boat groundings database (Figure 4.30). As expected, boat groundings occur mainly near reef areas, and are more likely to occur in popular reef destinations.

FIGURE 4.30
FMRI BOAT GROUNDINGS DATA IN THE UPPER KEYS



Snorkeling and Diving Impacts on Coral

Recreational SCUBA diving causes damage to reefs at exponentially increasing rates as diving intensity increases (Hawkins and Roberts 1992). The total dive site area in the Florida Keys is 217 nautical square miles (Kearney and Centaur 1991). A third of the tourists in the Keys participate in scuba diving or snorkeling (Monroe County Tourist Development Council 1997-2001). Nearly 90 percent of the significant dive spots are located in the upper Keys and are popular because of their accessibility and the number of dive operations available.

A Florida study showed divers touched coral heads an average of seven times during a 30-minute interval, while five percent of divers have more than 20 incidents per 30-minute dive (Tagle 1990). Snorkellers generally stand on corals and stir up large amounts of sediment, but

they usually have fewer contacts than scuba divers. Scuba divers generally touch corals when pushing off the substrate and when finning. Indicator species considered for diver damage were branching corals as opposed to massive corals (Paryente et al. 1999, Roupheal and Inglis 1995, Hawkins and Roberts 1992). However, sanctuary-wide coral monitoring data exists only for 4 years, rendering identification of long-term changes in coral densities difficult (Jaap et al. 2001). Diver damage to corals is unlikely to have major consequences for local coral populations, but may be substantive enough to affect the aesthetic appeal of the sites (Roupheal and Inglis 1995).

Recreational Fishing

Recreational fishing is an integral part of life in the Florida Keys. The study team spent a considerable amount of effort researching the relationship between development, population, recreational fishing effort and the status of the fisheries. The primary means by which development is likely to impact fisheries in the Florida Keys include direct fishing pressure, production of pollutants affecting fisheries, and destruction of essential habitat. Commercial fisheries were not rigorously considered because commercial fishing pressure is largely independent of residential and tourism development patterns. The number of commercial vessels in the Keys has remained almost constant since the early 1960s (Bohnsack et al. 1994).

Catch per unit effort (CPUE) commonly provides a measure of stock abundance, but other factors may also influence catch. Bohnsack 1994 point out that “better data are particularly needed for recreational fisheries although the task will be complex considering the number of participants, various modes of fishing (private boat, shore, bridges, guide boats, headboats, charter boats), the various species targeted (e.g., inshore flats, reefs, offshore trolling), and the various goals of individual participants (trophy fish, food, excitement, catch-and-release, ‘just catch something’).” Further complicating CPUE, are the changes due to a rapidly growing fishing power per vessel (Mace 1997). As a result, “catch per boat day” has a much different meaning than ten or even five years ago, rendering year-to-year comparisons questionable. CPUE evaluation is also complicated by the fact that guided services, including guide, charter, and head boats, are adept at altering fishing targets when CPUE weakens, in order to provide satisfaction to clients. For all these reasons, available CPUE data are difficult to use to predict impacts of land development activities.

Ault et al. (1997) suggested that the Florida Keys reef fish stocks exhibit classic overfishing patterns with more vulnerable species being progressively depleted (citing Munro and Williams 1985 and Russ and Alcala 1989), and that several reef fish stocks are overfished according to NOAA definitions (citing Rosenberg et al. 1996). However, these conclusions do not clarify quantitative relationships between land development and fishing pressure. A recent study by the FKNMS reported higher densities of several fish species occurring in no-take zones of Sanctuary Preservation Areas than in uncontrolled fishing areas, but this information was not quantitatively related to fishing pressure (NOAA 1998).

4.7.3 Quality of Life

Test results of the CCIAM can be contrasted with the ranking of quality of life issues identified through the Public Involvement and Information Program (PIIP). The mean ranks were divided by the smallest rank and values were grouped in categories from 1 to 3.5 (Table 4.20). Water quality and conservation of habitat obtained the highest rank. Water quality would tend to improve with the implementation of the stormwater and wastewater master plans, as indicated in the Smart Growth and Scenarios 1-5. The Smart Growth and Scenarios 1-5 also include the acquisition of lands for conservation, thereby providing for increased conservation.

TABLE 4.20
**NORMALIZED RESULTS FROM THE COMMUNITY CHARACTER/
QUALITY OF LIFE ISSUES RANKING**

Parameter	Relative Rank
Water Quality Protection/Improvement	1.0
Conservation of Existing Habitat	1.0
Maintain Current Community Character	1.5
Decrease Level of Traffic	1.5
More Land Use and Development Growth Controls	2.0
Affordable Housing	2.0
Improve Safety on U.S. 1	2.0
Strengthen Enforcement of Existing Government Regulations	2.0
Protection of Property Owner's Rights	2.0
Decrease Level of Tourism	2.0
Current Land Use and Development Growth Controls	2.5
Land Recreation Opportunities	2.5
Water Recreation Opportunities	2.5
Current Level of Tourism	2.5
Reduce Government Regulation	3.0
Less Land Use and Development Growth Controls	3.0
Increase Level of Tourism	3.5