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Development of a Methodology for Determining Optimum Locations for Wildlife Crossings on State Highways Using a Geographic Information Systems Approach, with Application to Key Deer on Big Pine Key, Florida

Prepared for
FLORIDA DEPARTMENT OF TRANSPORTATION

Prepared By
THE UNIVERSITY OF FLORIDA
DEPARTMENT OF LANDSCAPE ARCHITECTURE

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Final Report

Prepared for the Florida Department of Transportation

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Acronyms

Digital Ortho Quarter Quad	D.O.Q.
Environmental Systems Research Institute	E.S.R.I.
Florida Department of Transportation	F.D.O.T.
Florida Geographic Data Library	F.G.D.L.
Florida Marine Research Institute	F.M.R.I.
Florida Resource Environmental Analysis Center	F.R.E.A.C.
Geographic Information Systems	G.I.S.
Global Positioning System	G.P.S.
Mile Marker	m.m.
South Florida Water Management District	S.F.W.M.D.
US Army Corps of Engineers	U.S.A.C.E.
U.S. Fish and Wildlife Service	U.S.F.W.S.

1.0 Background

Since the early 1980's, Florida Department of Transportation has recognized the need to reduce the mortality of the endangered key deer. Speed limit reduction, signs, clear-cut maintenance on the shoulders, radio advisories, no-passing zones and increased surveillance have all been tried with mixed success. In 1995, a concept study was begun to look at alternatives to reduce the deer mortality. This study, entitled *"US-1/SR5 Key Deer/Motorist Conflict Study"*, proposed a solution that integrated structural and non-structural measures. It included the use of deer exclusion devices along the corridor and at key intersections. Deer underpasses were proposed in the undeveloped section of Big Pine Key and non-structural measures were combined in the developed section to increase driver awareness. Questions remained about the optimum location for the crossings in both the developed and undeveloped sections of Big Pine Key. Connections to large habitat areas to the north and south of U.S 1 were deemed important and warranted more study.

1.1 Original Scope of Work

In May 1997, F.D.O.T. contracted with researchers at the University of Florida Department of Landscape Architecture to develop a methodology for determining optimum locations for wildlife crossings on State highways using geographic information systems (G.I.S.). The methodology was then to be applied and tested on a portion of US-1/SR-5 in Big Pine Key, Monroe County, Florida, with specific focus on the highway mortality problems involving vehicular collisions with key deer. In addition to the development of this methodology, there was to be a literature search for relevant information relating to the natural history and habits of Florida Key deer. This search was to include movement of wildlife in corridors, wildlife mortality on highways, intersections of wildlife corridors and highways, and effective and safe location of wildlife crossings.

This project was to be done by the University of Florida, Department of Landscape Architecture, in conjunction with the University of Florida Geoplan Center and the F.D.O.T. The work would be coordinated with the United States Fish and Wildlife Service (USFWS) and the Florida Game and Fresh Water Fish Commission (FGFWFC).

The following is a summary of the original scope of services:

Task 1: Develop Task Assignment Schedule

Task 2: Literature Search

The University will use the State University System library and the internet to review publications, references, journals, periodicals, conference proceedings and case studies for relevant information relating to the following:

- the natural history and habits of Florida Key deer
- movement of wildlife in corridors
- wildlife mortality on highways

- intersections of wildlife corridors and highways
- effective and safe location of wildlife crossings

A summary of findings will be included in the final report with a bibliography and listing of sources.

Task 3: Methodology Development
The University will develop a methodology for determining optimum locations of wildlife crossings on state highways. This methodology will identify and relate certain variables as to their importance in determining wildlife crossing locations. The final report will explain the rationale for selection of variables and their relative importance. Certain assumptions will be made and tested using G.I.S. models to determine accuracy and effectiveness. These tests will be run on Arcview© software. The process and results will be included in the final report.

Task 4: Acquisition and Development of G.I.S. Mapping
The University will acquire all available, relevant G.I.S. coverages for Big Pine Key. Other coverages will be developed from data supplied by the U.S.F.W.S. and any other agencies that have relevant data. New map coverages will be created from existing data, maps, field work and observation. Field work will be conducted to verify accuracy and collect data which is not available on other data bases.

Task 5: Application of Methodology on Florida Key Deer, Big Pine Key
The University will test the final methodology on the Florida key deer located on Big Pine Key. Maps at an appropriate scale will be produced to graphically illustrate the methodology of locating Key deer crossings at certain locations. A summary of the process and the related maps will be included in a final report.

1.2 Modified Scope of Work

At a meeting in February 1998 between all involved individuals and agencies, changes to the original scope of work were agreed upon. Through the course of the project, certain key tasks and issues arose that were not apparent when the original grant proposal was written, while other tasks began to lose importance and relevance. For instance, Task 2 (literature search) was yielding little in the way of new material beyond the original report "*US-1/SR-5 Key Deer/ Motorist Conflict Study*". Task 3 (development of a methodology for determining the optimum locations for wildlife crossings on state highways) was virtually impossible to develop as a universal or generic model that would be appropriate for specific applications. The unique differences between different species, the variety of roadways and roadway contexts, and the complexity of dealing with multiple species make such a model so general that it could not be effective for a specific highway at a specific location with specific species. Task 4 (Acquisition of G.I.S. coverages) was substantially complete, but needed ground truthing. Discussions at this meeting concluded that an additional, more current task should be added— determining wildlife corridors. Other tasks would be modified. The additional task (Task 6) would be to develop a

strategy for identifying potential deer movement corridors that could connect habitat and direct deer through the commercial district of Big Pine Key. This task was to include analysis of G.I.S. data already collected, with some additional information to be gathered on site, such as location of structures, fences and other pertinent data. Task 6 would also include a process for prioritizing lands for acquisition, etc. so as to create viable wildlife corridors. To accomplish this additional task, it was decided to eliminate Task 2 (literature search) and Task 3 (development of a general methodology) for reasons stated above. It was further agreed to expand Task 4 to include the location of building footprints and fences in the commercial area.

In summary , the modified scope of services was changed to:

Task 1: Develop Task Assignment Schedule
The original schedule had to be revised to reflect a different end product.

Task 2: Literature Search (deleted)

Task 3: Methodology Development (Generic methodology deleted)
A site specific methodology was developed for Key Deer on Big Pine Key.

Task 4: Acquisition and Development of G.I.S. Mapping
Additional coverages were needed to fulfill Task 6.

Task 5: Application of Methodology on Florida Key Deer, Big Pine Key

Task 6: Prioritize Lands for Wildlife Corridors (new task)
The U.S.F.W.S identified three specific habitat target areas to route deer. One area was to the north of U.S.1 and two areas were to the south of U.S. 1. U.S.F.W.S. also indicated a location where deer crossings were proposed. The wildlife corridors were to link these elements.

2.0 Development of the G.I.S. Model for the Key Deer on Big Pine Key

2.1 Identify the Data Necessary for this Project

The first step was to determine what data was necessary for this particular study. Lists were compiled of potential data fields, then the fields were evaluated as to their pertinence to this study.

Data generally fell into one of two broad categories involving the particular species and the specific project site. Pertinent species characteristics of the Key deer included behavior and movement patterns, preferred habitats, forage and cover, etc. Equally important were site characteristics and context. These included barriers and other physical characteristics that may affect wildlife movement, roadkill patterns along U.S. 1, property appraisal data, etc.

A third category— "what if"—was determined to be necessary as well. Certain possibilities, such as using grade-separated crossings, had been suggested; therefore, data that could be important in evaluating possible scenarios or solutions needed to be gathered, as well as the more objective existing conditions and generic species data.

When the potential data fields were identified, they were evaluated as to their importance to this particular project. Some data fields were eliminated in this step. For example, the locations of potable water would likely be important for almost any species being studied, but for this study, it was determined that the water sources were everywhere and had no discernible pattern or impact on movement (Stieglitz, personal interview). As they had little impact on wildlife crossings at this site, they did not need to be mapped or included in further work.

The next step in this phase was to determine the boundaries of study for each data field. Data fields relating primarily to roadkill included the U.S. 1 right-of-way and immediately adjacent properties. Some, like property appraisals and habitat value, were important in evaluating roadkill and determining corridor routes. These covered far more of Big Pine Key than the U.S. 1 right-of-way, as they had to include the three target habitats that the corridor needed to connect.

2.2 Finding and Converting Existing Data

Considerable data necessary to the study had already been compiled by various agencies, but finding it was occasionally difficult. When data was found, it often had to be re-formatted, since this study was to use a G.I.S. approach. All data needed to be compatible with Arcview© software.

Beginning in May of 1997, the study team collected available G.I.S. coverages from County, State and Federal agencies. The Florida Geographic Data Library (F.G.D.L.) at the Geoplan Center at the University of Florida had incomplete and inadequate data layers for Monroe County; therefore, it was necessary to seek coverages from other sources. For example, the study team obtained future land use and habitat coverage from the Monroe County Planning Department. The team also obtained another habitat coverage, as well as roads and marina coverage for Big Pine Key from the Florida Marine Research Institute (F.M.R.I.). The team obtained a Digital Ortho Quarter Quad (D.O.Q.) for Big Pine Key from the Florida Resource Environmental Analysis Center (F.R.E.A.C.) in Tallahassee. This was sent on a digital tape that was compiled through various C and Fortran programs. The team also exchanged data with the U.S. Army Corps of Engineers (U.S.A.C.E.), who are working on a digital data library for the Keys for the Florida Department of Community Affairs. (See list of contacts and sources in the appendix.)

Low altitude aerial photographs were scanned to give a preliminary base including location of buildings, land uses, and other data.

2.3 G.I.S. Coverages Created by the Study Team

Because of the specifics of working with a particular species at a particular site, and because of the detail necessary to solve the problem, some data fields did not exist and had to be created by the study team. These fields included fences and other barriers, potential for grade-separated crossings, locations where deer tend to regularly cross the highway, etc. Again, a key concern was to format the data in G.I.S. coverages that were compatible and could be manipulated.

A system for correlating data was necessary. One of the most important data fields, the roadkill data compiled by the U.S. Fish and Wildlife Service, used a nominal identification system that tied roadkill statistics to the nearest mile marker and/or power pole (e.g., number of males killed at mile marker 33). Although this data was originally all text, it could be expressed in the graphic format of G.I.S. Additionally, it served as the basis for a method of identifying points that could accurately locate other data. Using mile markers, power poles and points every tenth of a mile on U.S. 1 through Big Pine Key, the team could correlate non-graphic data into G.I.S. maps. This location system proved to be valuable in working with all the GPS coverages and other G.I.S. data, as it gave consistent and easily identified points of reference for all data.

In June, 1997, the study team traveled to Big Pine Key. Using a Trimble global positioning system (GPS) with sub-meter accuracy, the team first located mile markers, power poles, and points every tenth of a mile. They then located:

- visible wildlife trails
- fences
- buildings
- grassed areas on the U.S. 1 right-of-way
- wooded areas adjacent to road
- areas with potential for grade separation

The study team obtained data from the Monroe County Property Appraiser. From this data coverages were developed that indicated:

- property ownership
- vacant land
- land with structures
- property value
- homestead exemption

These were the criteria that seemed most important in determining potential wildlife corridors based on cost-effectiveness, feasibility, etc.

As the study progressed, other data fields were studied, including:

- habitat value
- religious and other land uses that the client wished excluded from consideration

The following sections describe each coverage in more detail.

2.4 Querying the Data

The following list of questions were used to query the collected data in the search for correlations and patterns.

- Where are the highest number of road kills along the corridor? Gender? Time of day? Age?
- What type of habitat is most prevalent nearest the highest number of road kills?
- Is there a relationship between road kill and highest number of visible trails?
- Is there a relationship between grass on the road R.O.W. and road kills?
- Is there a relationship between barriers and roadkills?
- Is there a relationship between grade separation and roadkills?
- What privately owned lands are the least expensive links to publicly owned habitat?

These questions are answered in the following sections.

2.4.1 Roadkill by Mile Markers

In 1985, the U.S. Fish and Wildlife Service started keeping records of key deer highway mortality by location, gender, and age, as well as other information not considered pertinent to this particular study. Given that overall herd stability depends primarily on the doe population, roadkill was described by number and gender.

Figure 1 shows the locations of each 1/10th mile marker with the total numbers of roadkill through 1997. Percentages of doe kill are indicated in red. Total numbers of roadkill are shown in the center of the pie diagram.

Finding:
There are high numbers of kill at the east and west ends of the corridor near the respective bridges. There are also high numbers near MM 32 and close to the curve halfway through the corridor. There does not appear to be any pattern regarding gender, age or time of day.

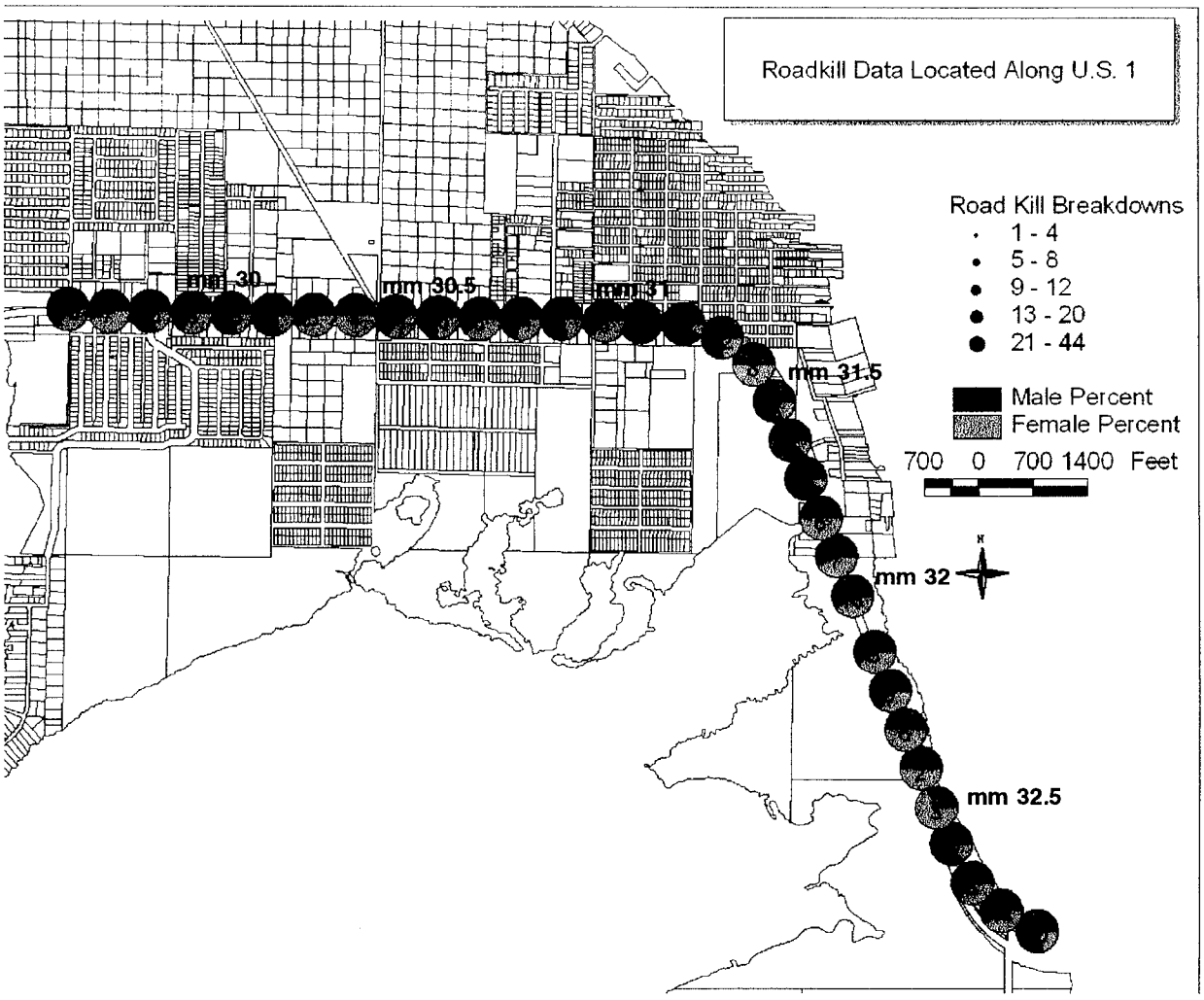


Figure 1. Roadkill Data Located Along U.S. 1

2.4.2 Grass on R.O.W.

Numerous roadkill studies indicate that food and water in or immediately adjacent to the right of way can increase wildlife mortality and collisions. Key deer frequently forage on the U.S.1 right of way for food. There is little or no potable water immediately adjacent to U.S. 1; the most significant watering areas to the north and south of U. S. 1 are quite distant. Water was not determined to be an important coverage for this study, but might there be a correlation between the grass on the right of way and the numbers of road kill? Using the global positioning system, the study team located where significant areas of grass occurred along the right of way.

Finding:

A comparison between the location of grass on the right of way and road kill data showed no significant relationship between the two sets of data at this site.

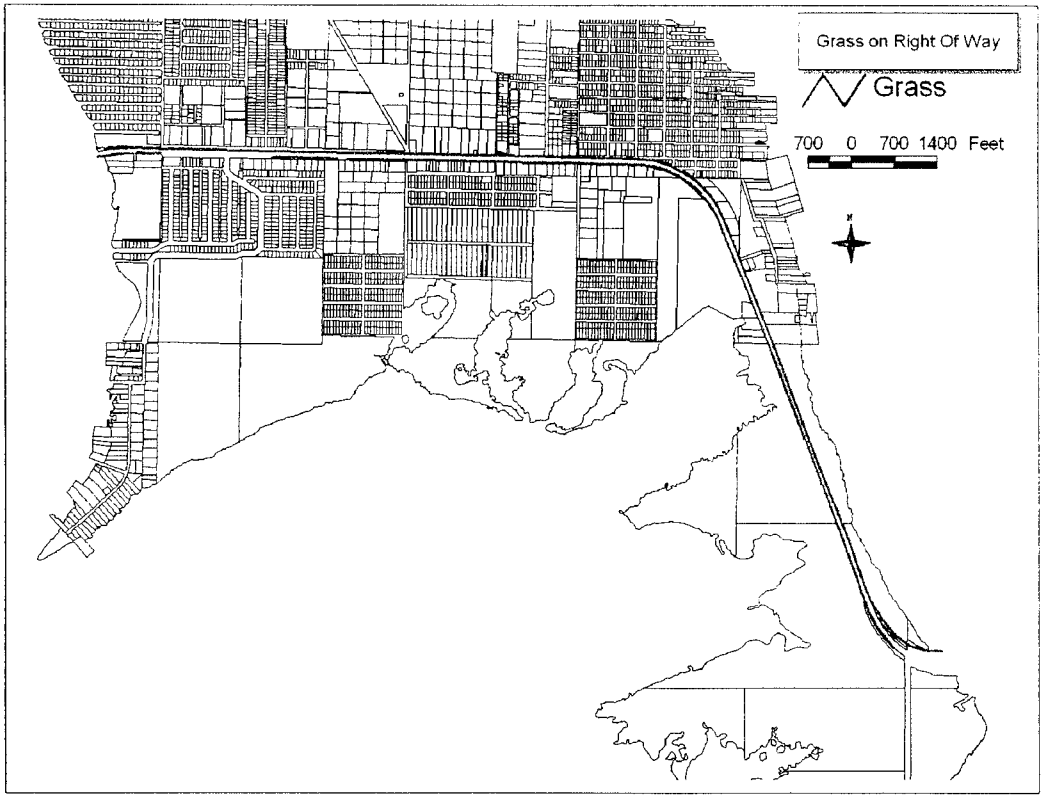


Figure 2 Grass On R.O.W.

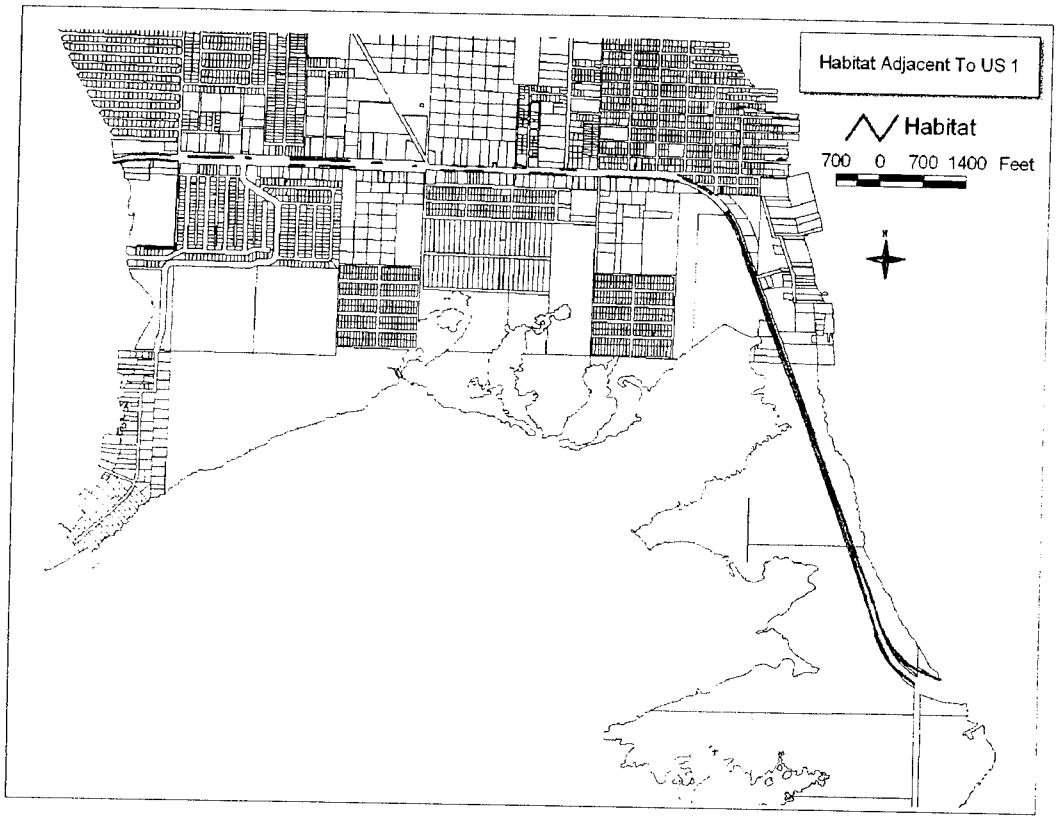


Figure 3 Location of Attractive Habitat Areas Adjacent to U.S. 1

2.4.3 Habitat Proximity

Land uses along U.S.1 change significantly and quickly from the eastern end of Big Pine Key to the western end, with natural habitat right next to busy commercial areas. Adjacent to the U.S. 1 corridor, pockets of undisturbed natural wooded areas plus open landscaped areas (church property, residential areas, etc.) provide habitat and movement corridors for the key deer. Using the global positioning system, these areas were located.

Finding:

A comparison between the location of habitat and road kill data shows that there are areas of high rates of mortality adjacent to areas of habitat, but there are also high mortality rates in areas without adjacent habitat.

2.4.4 Habitat Value

Using habitat data obtained from the Monroe County Planning Department and the U.S. Fish and Wildlife Service, habitats for the majority of Big Pine Key were evaluated and ranked in order of importance. Unlike the majority of coverages developed for this study, this covered a much larger area than the US 1 R.O.W and adjacent properties. This data could be studied for two major issues:

1) existing habitat and its impact upon movement
2) potentials for creating more viable wildlife corridors and helping to funnel deer to appropriate crossings.

The study team queried the data to see if there was a correlation between the location of certain habitat types adjacent to the corridor and the road kill numbers. The study team query used a 200 meter radius around each mile marker location.

Finding:
When habitat type was compared with road kill numbers, it was determined that there was no relationship between the type of habitat adjacent to the corridor and the road kill numbers. Habitat was however important in ultimately determining corridors.

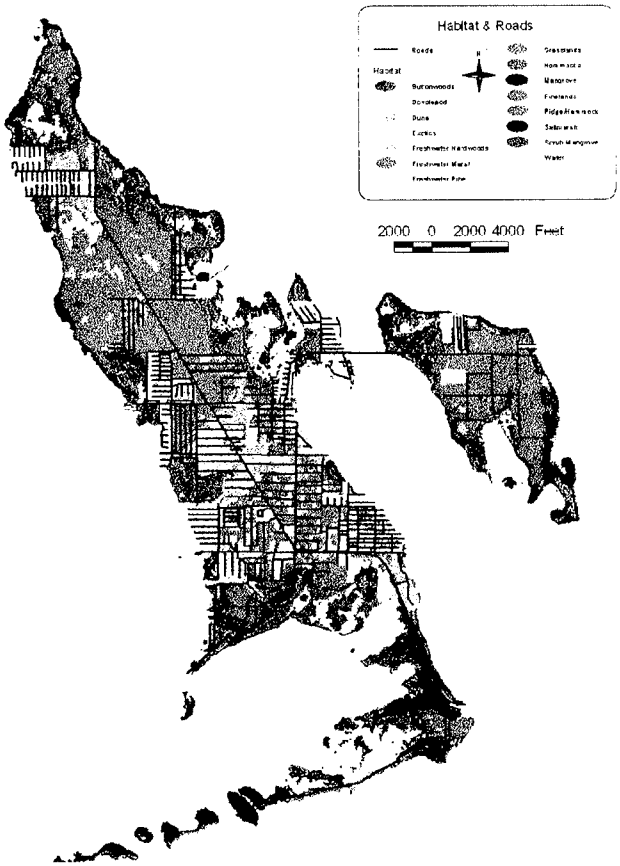


Figure 4 Map Showing Habitat

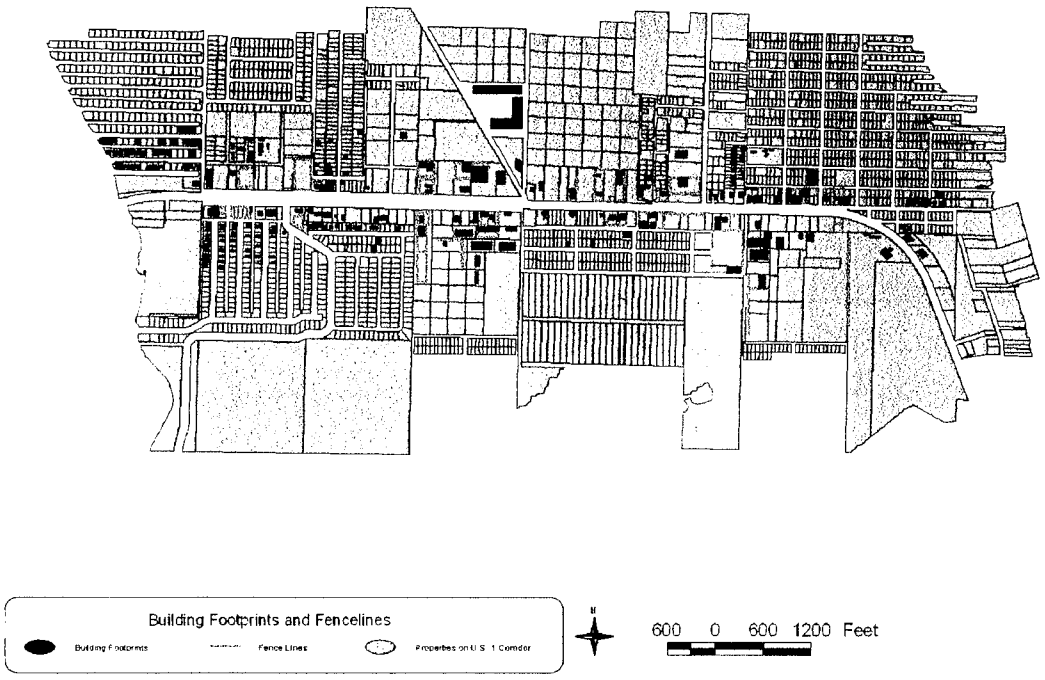


Figure 5 Barriers and Building Footprints

2.4.5 Barriers

In other roadkill studies, barriers have proved to have significant impacts on wildlife movement; therefore, it was necessary to determine if existing barriers along the corridor affected deer movement and mortality.

Barriers at this site were defined as buildings, impenetrable fences (i. e. chain link) and walls over 8' high. Using the global positioning system, 8' high fences were located and entered into G.I.S. Low altitude aerial photo images supplied by F.D.O.T. allowed building footprints to be located. These images were scanned and rectified to be consistent with other coverages, then the footprints were digitized to create a building footprint coverage. These were then ground-truthed to account for additions, demolitions, and renovations.

Finding:
There is some correlation between barriers and road kill numbers. For instance, the numbers of road kill are slightly higher adjacent to a narrow easement just west of the Coca-cola distributor lot. However, overall the deer move across the corridor in no particular pattern relative to barriers.

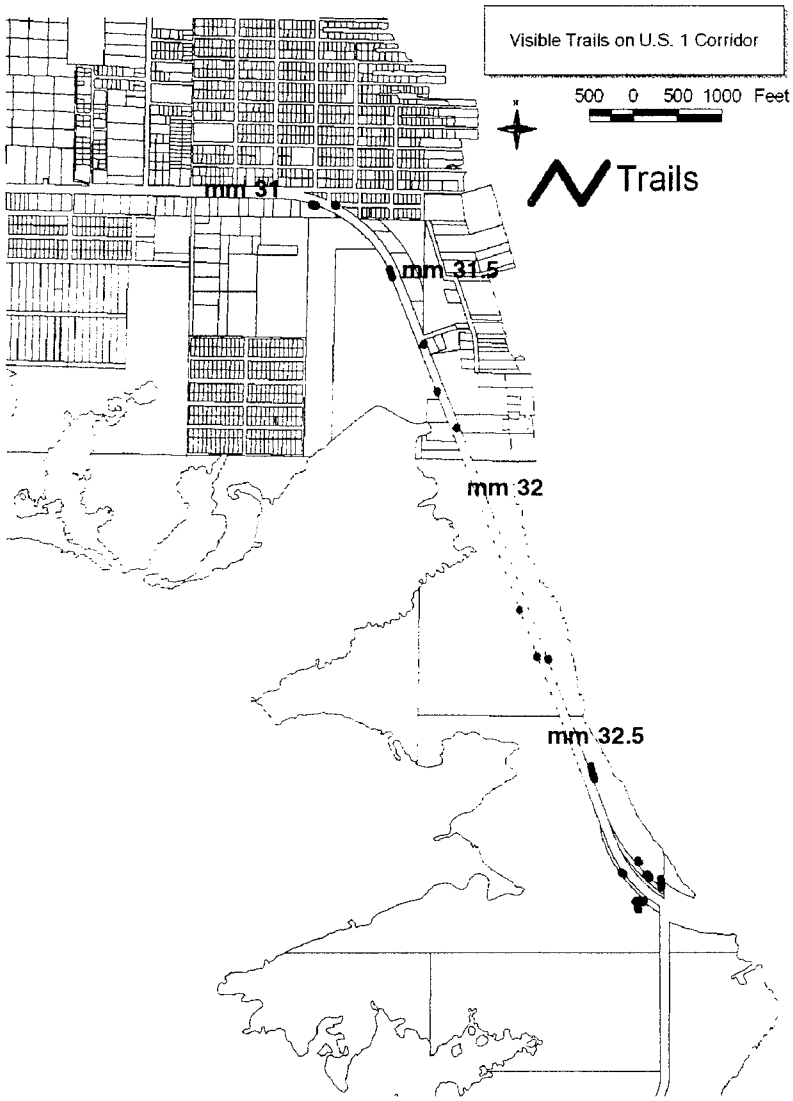


Figure 6 Location of Visible Trails Along U.S. 1

2.4.6 Existing Visible Trails

Using the global positioning system, all visible trails were recorded. Trails were identified by deer tracks, gaps and tracks through vegetation, and other physical traces. Trails ranged from wide, unvegetated areas full of visible deer tracks on the east end of the corridor to small, almost undetectable trails. The inability to accurately document physical trail traces in paved areas and other developed areas made complete identification difficult; therefore, the expertise and experience of U.S Fish and Wildlife Service personnel was invaluable in determining trails in these areas.

Finding:
The location of visible trails directly related to high numbers of road kill at a certain locations. At m.m. 32.8, where the highest number of trails are visible, the highest

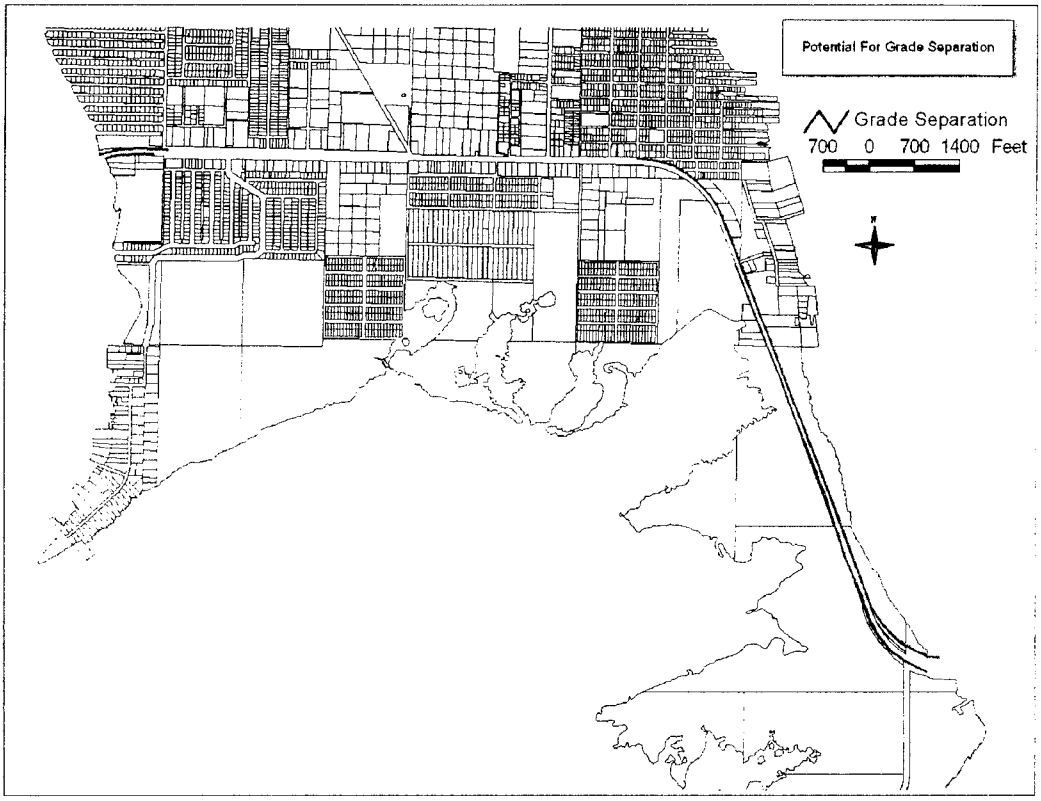


Figure 7 Potential Locations for Grade Separated Crossings

number of roadkill also occurs with a total of 44 fatalities. Also between m.m. 31.2 and 31.8, there is a correlation between high numbers of road kill and numerous visible trails. A total of 73 kills occurred between m.m. 31.2and m.m. 31.8.

2.4.7 Potential for Grade Separation

Because grade separated crossings had been discussed as a possible option, the study team located areas along the corridor that had a 3 foot or greater elevation change 20 feet from the road's edge. This potential could represent cost reduction in the future construction of a grade separated crossing.

Finding: There is potential for a grade separated crossing north and south of the road from m.m. 31.15 to m.m. 32.9. There is also potential for grade separation at the west end of the corridor (see Figure 7)

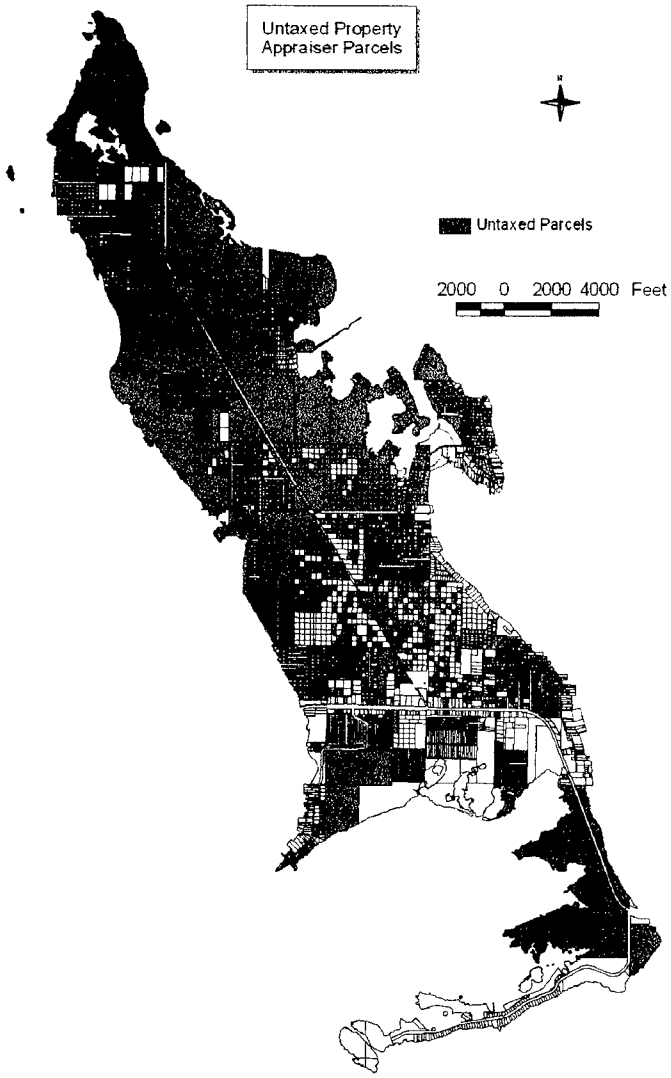


Figure 8 Untaxed Parcels

2.4.8 Property Appraiser Data

The study team obtained data from the Monroe County Property Appraiser. From this data coverages were developed that indicated:

- property ownership
- vacant land
- land with structures
- property value
- homestead exemption

These were the criteria that seemed most important in determining potential wildlife corridors based on cost-effectiveness, feasibility, etc.

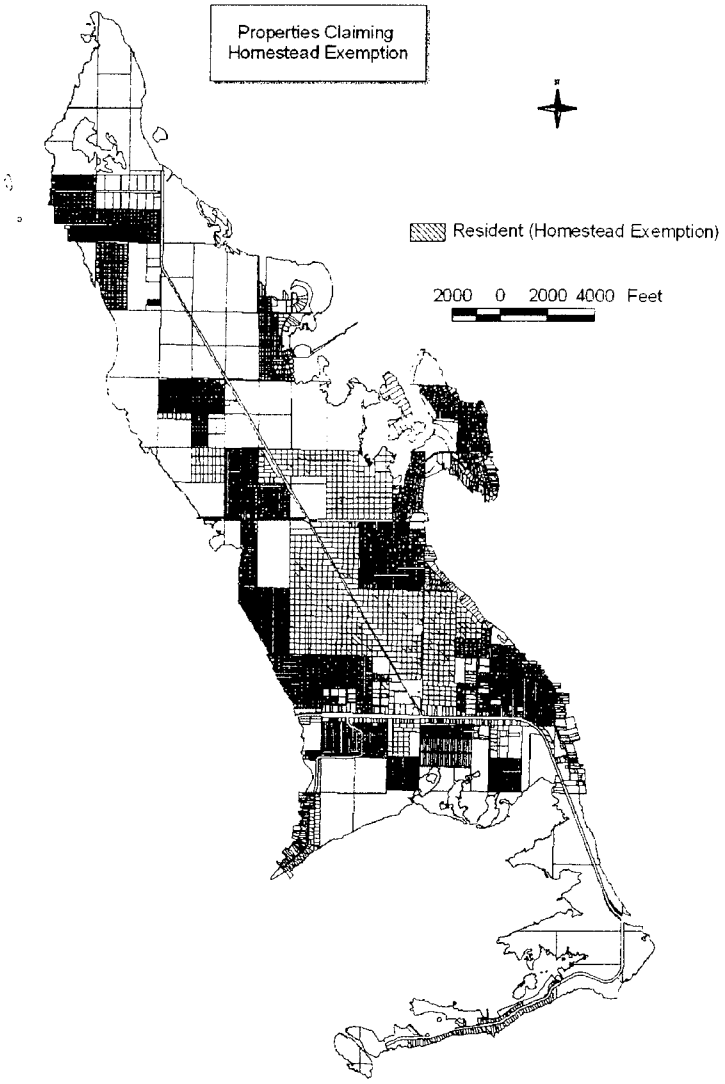


Figure 9 Properties With Homestead Exemption

From a number of sources, information concerning land use, permanent vs. nonpermanent residents, government-owned lands, vacant lots, and property value assessments were put into a G.I.S coverage that included far more of Big Pine Key than most of the other maps. This data, along with habitat value, was to be used for determining optimum corridors that could link habitat areas north and south of US 1.

Assigning value and priorities to parcels was important in this section. The original data gave property values for the lot or parcel. As these varied in size, relative values were needed to better fit into the G.I.S coverage. Relative values were determined by taking the appraised value of the land and dividing the acreage into it.

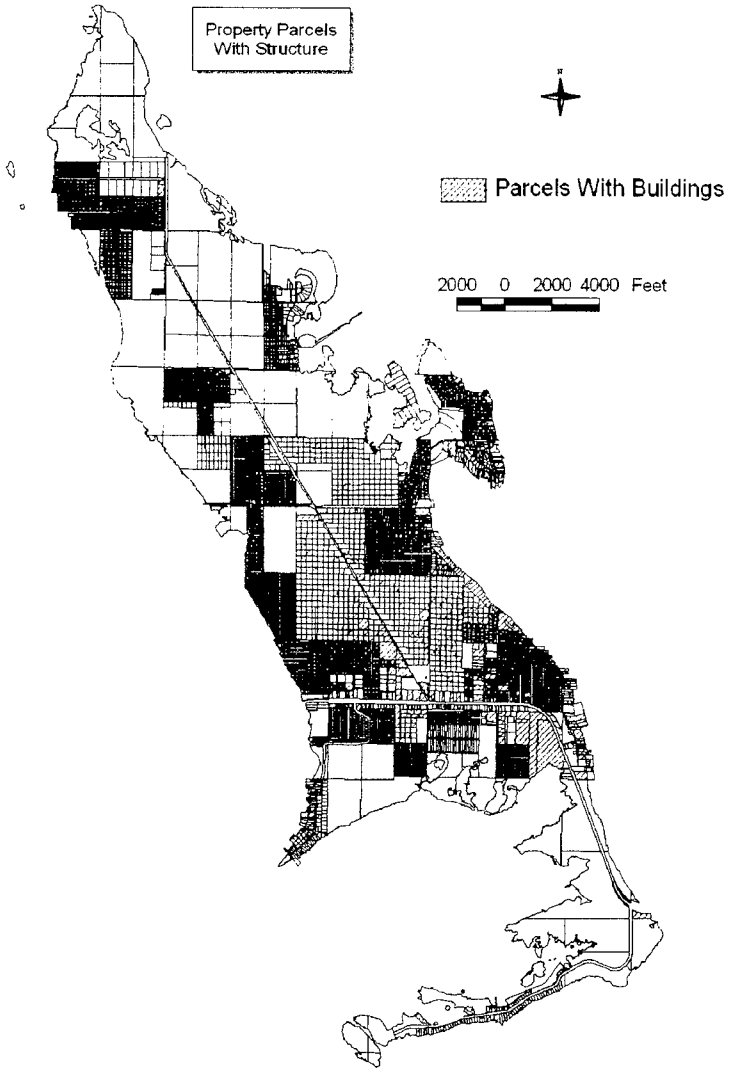


Figure 10 Properties With Structure

The original property appraiser's data was converted into a grid of 2.5 meter cells. The grids were then prioritized. Priorities were based upon suitable habitat, costs, and feasibility. This step will be discussed in more detail in the following section 3.0.

3.0 Weighing and Analyzing Data/Establishment of Key Deer Corridors

Locations can be determined for key deer crossings by weighing and analyzing the data shown in section 2.4. These locations have no validity if it is not possible to link large areas of undeveloped deer habitat with the optimum locations for key deer crossings on U.S. 1. To establish a corridor, it is necessary to use existing government owned lands or lands that can be purchased reasonably. It would also be

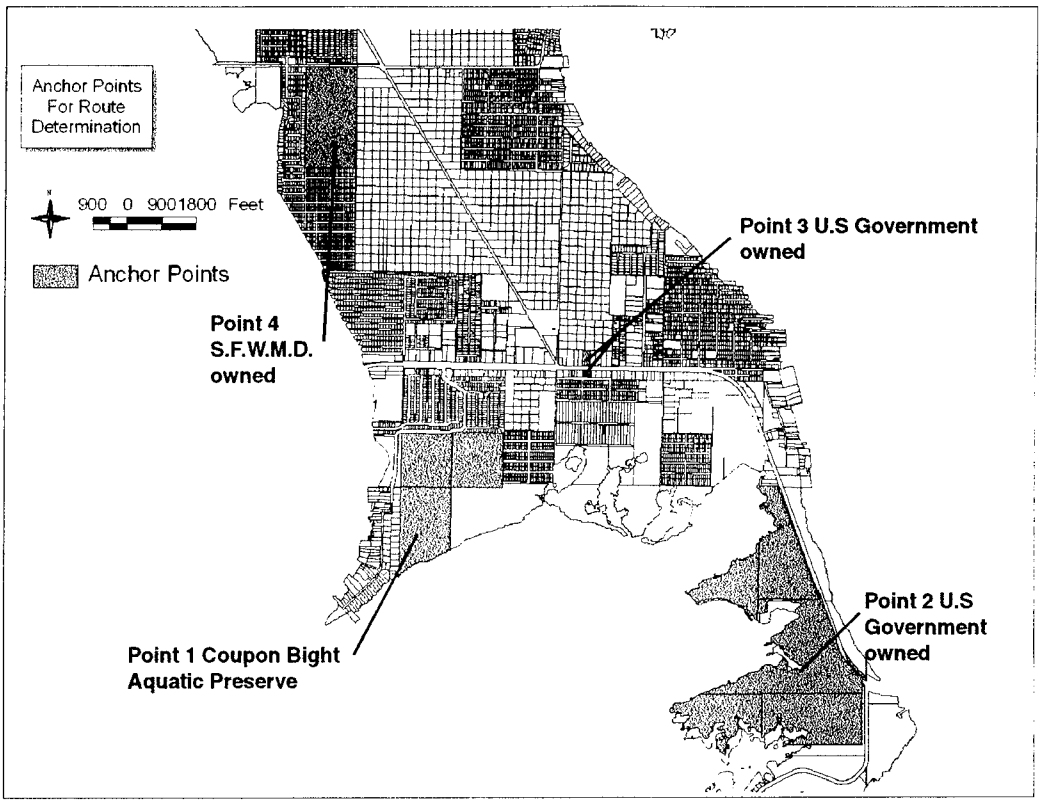


Figure 11 Anchor Points

beneficial if the potential corridor lands were valued deer habitat such as fresh water marsh or freshwater pines. A model for establishing the least cost path can be determined by querying the property appraisal data for assessed value, homestead exemption, vacant lands and ownership. Also, habitat value can be factored so that valued habitat has a lower cost and is thus more favorable for corridor acquisition.

The study team, with Barry Stieglitz of the U.S.F.W.S., determined anchor points that either cross U.S. 1 or are destination end points of large government owned tracts of undeveloped land. The assumption taken was that key deer could be directed by fence to a point of safe crossing linking large areas of habitat. The anchor points were as follows:

Point 1	97 acres of land that is part of the Coupon Bight Aquatic Preserve and 42 additional contiguous acres owned by the State for a total of 139 acres
Point 2	321.3 acres of land owned by the U.S. government
Point 3	5 parcels of land totaling 10.72 acres on the south side of U.S. 1 and 2 acres across and north of the highway owned by the U.S. government.
Point 4	78.7 acres of land owned by S.F.W.M.D.

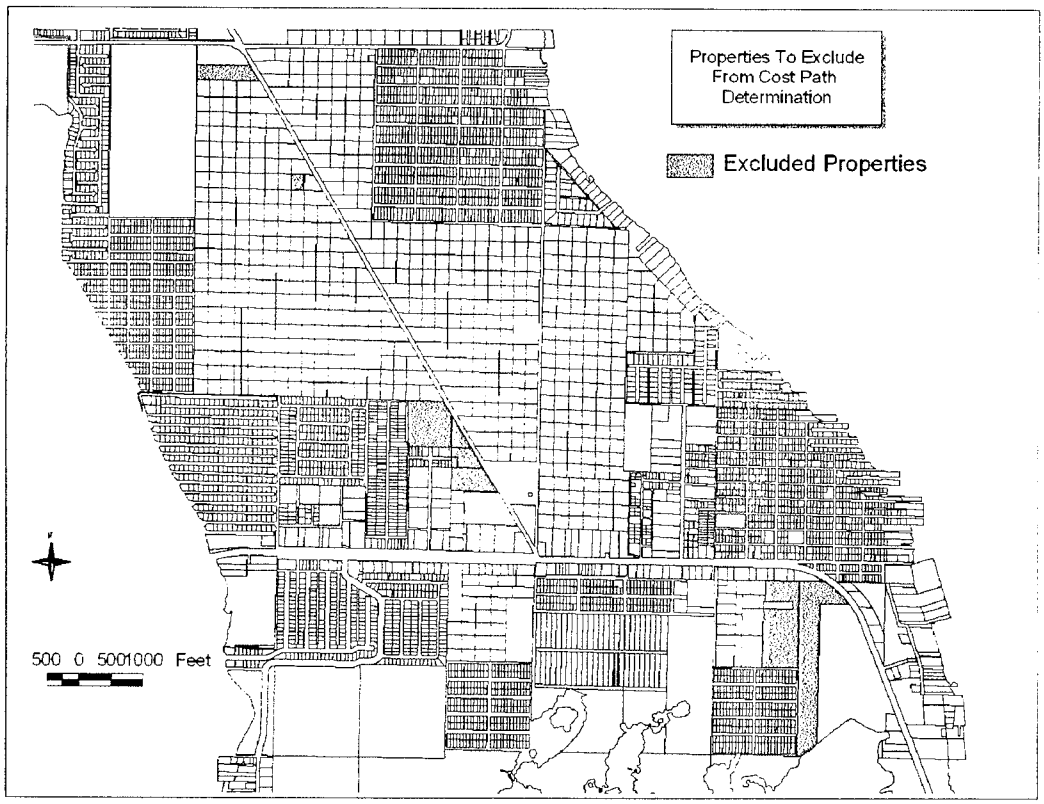


Figure 12 Properties To Be Excluded

3.1 Properties Not to be Considered for Corridors

U.S.F.W.S. requested that certain properties not be considered when determining corridors. These properties are as follows:

- 60.625 Acre Parcel owned by the government. RE Number 112160, located between milemarkers 32.4 and 31.9 on the south side of US 1
- 97.845 Acre Parcel owned by Coupon Bight Aquatic Preserve , RE Number 111990 & 112020, located approximately .5 miles south of the area between milemarkers 29.7 and 30.2
- 3.091 Acres of Parcels owned by the government located on the U.S. 1 by milemarker 30.6 , RE Number 111078.0002, 275540, 275530, 275520, 275510, and 275500
- The northern area of the key with parcels owned by The Nature Conservancy, The South Florida Water Management District, and the U.S. Government.

The U.S.F.W.S. requested that the Catholic Church parcel (RE Code 110400) be removed from consideration. It must be noted that this parcel will have to be crossed at some point as it extends from U.S. 1 south to the Atlantic Ocean completely isolating anchor point 2.

Other Parcels to Avoid Routing through by Request from U.S.F.W.S.

- RE 11004: Episcopal Church
- RE 111074-066 and -068: Lutheran Church
- RE 11165: Road prison
- RE 11147: Baptist Church
- RE 11145: Methodist Church
- RE 110400: Catholic Church
- RE 111460: Fire station
- RE 110830-000100: Cemetery

3.2 Habitat Data

As part of the analysis, the Study Team requested that U.S.F.W.S. rank each habitat present on Big Pine Key according to its value as key deer habitat. U.S.F.W.S. provided a ranking of each habitat type. The U.S.F.W.S. requested that the habitat types "exotics" and "developed" be ranked as to virtually eliminate them from consideration. The following habitats were not weighted as they either 1) do not appear to exist on Big Pine in sufficient quantity to warrant addressing them, or 2) appear to be almost entirely within public conservation ownership:

- Dune - Minimal presence (but should be high valued if present)
- Grasslands - Primarily in public conservation ownership

The following scores based on the ranking were assigned to each habitats type as follows:

Habitat Type	*Score*
Freshwater Marsh	1
Freshwater Pines	2
Pinelands	3
Freshwater Hardwoods	4
Ridge/Hammock	5
Hammocks	6
Buttonwoods	7
Saltmarsh	8
Scrub Mangrove	9
Mangrove	10
Water	11
Exotics	20
Developed	30

Table 1 Habitat Scores

3.3 Corridor Determination Methodology

To guide the process of corridor determination, certain parameters were given by the U.S.F.W.S.:

- Corridors must link three specific target areas of habitat
- Corridors must link these habitat areas using anchor point 3 as the location for the proposed wildlife crossings on U.S. 1.

Key data (habitat value and property appraisal) were queried to determine optimal routes based upon values assigned by the team and clients. Values were determined based upon:

- land use
- vacant land was less valuable than land with structures
- property value
- property ownership
- government owned land was given priority
- lands owned by religious organizations were excluded (1 exception)
- lots with permanent residents were valued higher than those with non-permanent residents

The scores for each habitat were entered into the least cost path analysis. The analysis used a 2.5 meter grid cell size with habitat ranking as the grid cell value. The habitat coverage does not have any breaks (i.e. for roads) like the property appraiser coverage. This lack of breaks make it easier to run a cost path analysis just for habitat. This initial least cost path analysis provided the study team with a rough idea of where to place the corridor as per habitat ranking.

As expected, the best route for the corridor based on habitat ranking is not necessarily the most feasible and economical property to obtain. To determine feasibility for acquisition, the study team used the value from the property appraiser data as the main determinant for routing of the corridor. The habitat ranking data was united with the property appraiser data so that both attributes were in the same analysis

The ArcView© program can effectively perform least cost path analysis to determine optimal routings. The methodology used to determine the scores for routing was as follows:

The value field for each parcel was multiplied by a factor of .01 x the habitat ranking. For example, if a parcel had a value of $100,000, and this parcel was completely in Freshwater Marsh (the optimal key deer habitat with a habitat ranking of 1), we would multiply the value by .01 (.01 is one-hundredth the score of freshwater marsh) for a score of $1000. If, however, the same parcel were in a developed area (worst habitat for key deer) multiply the value by .3 (.3 is .01 x the rank of developed) for a score of $30,000. This methodology resulted in relative scorings of each parcel. In the tax appraisal data road right of ways have no assessed value. To prevent the program from choosing road right of ways as the path of least cost, the value for

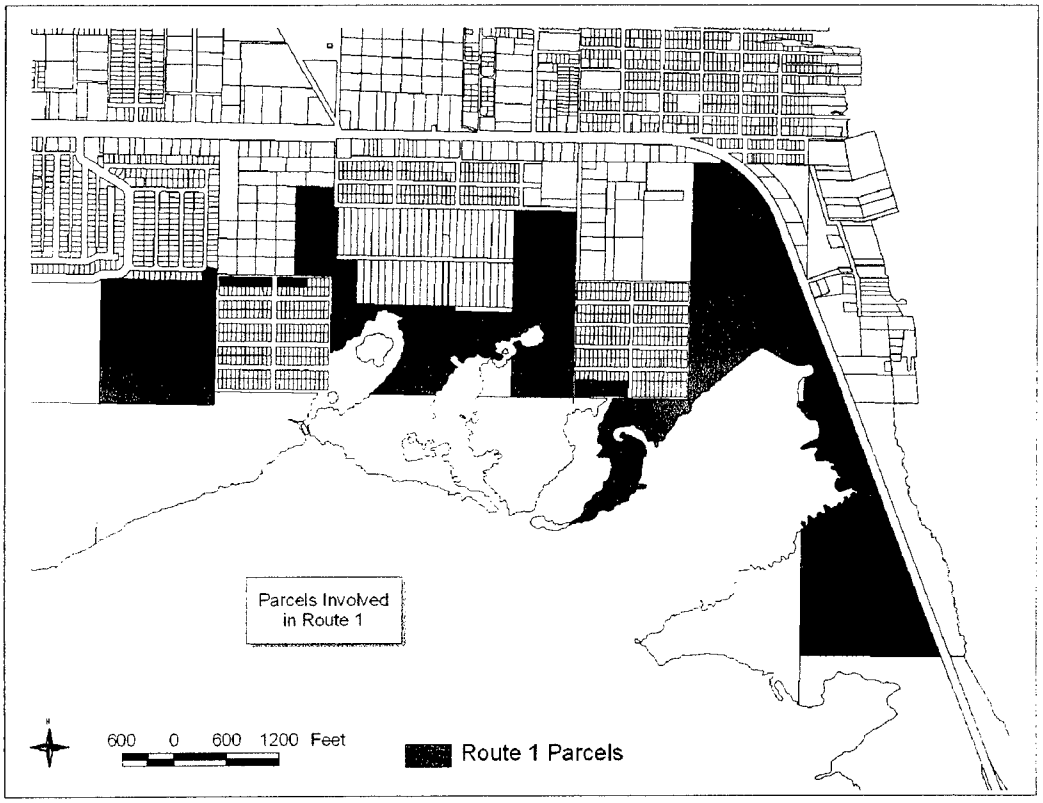


Figure 13 Least Cost/Best Habitat Route 1

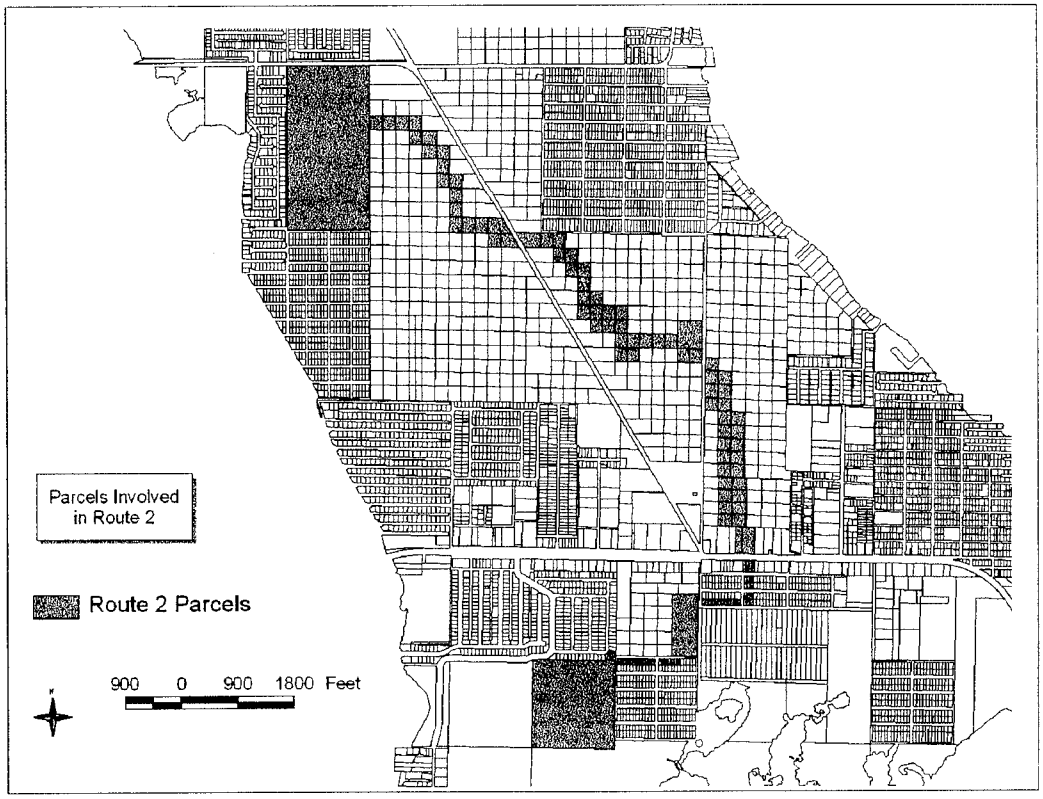


Figure 14 Least Cost/Best Habitat Route 2

each road right of way segment was input extremely high at $1,000,000. The modified values are simply relative scores that allow a least cost path analysis to be run on this data.

3.4 Results

The end result of our analysis gave provided us with two routes that went through each anchor point. Route 1 runs from anchor point 1 to anchor point 2. Route runs from anchor point 1 to anchor point 4 through anchor point 3. Some parcels are shared by both routes. Route 1 includes 51 parcels of 259.3 acres with a value of $1,382,774. 27.5 % of the parcels are not taxed. Route 2 includes 125 parcels of 218.5 acres with a value of $2,561,469. 66.4 % of the parcels are not taxed.

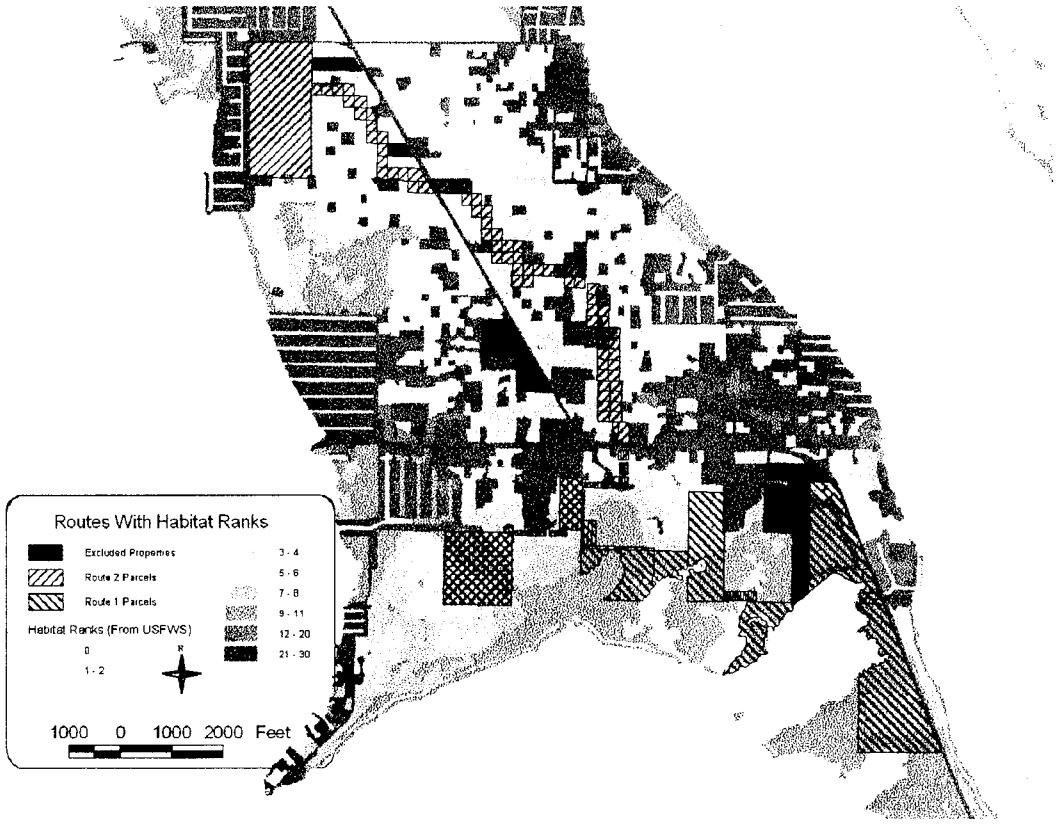


Figure 15 Least Cost Routes with Habitat and Excluded Properties

	# Of Parcels	Total Value Of Parcels	# of Parcels shared in Both Routes	Total Value Of Parcels shared
Route 1	51	$1,382,774	23	$98,028
Route 2	125	$2,561,469		

Table 2 Parcel Value

The results of the least path cost analysis can be seen in figure 15. The areas in shades of yellow are the habitat types. The darker the shade of the area, the less desirable that habitat is for the key deer. Route one (red dashed) crosses one of the parcels on the excluded properties list, but as stated earlier there is no other option. Route two (blue dashed) could have been $110,000 cheaper, but the study team decided to choose a slightly more expensive route so as to optimize available habitat.

4.0 Overall Findings

The study presented here (to identify optimum locations for key deer crossings and corridors on Big Pine Key) is very specific to key deer on Big Pine Key; however, the model can be adapted for other sites and species.

The model is a simple and flexible series of analytical questions:

1. Identify the goals and objectives of the study
   - What is to be found?
   - What are the parameters or limitations that will be set upon the study? (For example, properties to be excluded)
2. Identify pertinent variables
   - What are key specie(s) variables?
   - Of these, which are pertinent at this site?
   - What variables in and around the site are pertinent?
   - Are there any potential variables (such as the use of specific wildlfe control measures) that may be important?
3. Collect data
   - What existing data is available?
   - What needs to be generated for this study?
4. Get data to the correct format
5. Query the data
   - What specific questions should be asked?
   - How should variables be weighted ?

6. Run data to answer goals of the study
7. Evaluate solutions and refine as necessary

G.I.S. models such as the one in this report could be of great benefit to future F.D.O.T. sites, if adapted correctly. The key is to understand the specific site and specie. Many of the variables included in this report would be applicable for any crossing location study. Each site and specie must be examined to determine the crucial variables for that specific situation, as there will be important variables other than those used in this report. For instance, while watering hole locations were not deemed important to the key deer on Big Pine Key, those locations could be critical at another site and/or a different wildlife specie. The weight given each variable can change to more appropriately fit the situation. A variety of concerns must be considered--environmental impacts, impact upon the context as well as the site, cost benefits, feasibility, etc.

The resultant wildlife corridor routes shown in figures 13-15 in this report are not final--they are a basis from which to move forward. The length and scope of this study could not go into negotiations with property owners and other long-term issues. However, this study does provide current important data and a methodology for revising the routes as more finalized data is gathered.

The team recommends that another G.I.S data field be included in this particular project for further study--a field that rates feasibility and actual cost of obtaining property or gaining an easement.

During the course of this study, F.D.O.T. decided to locate two grade separated crossings. These are to occur at m.m. 31.5 and m.m. 32.5. The road kill data, visible trails locations, potential for grade separation, habitat proximity and value all support the decision to locate crossings at these locations.

5.0 Benefits

If key deer crossings are located correctly and are at locations that provide economically feasible links to important habitat, then the biggest benefit of this study will be a reduction of key deer road mortality. In addition, this study provides data that can be used to analyze and evaluate a range of future planning decisions (beyond just that of placing crossings). The data collected by this study can serve as a basis for long term acquisition, design, and management plans. It may also be useful to other researchers. The study team recommends that plans be made for regular updates of the data coverages and for evaluation of the effectiveness of crossings and any other measures taken (changes in ROW management, etc.)

5.1 Technology Transfer Plan

Copies of this report will be sent to F.D.O.T. , who will make it available to the U.S.F.W.S., the F.G.F.W.F.C. and the national and local environmental and scientific community.

A CD is included in this report with all relevant G.I.S. data. To use the CD, please refer to Appendix B of this report. A public domain viewer is included for readers who do not own Arcview©. A Powerpoint© presentation is also included on the CD.

APPENDIX A

Acquisition of G.I.S. Coverages

Agency:
Monroe County Planning Department
Contact: Kim Ogren
Contribution:
Future land use coverage
Habitat coverage for Monroe County

Agency:
Florida Marine Research Institute (F.M.R.I.)
Contribution:
Habitat coverage
Roads and marina coverage for Big Pine Key

Agency:
Florida Resource Environmental Analysis Center (F.R.E.A.C.)
Contact: Steve Hodge
Contribution:
Digital Ortho Quarter Quad
(D.O.Q.) for Big Pine Key.

Agency:
Monroe County Property Appraiser
Contact: Paul Sprague
Contribution:
Map graphics file of property appraiser data

Agency:
US Army Corps of Engineers (U.S.A.C.E.)
Contact: Susan McKeon
Contribution:
Resampled D.O.Q. to 2.5 meters of Big Pine Key

Agency:
Environmental Systems Research Institute (E.S.R.I.)
Contact: Michelle Lundeen
Contribution:
Linework in a ARCINFO/ARCVIEW readable format

* Source for all other G.I.S. coverages was University of Florida Florida Geographic Data Library (F.G.D.L.) or on site G.P.S. by Study Team

APPENDIX B

Instructions to examine CD

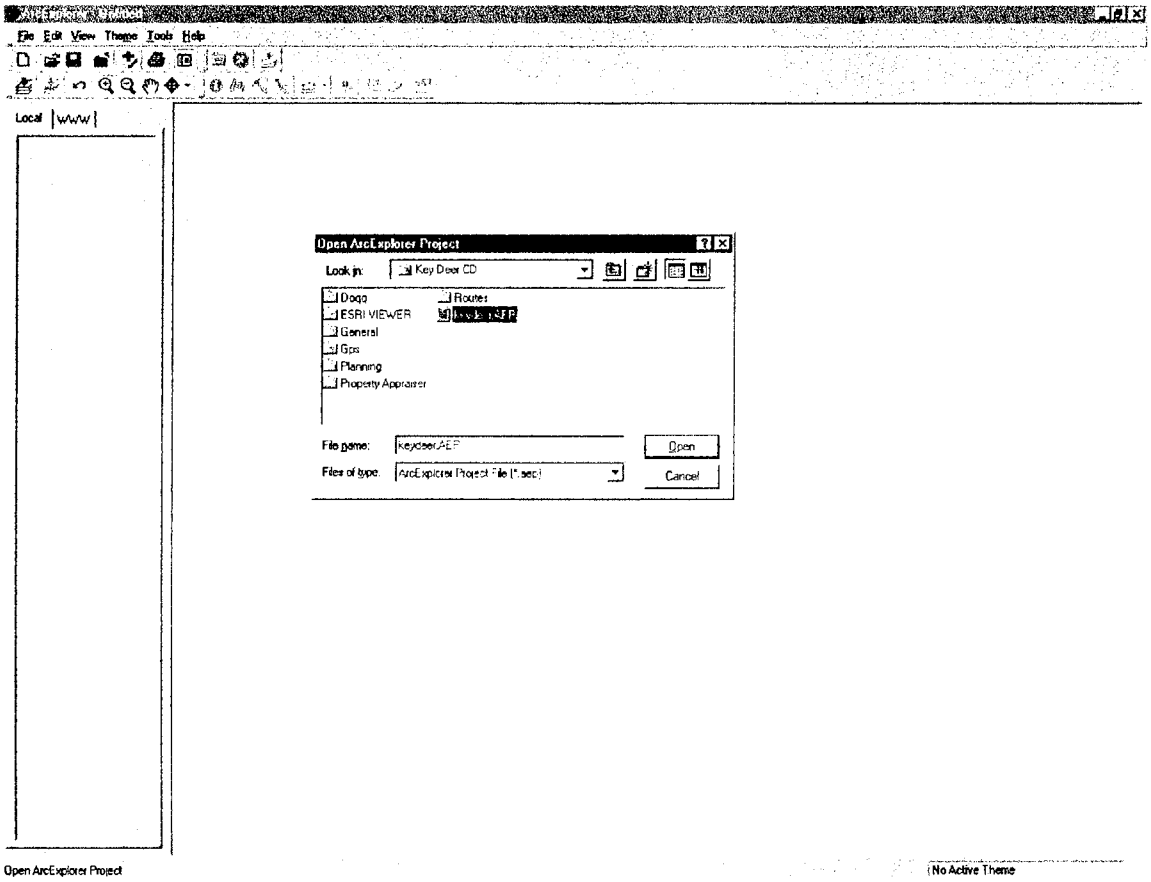
There are two ways to examine the data found on the Key deer CD included in this report.

1) If you have a copy of Arcview© 3.1 installed on your computer, you can use the project files (XX.apr) found on the CD. If your screen resolution is 1024x768 and you want to look at the data without copying it to your C: drive, use the project file named keydeercd 1024_768.apr. If you copy the keydeercd folder to your C: drive, use the project file named keydeercd 1024_768-1.apr. If your screen resolution is 1152x864 use the project file named keydeercd1152_864.apr. You could also make your own project files.

2) The second way to examine the data is to use the public domain viewer software provided on the CD, E.R.S.I. Arcexplorer version 1.1.488. The instructions for installation and use are as follows:

To Examine Key Deer Project on CD Using Arcexplorer

- First Install ArcExplorer by placing Key Deer CD in drive. Go to **start** and then **run**
- **Browse** to the Key Deer CD folder
- **Open** the Key Deer folder, then **open** the ESRI Viewer folder
- **Select** the file arcclient.exe, then click **open**
- Click **ok** in the run window; this will start the install process loading ESRI's GIS viewer on your computer system
- After arc explore 1.1 install opens, click **next** to start the install process
- **Select** a destination directory (or even easier just take the default directory, click next)
- **Choose** components. The web browser is not necessary to view key deer data, but if you have hard drive space you might want to load it anyway.
- **Select** a program folder or just take the default, click **next**
- If you want a shortcut leave yes selected and click **next**
- Click **next** to begin installation
- When you get a message saying install is complete click **finish**
- After ArcEplorer is installed **Double click** ArcExplore icon on desktop
- After program loads, go to file then **select** open project. **Path** to the file keydeer.aep on the Key deer CD in the Key deer folder as shown below. **Select** the file and click **open**



In ArcExplorer there is only one window present to show all the coverages. **Scroll** down the left window to examine all the shapefiles that are present on the CD. The scroll arrows are either at the top or bottom right of the table of contents window. By clicking the box you want you can make the coverage visible. To edit the visual representation of any of these coverages click on the table of contents name. In this window ,under properties, you can change colors, names etc. if you desire.

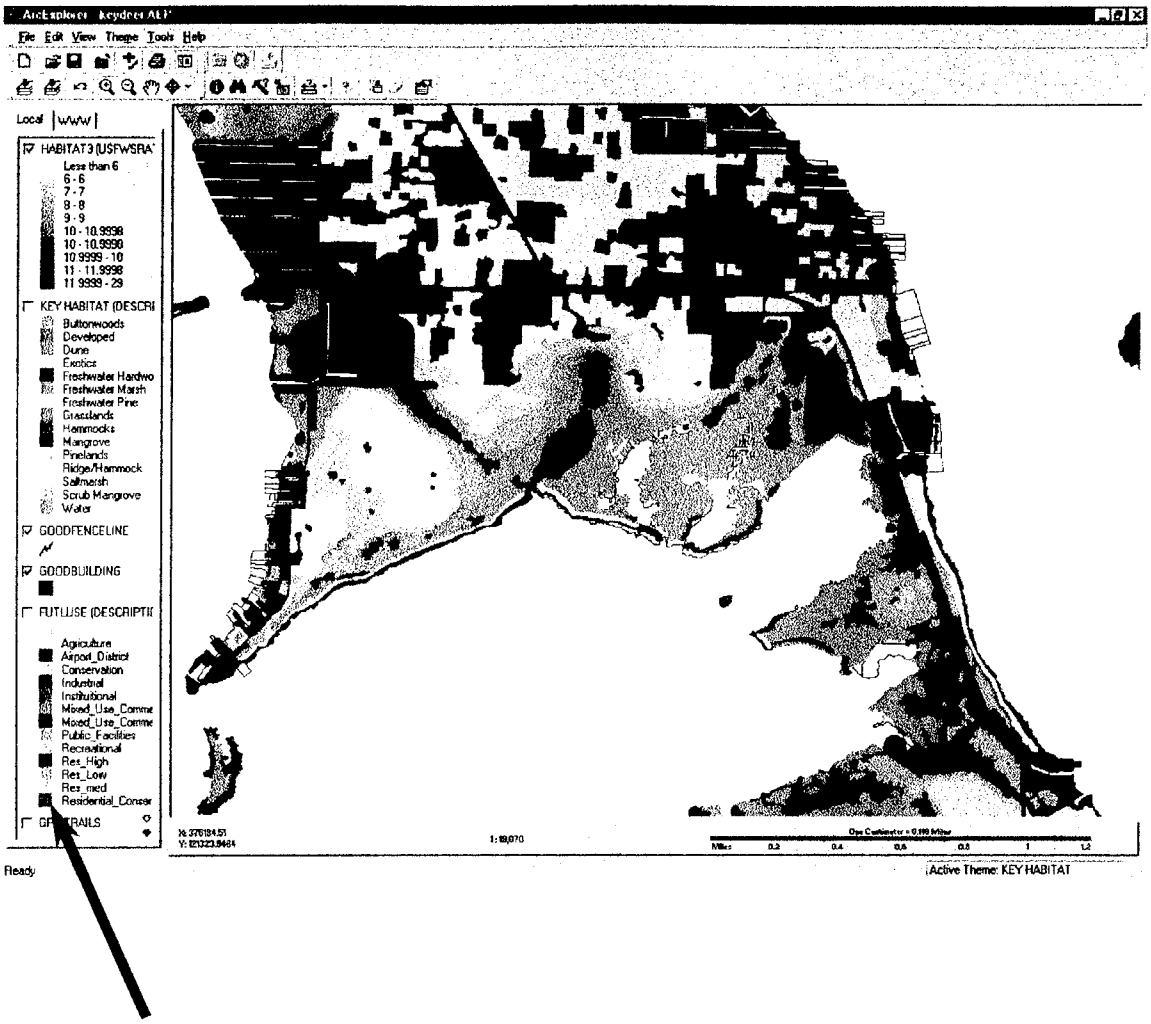


Table of Contents

To look at the data associated with each theme, you must make the theme active. **Click-drag** the title of the coverage to the top on the menu and **drop. Click** on the theme title and the I (identify) button becomes active. When the "I" cursor is placed over an active feature **click** once to see the data associated with that feature. It will appear in a separate information box. **Click** on the title makes the theme active not just checking the box –a thin grey box should appear around the title when active.

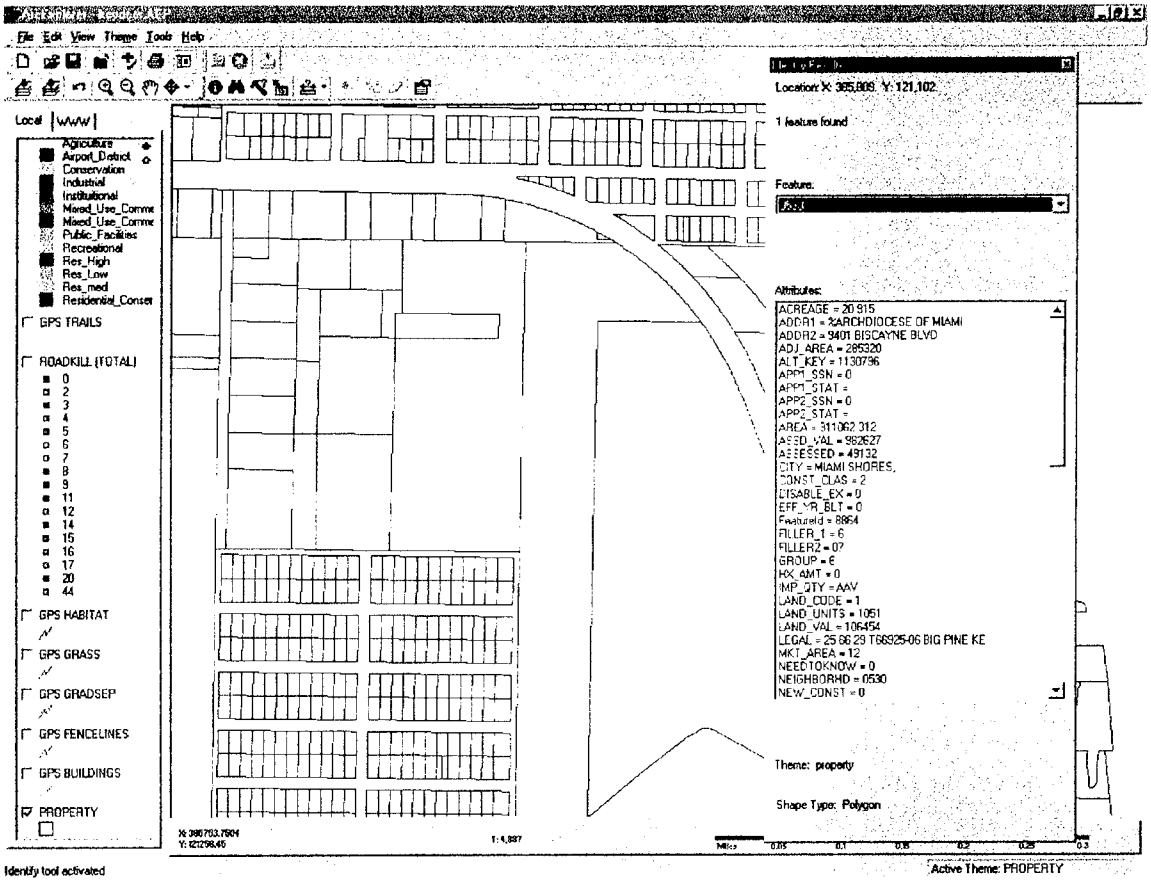
Table of Contents Description

- Untaxed Parcels

These parcels are lands that are owned by not for profit organizations or government that pay no tax.

- Route 2 Parcels

These are parcels that link to the north and south two government owned habitats



You can zoom in or out by selecting the zoom icon on the toolbar either + for in and – for out. The edit menu also provides the user with the functionality to export the views into two graphics formats, Bitmap (BMP) and enhanced meta file (EMF).

that are identified as the least-cost based on assessed value.

- Route 1 Parcels

These are parcels that link east and west two government owned habitats that are identified as the least-cost based on assessed value

- Excluded Property

These are parcels that USFWS asked to exclude when looking for least-cost paths.

- Future Land Use

This shows the future land use designation.

- Road Kill Locations

This shows the roadkill locations on U.S. 1. These locations were mapped to the nearest tenth of a mile. Use the identify tool to see the sex and age of the deer at each kill location.

- Habitat

This map shows the location of natural wooded areas along the U.S. 1 corridor.

- Grass On Right Of Way

This map shows the location of grass along the U.S.1 corridor

- Building Footprints

This map shows building footprints along the U.S.1 corridor

- Visible Trails

This map shows the location of visible wildlife trails along the U.S.1 corridor

- Grade Separation

This map shows the location for potential grade separated crossing along the U.S.1 corridor.

- Fences and Barriers

This map shows the location of visible wildlife trails along the U.S.1 corridor

- Property Ownership

These are the tax assessor's maps showing assessed value taxed value, ownership, acres, and homestead exemptions.

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