

## Using Dynamic Segmentation to Create Home Ranges for Aquatic Species

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**ABSTRACT:** Aquatic biological species form food webs in the LaBranche Wetlands, Louisiana. This wetland is characterized by a series of interconnected bayous forming a network. The home ranges of fish are important to model spatially in the ecosystem due to their ability to move upstream and downstream as the top predator. These home ranges are modeled as segments in the network based on the dynamic segmentation methodology. The purpose of this paper is to enhance the spatial representation of the ecosystems to allow researchers a better interpretation of modeling results. This paper describes how to build a network of bayous, how to attach points to them and how to link segments using dynamic segmentation. Namely this paper discusses in detail the use of dynamic segmentation using ArcInfo™ and Arcview®.

### INTRODUCTION

Clean fresh water is essential to life. Unfortunately, when non-point source and point source pollution is discharged, most rivers, lakes, streams, creeks, etc., have been treated as a conduit for transporting waste downstream to the sea. In the process, the biodiversity of thousands of kilometers of waterways are affected, potentially harming human health, wildlife, and polluting coastal waters. The environmental problems affect human health and wildlife directly or indirectly.

Presently GIS is used in many applications, especially to study the environment and seek solutions. Calculation of pollutant loadings, graphs and GIS analysis can tell us about the water quality of river and lakes. Numerous studies have examined surface water using GIS. Hargrove et al., (1995) examined a river mile (It's not clear what Hargrove et al. examined) as measured along a curving centerline, and a linear distance from the riverbank on the Clinch River/Watts Bar Reservation using dynamic segmentation to develop route systems along the centerlines of all rivers. Byrne et al. (1997) described a dynamic segmentation application for California salmonid habitat inventory. Dynamic segmentation was used to associate fish habitat data with existing stream data. Using Arcview® software, spatial analysis can be performed by remote field personnel with the habitat data. Habitat data measured along existing georeferenced linear data are represented as events by dynamic segmentation.

There are three specific cases where dynamic segmentation is most useful. The first is in using a linear system of measure to denote precise locations, such as knowing how many miles it is to each turnoff or road sign on a state highway. The second is when features contain segmented data. The third is linear features containing one-to-many relationships, such as three bus routes along the same street or six routes along the same river. For this project, the fish species move within varying home range habitats. These home ranges are modeled as segments and dynamic segmentation enables the creation of different events along on the bayou linear feature. This paper presents the application of dynamic segmentation for the LaBranche Wetlands of Louisiana and describes: (i) how to build a network of bayous; (ii) how to attached points to them; and (iii) how to link segments using dynamic segmentation. Both ArcInfo™ and Arcview® were used for this research. First of all, vector linear features and aerial images were registered. Then a dynamic segmentation model was used to reference specific data or events (route, stations, vegetation, and species site-ID) to locations along a route or bayous, which generated four output dBASE files. The bayou routes, the sampling stations, vegetation, species site-ID and species home ranges were associated with each study area.

## METHODOLOGY

### Description of Study Area

The research site is located in St. Charles Parish, Louisiana east of New Orleans (Figure 1 and Figure 2). The LaBranche Wetlands includes Bayou Trepagnier, Bayou LaBranche, Bayou Traverse and other marshes and swamps in the map vicinity (Figure 3). The LaBranche Wetlands cover more than 14,000 acres of marsh and forested swamp (Binet, 2003). The LaBranche Wetlands are considered the most productive wetlands in the Lake Pontchartrain Basin. The wetlands provide important habitat for wildlife and also support commercial fisheries. Some organic compounds that affect aquatic organisms and human health such as polycyclic aromatic hydrocarbon (PAH) enter rivers or bayous.

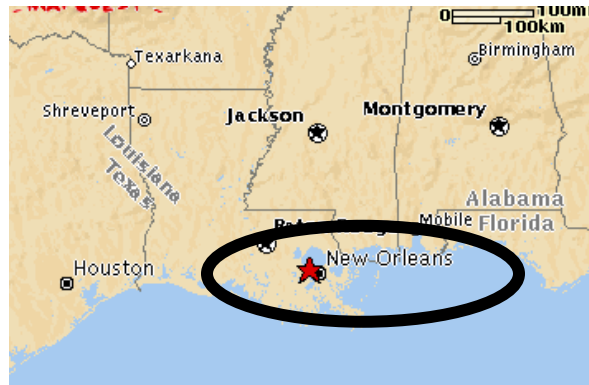


Figure 1: Showing New Orleans (USACE, 2002)

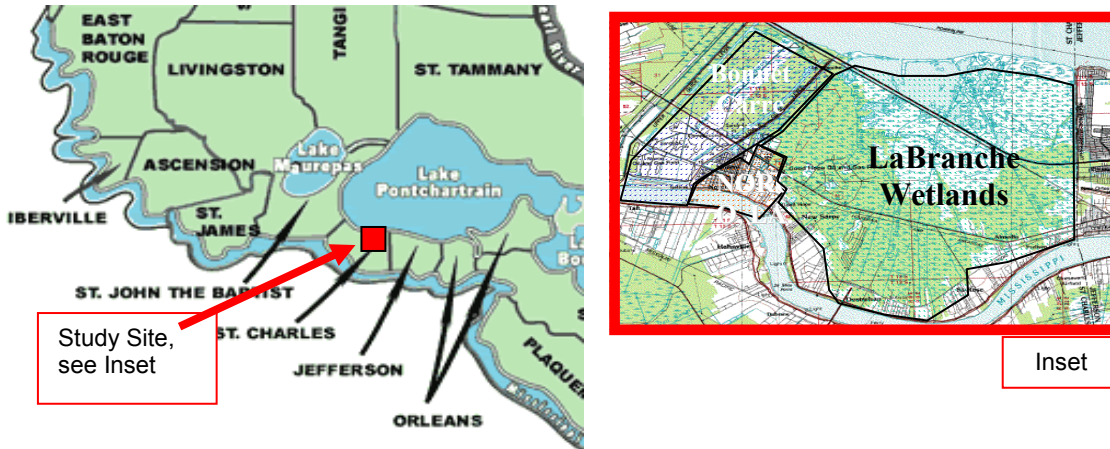
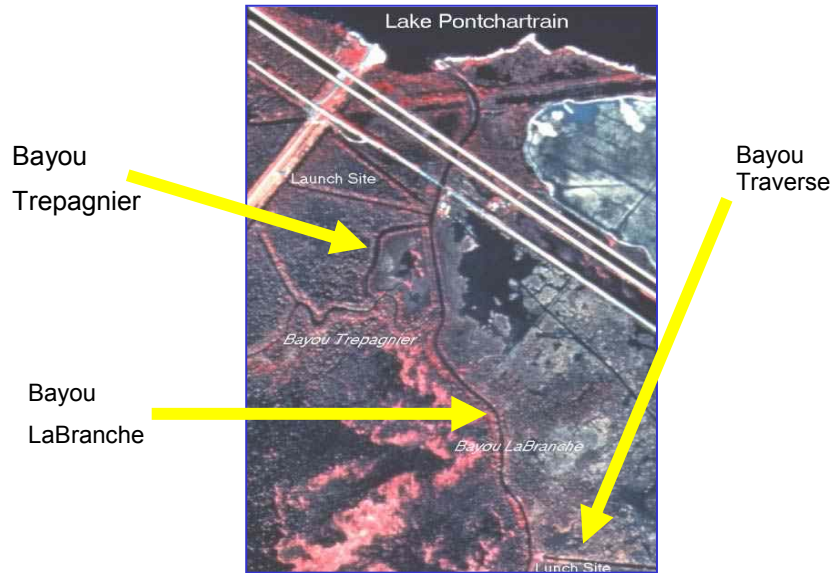


Figure 2: Location Map for Study Site Area Showing Lake Pontchartrain and the New Orleans area (USACE, 2002)



**Figure 3:** Study Area showing Bayou Trepagnier, Bayou LaBranche and Bayou Traverse (UNO Coastal Research Laboratory, 2001)

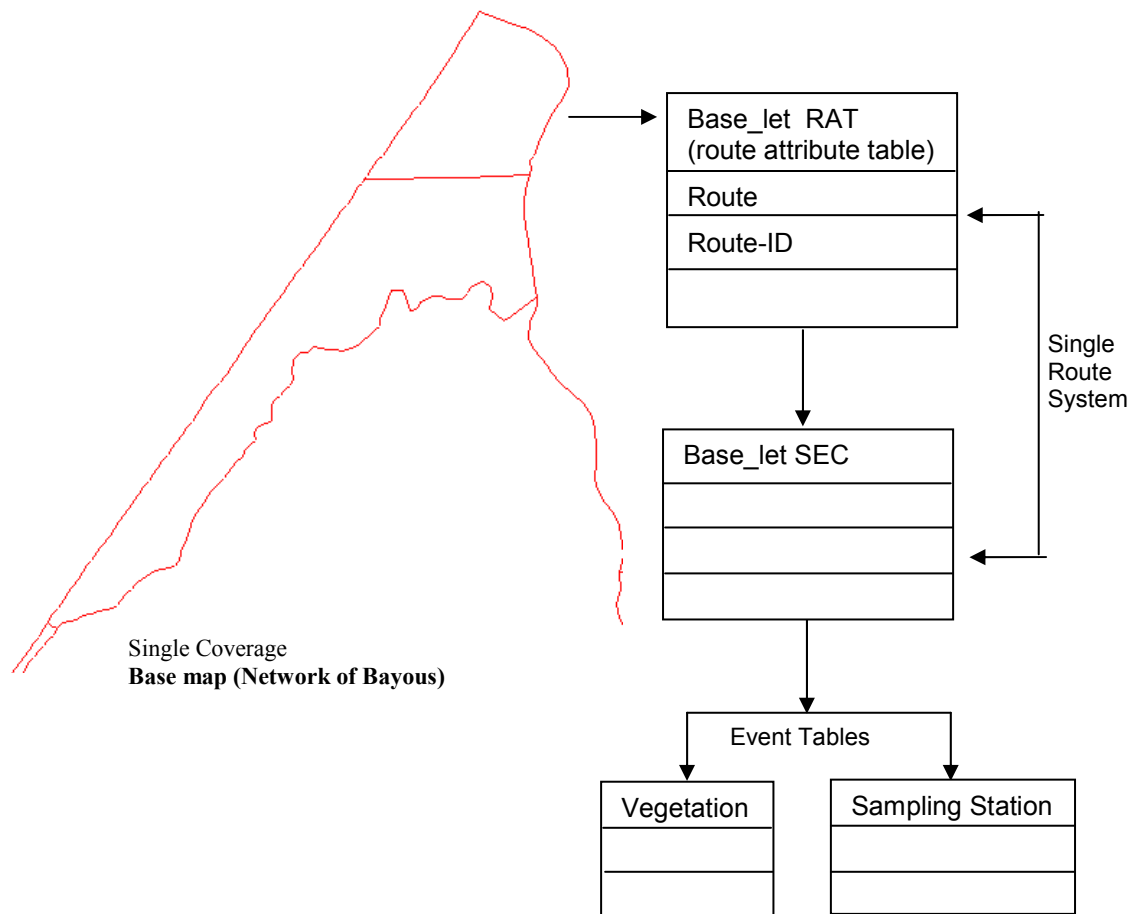
### Development of Dynamic Segmentation

Dynamic Segmentation is a data model within ArcGIS. It associates multiple sets of attributes to any portion of a linear feature, which is modeled using routes and route events, and provides a method for creating, editing, querying and displaying these attributes. Events store attributes associated with a route or a bayou. Routes are made up of linear features stored in known measurement units. Attributes of the events (is it attributes of the events or do events store attributes? Confusing!) include beginning and ending measurements along a route. Line, point, or continuous events can be used. Environmental Systems Research Institute's (ESRI) dynamic segmentation model traditionally uses the "F\_meas" (from measure), and "T\_meas" (to measure) fields to geo-reference linear or point features in event tables.

The methodology to develop the spatial representation of linear features, such as sampling stations and vegetation, consists of three basic steps: 1) creating a coverage from Arcview® to ArcInfo™; 2) building the route system; and 3) creating events.

### Project Specific Dynamic Segmentation

In this study, dynamic segmentation in ArcGIS was used to link sampling stations (point events), bayou routes (linear events), and vegetation (linear events) data to represent the network of bayous in the LaBranche Wetlands. Species site-ID (point events) and species home ranges (linear events) were associated with each study area. Route system design and events relating to route systems are shown in Figure 4.



**Figure 4:** Route System Design

There are three components necessary for the dynamic segmentation process:

- Arc-node topology (Engineers Canal, Bayou Trepagnier, Bayou LaBranche)
- A route system (bayous route)
- External database event tables (station tables and vegetation tables)

**Arc-node topology:** The arc-node topology was built upon an internal vector spatial data model in ArcInfo™. The Arc Attribute Table (AAT) describes the arc, the FROM and TO nodes of the arc, the length of the arc and the unique ID of the arc.

**A route system:** A route system is a linear feature on which attributes can be located. The Route Attribute Table (RAT) and section table (SEC), define the route system. RAT has the route and route ID. The section table is the intermediate table connecting the RAT to the arc attribute table.

**External database event table:** INFO stores data in files within a database. However, database information can be stored in files outside of the database. These files are referred to as external files. For example, feature attribute tables are stored as external INFO data files maintained in the coverage directory. An event is an attribute that can be tied to the route system based on distance measurement.

As shown in Figure 4, first the base map was created; the base map file name was “base\_let”. “Base\_let” route was created, the “base\_let” section was followed then event tables were created.

### Dynamic Segmentation Illustration #1 (Build the Base Map in ArcInfo™)

Study area coordinates were collected with a Global Position System (GPS) device (Trimble Explorer 3). All the bayou coordinates were collected as degree, minute, second or degree decimal, except Bayou Trepagnier. Bayou Trepagnier's coordinates were provided as Universal Transverse Mercator (UTM) coordinates from a previous survey. All coordinates were converted to a common UTM coordinate system. These coordinates were entered via a text file (Figure 5). There were 343 points that described the bayous within the LaBranche Wetlands.

Point Number	Eastings	Northings
1	753779	3326816
2	753753	3326798
3	753729	3326779
4	753681	3326741
5	753655	3326726
6	753598	3326769
7	753602	3326799
8	753605	3326831
9	753598	3326866
10	753573	3326887
11	753544	3326881
12	753520	3326860
13	753506	3326836
14	753482	3326816
15	753450	3326812
16	753420	3326817
17	753391	3326824
18	753367	3326820
19	753360	3326828
20	753337	3326816
21	753322	3326801
22	753312	3326782
23	753308	3326799
24	753296	3326770
25	753268	3326770
26	753266	3326759
27	753259	3326803
28	753255	3326787
29	753250	3326827
30	753235	3326852
31	753190	3326848

**Figure 5:** Example Point Text Files for LaBranche Network of Bayous

(Not sure that every step needs to be described with corresponding screen shots of the dialog boxes) The text file was converted to a shape file within Arcview®. The project file was opened in ArcGIS and under the scripts listing the script entitled GPStoshape was selected (Figure 6). The GPStoshape screen appeared (Figure 7). The RUN button was (the work is already done) then clicked at the top of the ArcView® window (see Figure 7). The Bayous text file was selected, along with in appropriate output shape file. Figure 8 shows study area Points as shape file in Arcview®. The base map was obtained as points in Arcview®. The base map needed conversion from point to line in ArcInfo™. The base map file name is “base\_let” shape file (base\_let.shp).

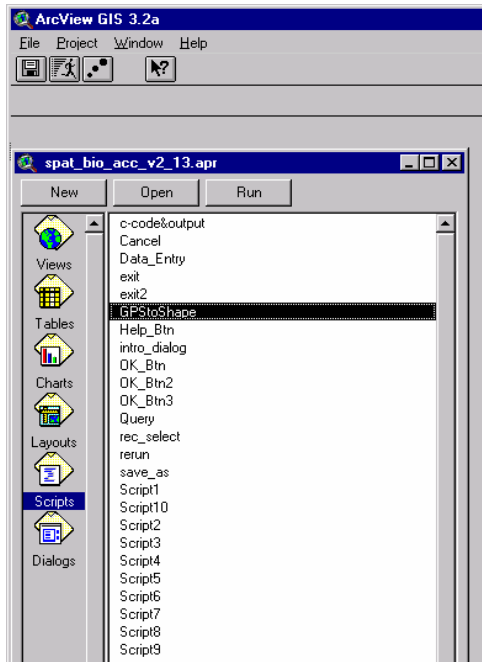


Figure 6: Scripts Button and GPStoshape

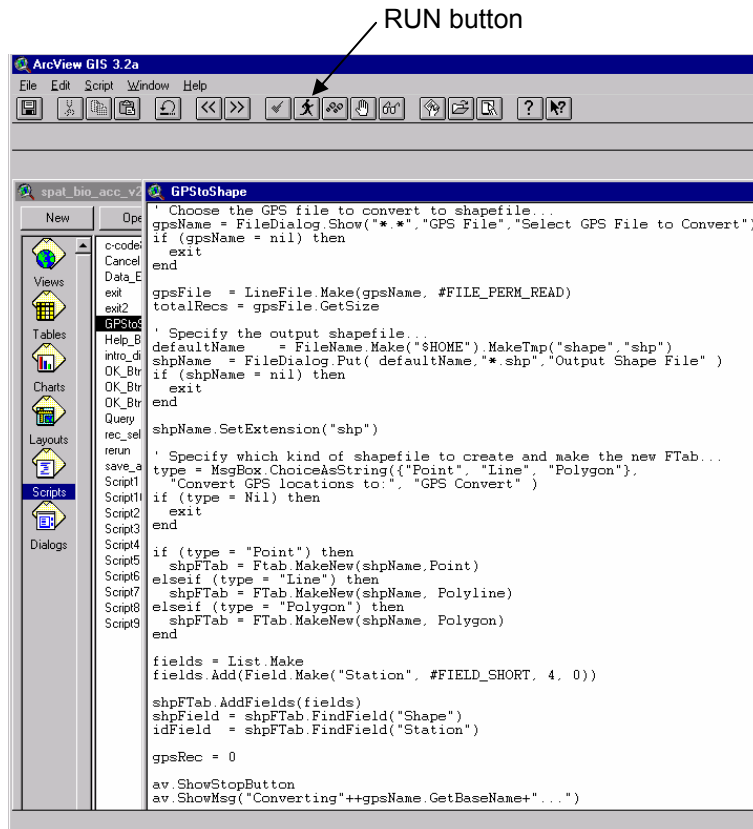


Figure 7: GPStoshape Script Window



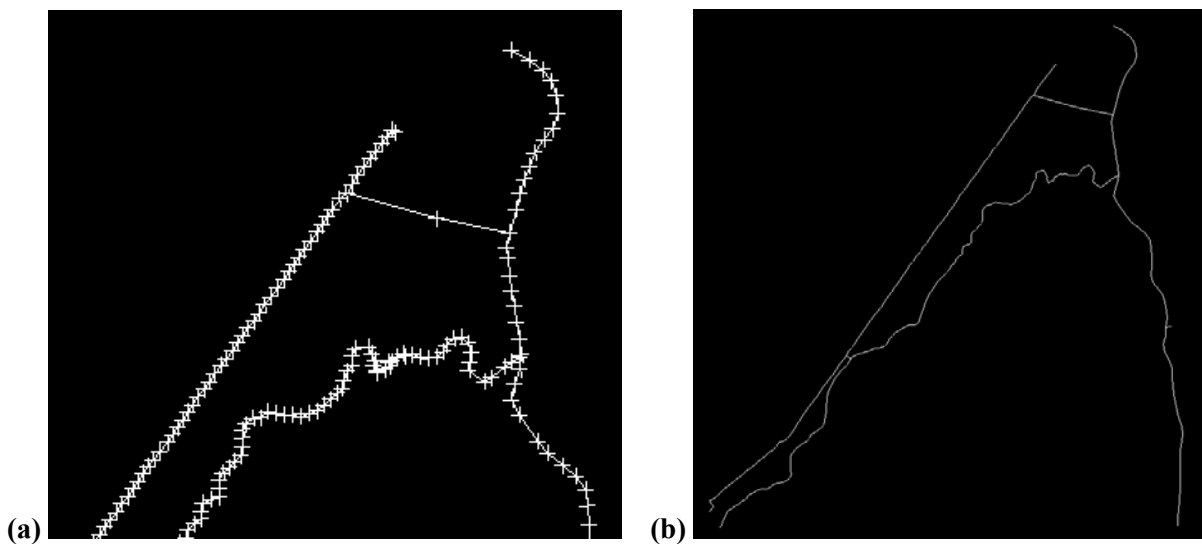
**Figure 8:** Study Areas Points as Shape File in Arcview®

ArcInfo™ works with commands that provide a set of tools for converting spatial coverage from Arcview® to ArcInfo™. The base map is called “base\_let”. The base\_let.shp file was converted to a coverage using the “shapearc” command in ARC. The base\_let.shp file includes Engineers Canal, Bayou Trepagnier, part of Bayou Traverse, Cut Cross Canal and Bayou LaBranche’s coordinates.

ArcPlot was used to create arcs for “base\_let” coverage because when “base\_let” coverage was selected in ArcPlot, label appeared (Figure 9a). The “Add Line” button (Figure 9b) within ArcEdit was used to create arcs between the labels of the entire coverage. The new arcs are shown in detail in Figure 10a and also as the arc coverage is displayed in ArcPlot (Figure 10b).



**Figure 9:** (a) Base\_let Coverage as a Label in ArcPlot and (b) the “Add Line” Button in ArcEdit



**Figure 10:** (a) Lines Between Two Labels, shown in ArcEdit and (b) Final Coverage shown in ArcPlot



## Dynamic Segmentation Illustration #2 (Create a Bayou Route in ArcInfo™)

To create a route, in ArcInfo™, under ArcEdit, the centerlines of the LaBranche Wetlands coverage were displayed. In ArcEdit, routes and sections can be edited using the Edit Feature commands. Table 1 shows the commands used to create bayou routes for bayous 1, 2, 3, 4, 5, and 6. The select path command was used to select a set of arcs and create a route. The cursor was used to graphically select the starting and the ending position in the respective Bayou. All the arcs were selected to generate the shortest-length path between them, in this case the LaBranche Wetlands. Finally, the “make route” command was used to build the route.

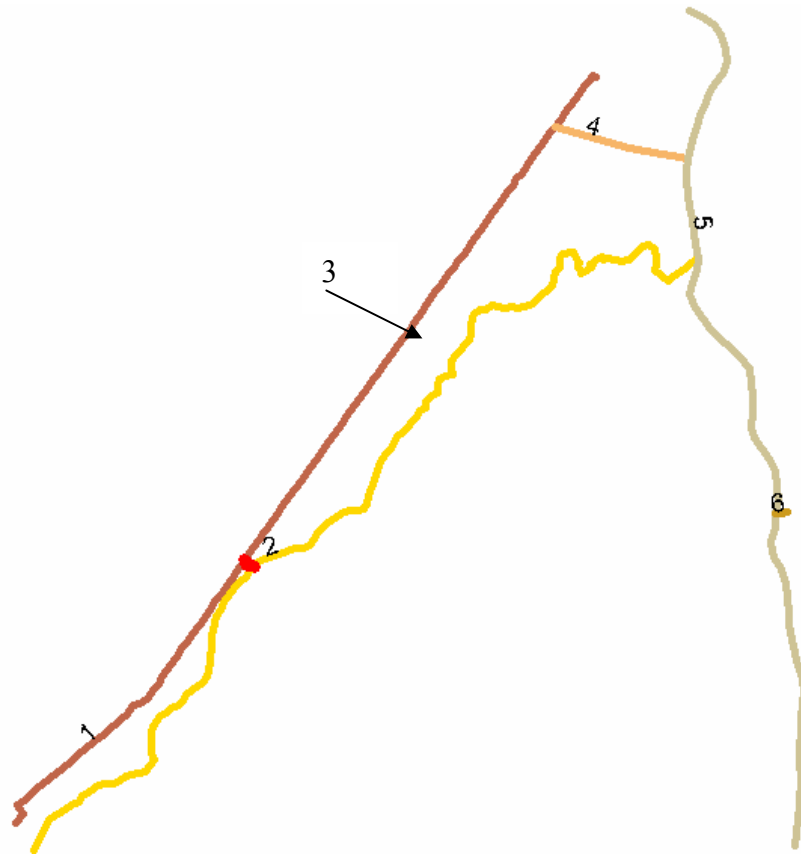
**Table 1: Create the Bayou Routes in ArcEdit with make Route**

```
Arcedit: edit base_let arc
Arcedit: drawenvironment arc node
Arcedit: draw
Arcedit: select path
          Point to the start of the path
          Point to the end of the path

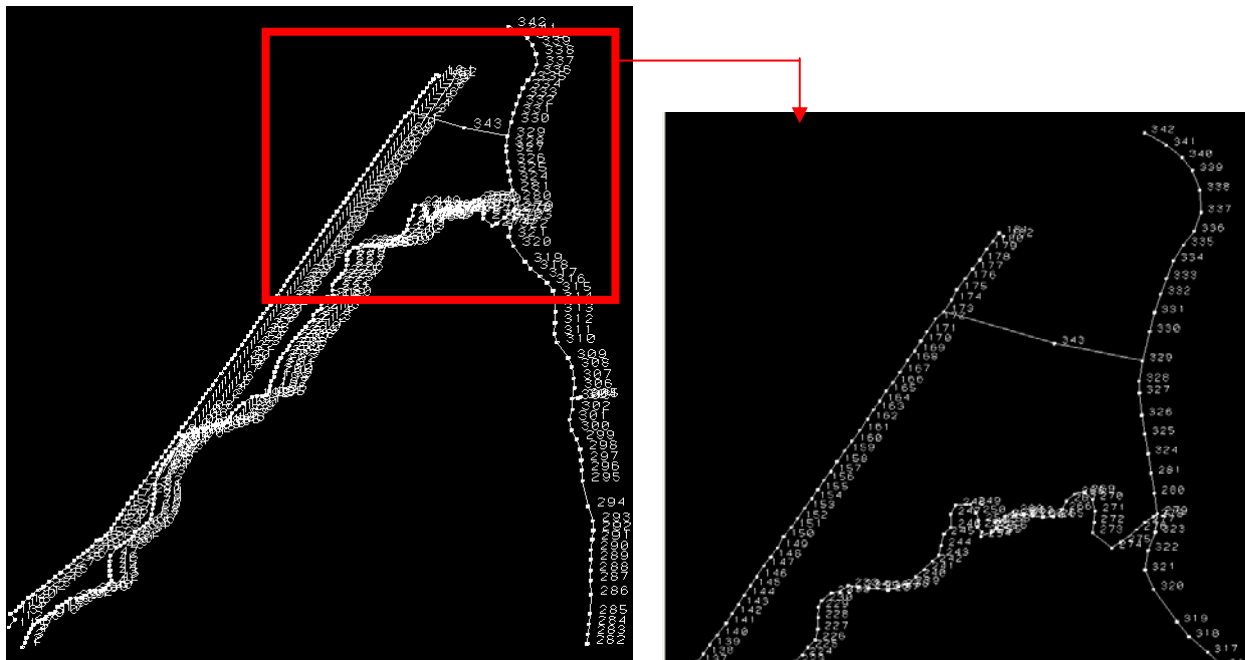
Arcedit: makeroute Bayous

Arcedit: drawenvironment arc off node off route.bayous
Arcedit: draw
Arcedit: editfeature route.bayous
Arcedit: select all
Arcedit: list
```

To illustrate the network of bayous, Figure 11 and Figure 12 show the study area and the network of bayous consisting of 6 bayou routes. All routes have specific names but since the names are long, the route names were collected under the bayous label. Bayou 2 shows “Bayou Trepagnier”; Bayou 1 shows “Engineers Canal”; Bayou 4 shows “Cross Cut Canal”, Bayous 5 shows “Bayou LaBranche”. Bayou 6 shows the beginning of “Bayou Traverse” and Bayou 3 shows the connector between “Engineers Canal” and “Bayou Trepagnier”, commonly referred to as “the cut at BTP 060”. Figure 12 shows all sections and as an inset, an enlarged section of “base\_let” coverage.



**Figure 11: Routes of Study Area within LaBranche Wetlands**



**Figure 12: Section of Study Area**

### Dynamic Segmentation Illustration #3 (use addroutemeasure to create the event table sampling stations.eve)

For the point events (Sampling stations) created by ArcInfo™, addroutemeasure was used. First of all, a text file that contains sampling stations' UTM coordinates was converted as station shape file. A script similar to the one shown in Figure 7 was used. Then, the ARC and TABLES commands were used to create the point events. The sequence of steps are described below and the specific commands are shown in Table 2.

1. The stations shape file was converted to stats\_utm coverage. Stats\_utm was the file name.
2. The Add route command was selected to find a route and measure location of a point in the specified input coverage.
3. The event source command was used to establish the database in which event tables are found and the items in the event table are used in subsequent event processing.
4. The event point command was used to create a coverage containing points representing selected point events in the specified input event table. Figure 13 shows points events (sampling stations) in the study area.
5. Figure 14 shows sampling stations' attribute tables (AAT). The attribute table includes information about sampling station such as, station name, collection, method, sample type, and species.

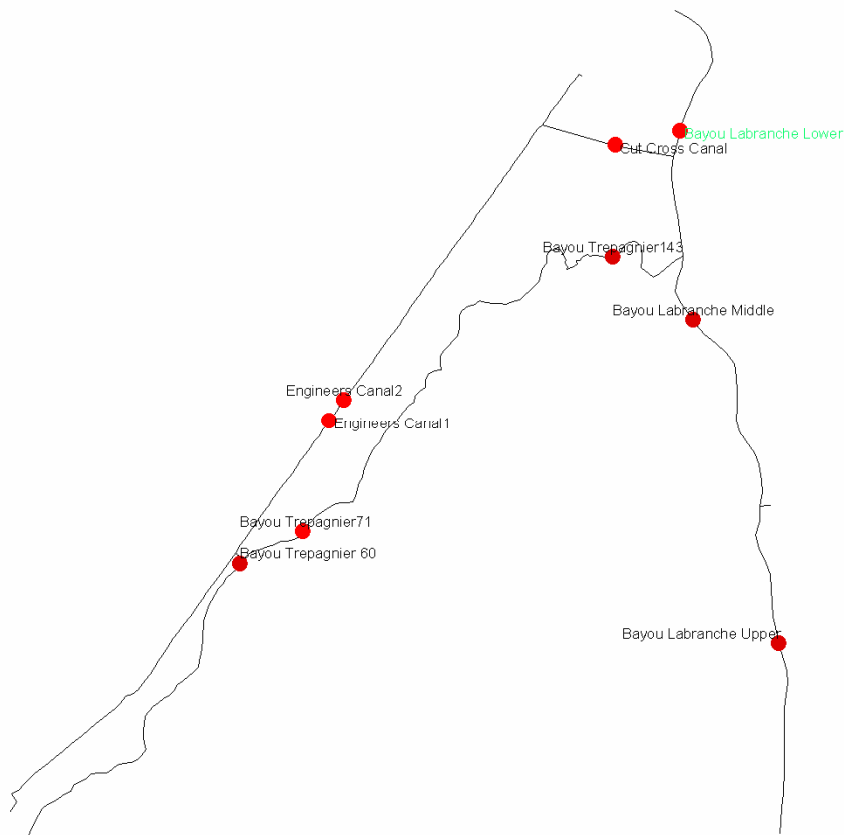


Figure 13: Sampling Events in LaBranche Wetlands

**Table 2: Commands to Create a Points Event Table**

```
Arc: shapearc station.shp stats utm point
      9 type 1 (point) shape records in
      c:\workspace\stats_utm

Arc: addxy stats_utm point
      Adding X, Y Coordinates to stats_utm.pat

Arc: tables
      Copyright © 1982-2000 Environmental Systems
      Research Institute, Inc.
      All rights reserved.
      TABLES Version 8.0.2

Tables:select stats_utm.pat
      9 Records Selected.

Arc: addroutemeasure stats_utm base_let bayous stat_utm.e_tab point 15

      Record   STATS_UTM#   BAYOUS#   MEASURE
      1         1         1       583.212
      2         2         1      1475.029
      3         3         1      3060.717
      4         4         2      2583.555
      5         5         5       406.321
      6         6         3      4311.051
      7         7         3      2053.130
      8         8         3      1722.240

Arc: eventsource add point stat_utm stat_utm.e_tab info

      linear bayous# bayous# measure

Arc: eventsource list

      Writing route, measures to stat_utm.e_tab

Arc: list stats_utm.e_tab
      Source name:STAT_UTM
      Event type: POINT
      Event Table name: STAT_UTM.E_TAB
      Database: INFO
      Relate type: LINEAR
      Route key item: BAYOUS
      Event key item: BAYOUS#
      Point measure: MEASURE

Arc: event point base_let bayous stat_utm sampling_st
      Creating output coverage SAMPLING_ST
```

Attributes of Sampling_st.shp				
<i>Station</i>	<i>Collection</i>	<i>Method</i>	<i>Sampletype</i>	<i>Species</i>
Engineers Canal2	VJT-123	Electroshock	Fish	Micropterus salmoides
Engineers Canal1	VJT-111	Electroshock	Fish	Cyprinus carpio
Bayou Trepagnier143	VJT-114	Electroshock	Fish	Micropterus salmoides
Bayou Trepagnier71	VJT-109	Electroshock	Fish	Mugil cephalus
Bayou Trepagnier 60	VJT-110	Electroshock	Fish	Lepomis macrochirus
Cut Cross Canal	VJT-116	Electroshock	Fish	Mugil cephalus
Bayou Labranche Lower	VJT-115	Electroshock	Fish	Lepisosteus oculatus
Bayou Labranche Middle	VJT-113	Electroshock	Fish	Lepisosteus oculatus
Bayou Labranche Upper	VJT-112	Electroshock	Fish	Lepomis macrochirus



**Figure 14:** Sampling Stations Attribute Table, Stations and “Base\_let”

#### **Dynamic segmentation illustration # 4 (Create Line Event (Vegetation))**

A vegetation text file containing vegetation coordinates was converted to a shape file using a script in Arcview<sup>®</sup>. In the summer of 2002, coordinates for each vegetation type in the study area were collected using a GPS instrument for the beginning and end points of the cypress area, grass area and tree area as observed along the bayous by boat, and photographs were taken for hyperlinks. The shape file name is “vetr”. “Vetr” shape file was converted to coverage in ArcInfo<sup>™</sup> (Table 3).

**Table 3: Conversion from Vegetation Shape File to Coverage**

```
Arc: shapearc vetr.shp vetr point
      215 type 1 (point) shape records in c:\workspace\vetr
Arc: ADDXY VETR POINT
      Adding X, Y Coordinates to vetr.pat
Arc: tables
      Copyright © 1982-2000 Environmental Systems Research
      Institute, Inc.
      All rights reserved.
      TABLES Version 8.0.2
Tables:select vetr.pat
      343 Records Selected
```

As Table 3 shows, the shape file was converted to point coverage. These points have to be converted to lines in ArcInfo™ and the segments should show vegetation areas, such as a tree, grass and tree areas. For example, point 1 to point 4 must be trees in Bayou Trepagnier. From point 147 to point 157 must be grass. The “Generate” command was used to create lines and show the vegetation type for that segment. Pointnode command was used to build nodes in Arc. Addroutemeasure was used to create the event table “vetr.eve” (Table 4). Event table was related with “base\_let” and bayous route (Table 4).

**Table 4: Create the Event Table**

```
Arc: arcshape vetr.shp vetr point
Arc: addxy vetr point
Arc: generate vetr
      Generate:lines
      ID=1
      X,Y=753779,3326816
      X,Y=753681,3326741
      X,Y=753655,3326726
      ID=end
      Generate=quit
Arc: clean vetr
Arc: build vetr line
Arc: pointnode vetr vetr 10
      Building nodes...
Arc: list vetr.nat
      Record   ARC#   VETR#   VETR-ID  STATION  X-COORD  Y-COORD
      1         10     1       193      193      753752   3327926
      2         8      2       176      176      753332   3327627
      Continue? N
Arc: list vetr.aat
      Record FNODE#  TNODE#  LPOLY#  RPOLY#  LENGTH  VETR#  VETR-ID
      Table 5.4: Create the Event Table (Continued)
      1       7       23     0        0    4563.210  11
Arc:addroutemeasure vetr base_let bayous vetr_ev node 10
      Writing route, measures to vetr_ev
Arc:relate add fnode, vetr.nat, info, fnode#, vetr#, link, ro
Arc:relate add tnode, vetr.nat, info, tnode#, vetr#, link, ro
Arc:list vetr_ev
      Record   VETR#   BAYOUS#   MEASURE
      1         1         5         0.422
      2         2         1         0.207
      Continue? N
Arc:relate add meas,vetr_ev,info,vetr#,vetr#,linear,ro
Arc:additem vetr.aat vetr.aat from 4 12 f 3
      Adding from to vetr.aat to produce vetr.aat
Arc:additem vetr.aat vetr.aat to 4 12 f 3
      Adding to to vetr.aat to produce vetr.aat
Arc:additem vetr.aat vetr.aat bayous# 4 5 b
      Adding bayous# to vetr.aat to produce vetr.aat
Arc:tables
      Copyright <C> 1982-2001 Environmental Systems Research Institute , Inc.
      All rights reserved.
      Tables 8.1.2 <Thu Oct 18 10:39:05 PDT 2001>
      Tables:select vetr.aat
      21 Records Selected.
      Tables:calc from = fnode//meas//measure
```

```
Tables:calc to = tnode//meas//measure
Tables:calc downstream# = fnode//meas//bayous#
Tables:end
Leaving TABLES...
Arc:eventsourcing add linear ve_so vetr.aat info linear
bayous# bayous# from to
Arc: eventsourcing list
Submitting command to Operating System...
Arc:eventsourcing list
Source name:VE_SO
Event type:LINEAR
Event table name:VETR.AAT
Database:INFO
Relate type:LINEAR
Route key item:BAYOUS#
Event key item:BAYOUS#
From measure:FROM
To measure:TO
Arc:eventarc base_let bayous ve_so vegetation
Creating output coverage vegetation
```

Vegetation was obtained as a coverage in ArcInfo™. Vegetation was converted to a shape file in Arcview®. Figure 15 shows how to convert from a coverage to a shape file in Arcview®. The file name of the vegetation shape file is vegetation.shp. Figure 16 shows vegetation types in the study area. Figure 17 shows each bayou route as a number, and points show each station. Each station's name was shown in a Layout with the types of vegetation.

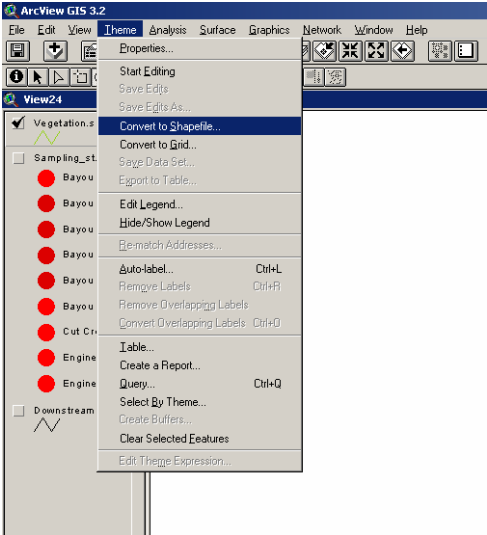


Figure 15: Conversion Button in Arcview®

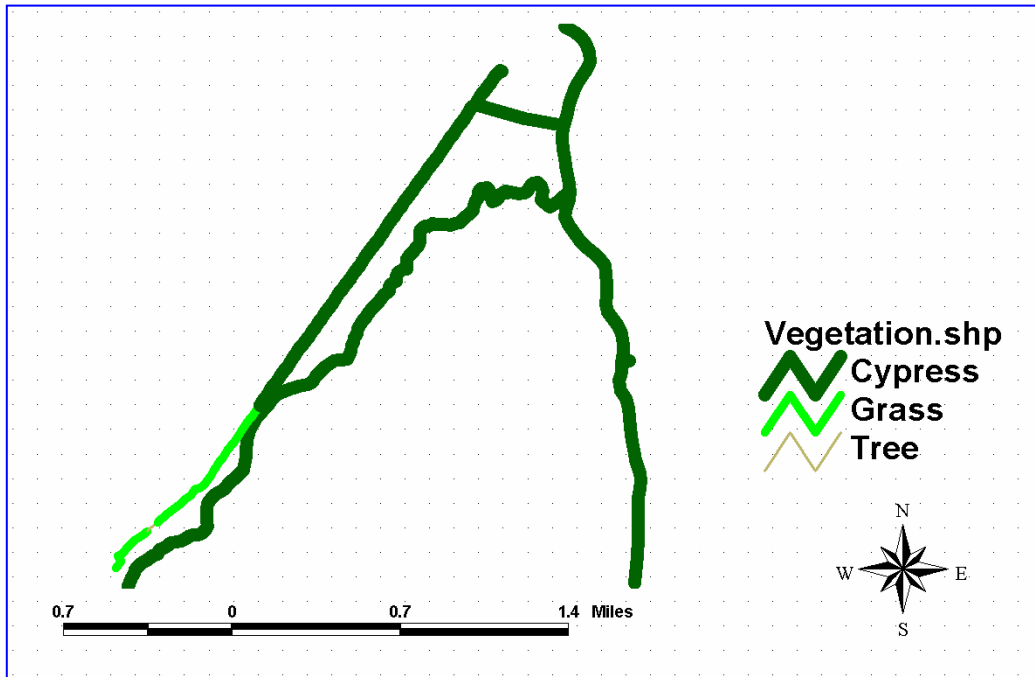


Figure 16: Types of Vegetation

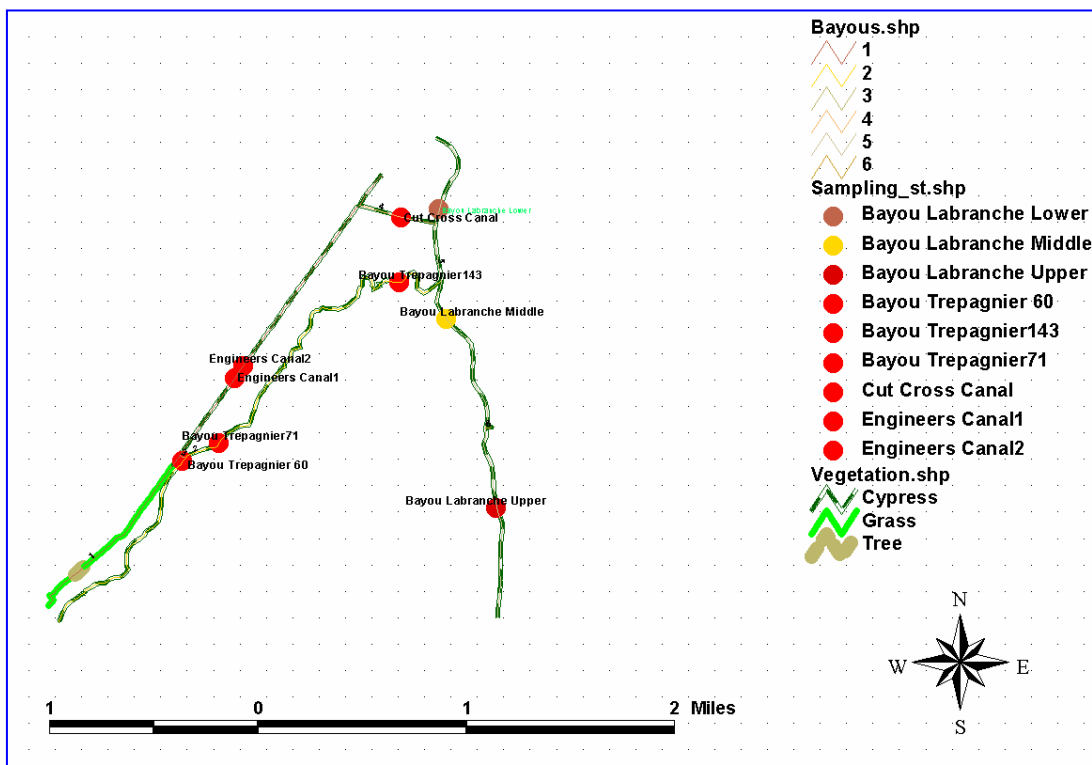
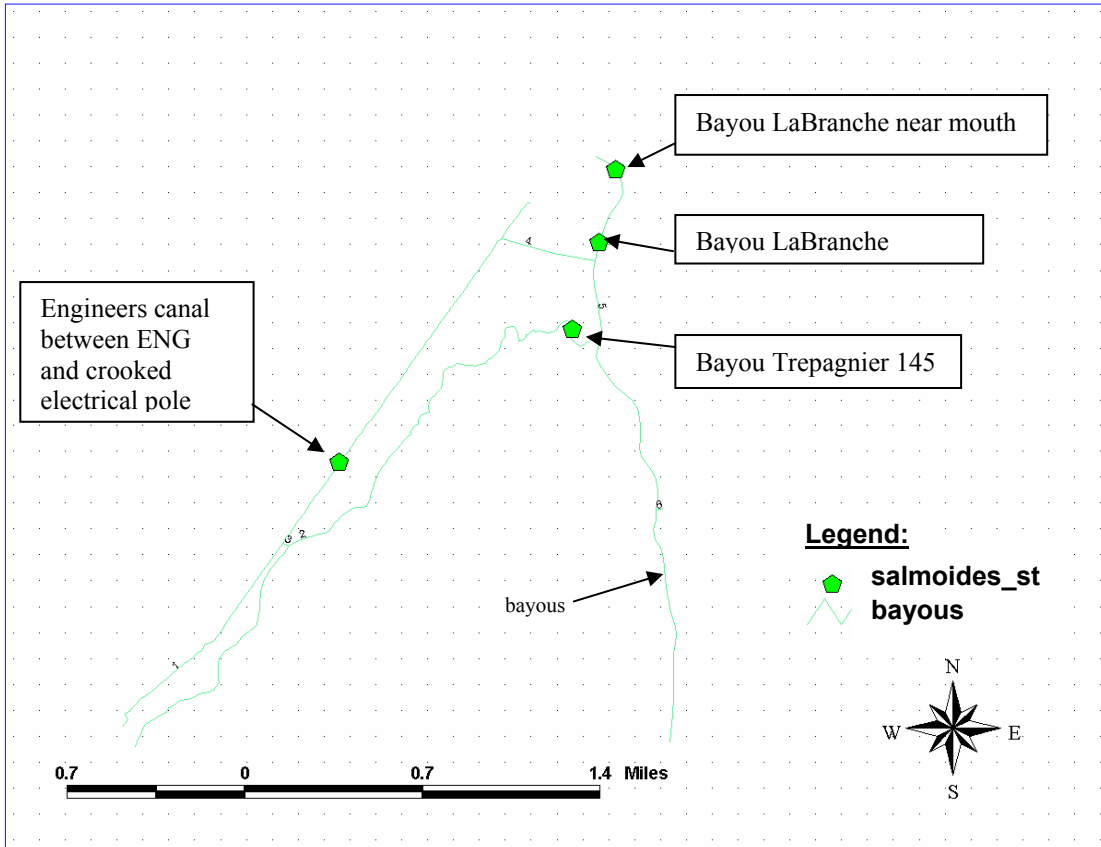


Figure 17: Bayous Route, Types of Vegetation and Sampling Stations

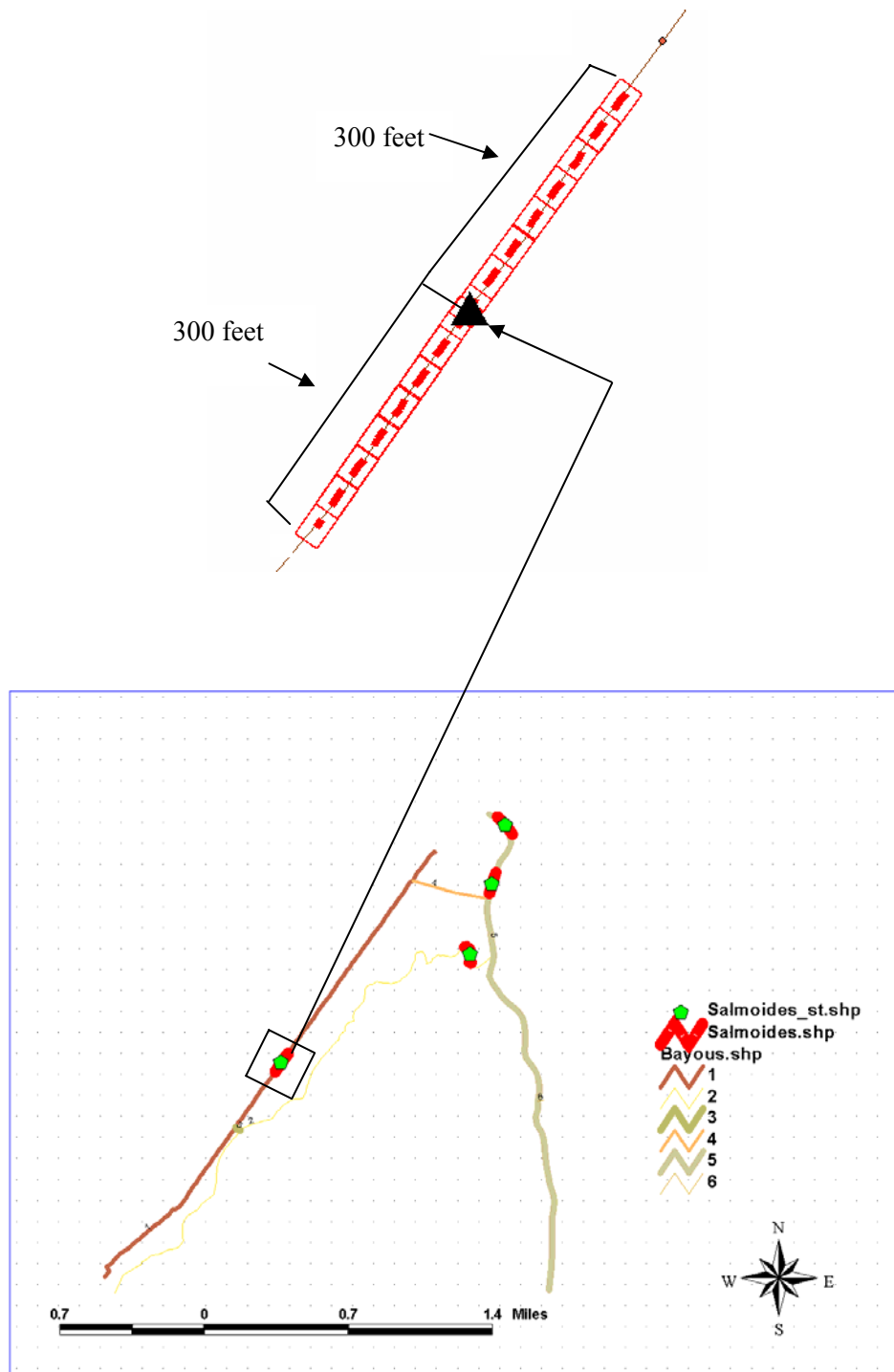


### **Dynamic Segmentation Illustration # 5 (Create Species home range)**

In the study area, fish were marked, released and recaptured in order to get an idea of their home range. So far, only one species has been released and recaptured, that is, the *Micropterus salmoides* or largemouth bass. The home range location and specific fish type, such as, largemouth bass, can be defined within ArcGIS. First of all, the largemouth bass release/recapture locations were determined based on the field reports provided by the field technician. The areas of these sites were bound by specific landmarks along the bayous, such as: along Engineer's Canal between ENG and the "crooked electrical pole"; along Bayou LaBranche Lower between Bayou Trepagnier 145 and Bayou LaBranche near the mouth (Figure 18). The largemouth bass home ranges were not certain at the time of this writing and it was assumed to be an average home range of 300 feet (90 meter) up or down from the site ID. Lewis (1967) found that the fish could move 300 ft in a pond; This implies that from where you capture the fish, the fish can move 300 ft in any direction. For a linear waterway it still means 300 ft in any direction but in reality they can only move 300 ft "up" and 300 ft "down" along the bayou. This home range distance was selected even though this data was reported for a pond, namely a closed system. The current study indicates larger home ranges, but there is not enough data to set a specific home range for the largemouth bass in the LaBranche Wetlands. Species home ranges can be defined for the current study, but assumptions were made to show the functionality. These areas coordinates were defined with the measure button in Arcview® and ArcGIS, and converted to a shape file. The shape file name is "m\_salmoides" shape file. The shape file was converted to coverage with "ARC" command in ArcInfo™ (Table 5.5). Then the generate command was used to create lines in ArcInfo™ (Table 5.5). Figure 19 shows all site IDs, areas of largemouth bass home range can be found 300 feet up and down from each site ID, and as an inset, an enlarged section of the bass coverage. The triangle shows the site ID where *Micropterus salmoides* were released and recaptured.

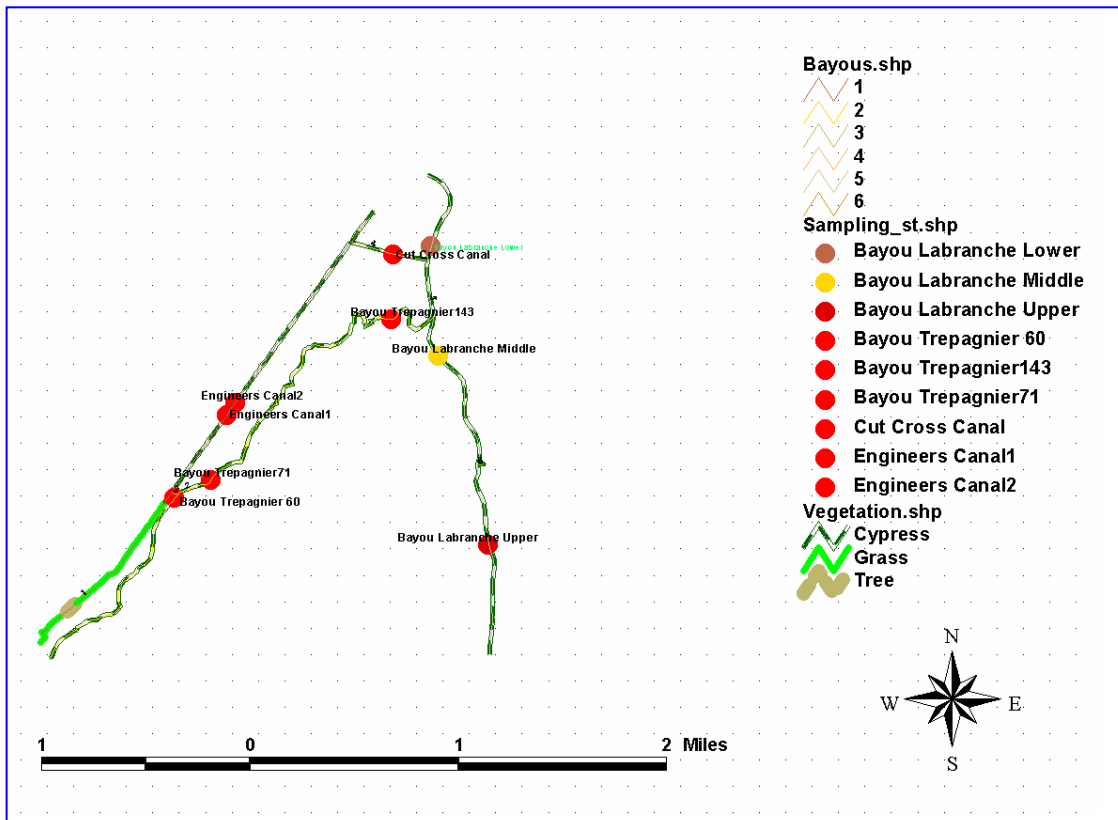


**Figure 18:** Largemouth Bass Site ID



**Figure 19: Site-ID and 300 Feet up and Down from Site-ID**

Vegetation, sampling station, and bayous route linearly segmented data were created. The routes and routes events were connected with the real photographs. Figure 20 shows bayous route, types of vegetation and sampling stations.



**Figure 20:** Bayous Route, Vegetation Types and Sampling Stations

When the “Identify button” is active in Arcview<sup>®</sup>, the desired point or line on the map can be selected by a mouse click to access information about that point or line. Figure 21 shows the information contained in the attribute table of the vegetation event as defined previously.

To associate information from the attribute table, with a location on the map, data was selected in the attribute table, and highlighted in yellow at the pertinent location. At the same time, the data popped up on the map, and gave information about the stations’ name, water temperature, air temperature, dissolved oxygen, salinity, collectors, organism weight and length, species name, and when they were collected, etc. (Figure 22). The big point (Engineers Canal 2) shows the point selected from the attribute table in Figure 22.

Finally, the map (Figure 23) contains information about the study area bayou routes, sampling stations, and types of vegetation. Figure 24 shows where the largemouth bass lives and where or at which site bass were released and recaptured along with vegetation types. Figure 24 displays the site-ID as the *salmoides\_st* shape file, overlaid with the vegetation shape file. Assumptions were made between relationship type of vegetation and species home ranges. This map showed that the largemouth bass likes to live in cypress area or grassy areas.

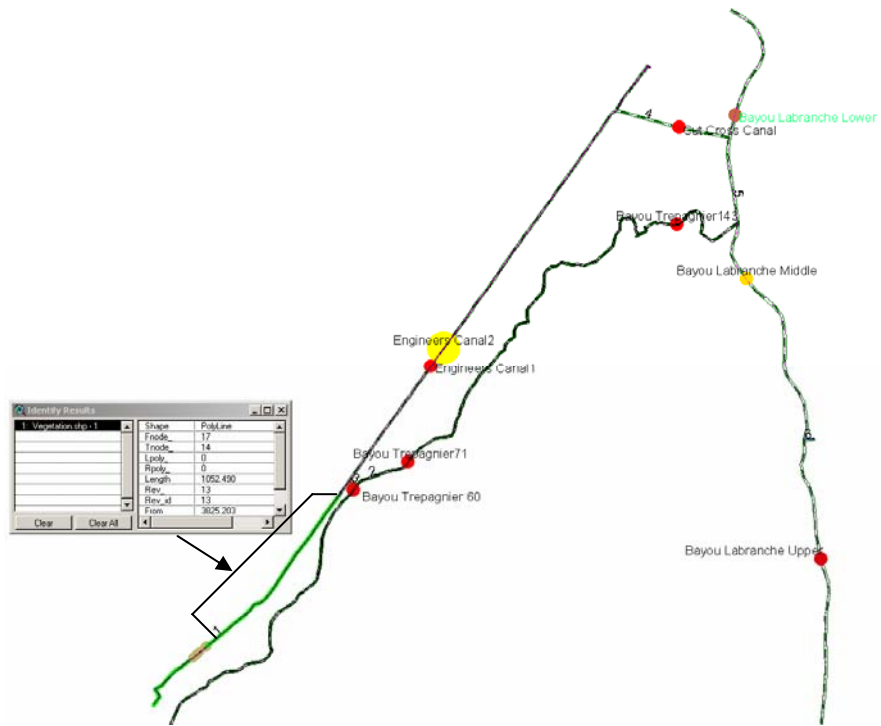


Figure 21: Identify Button to Get Information about Data

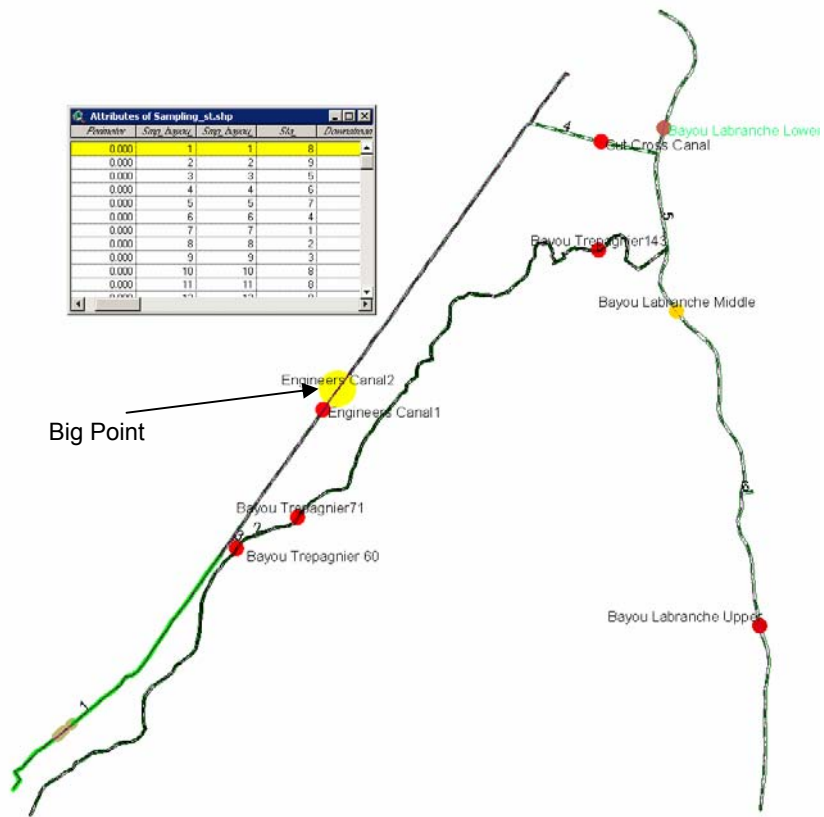
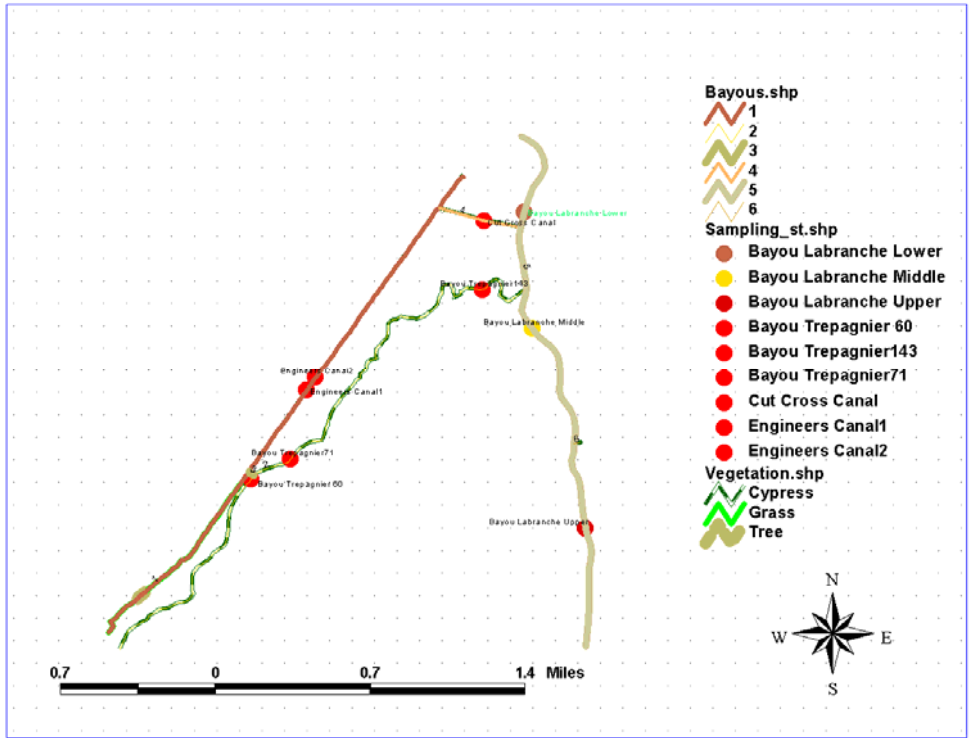
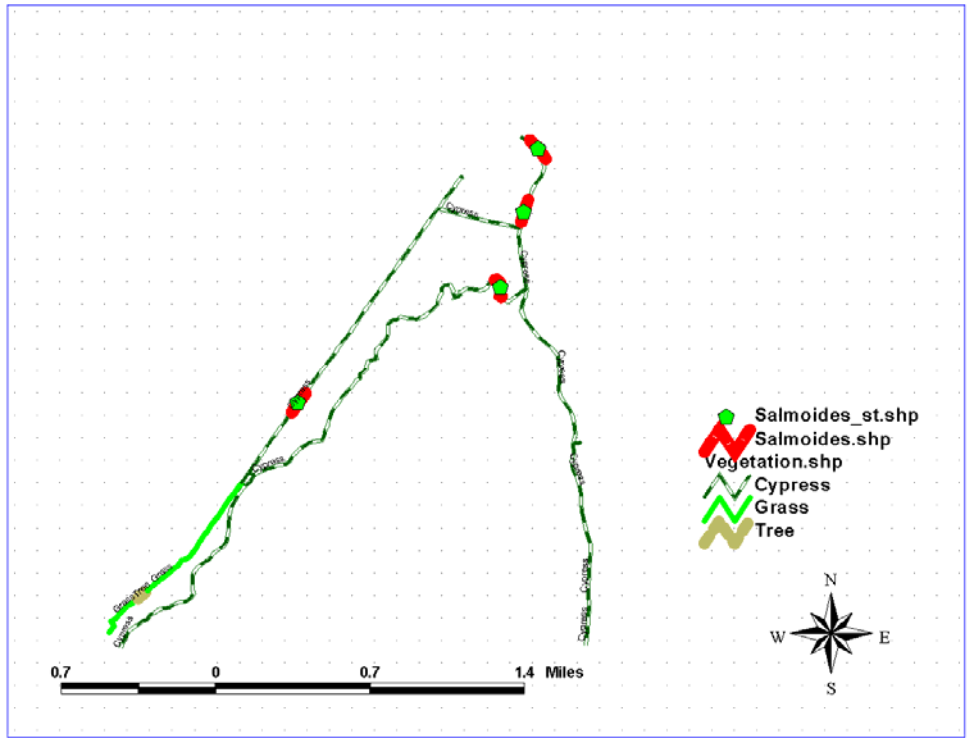


Figure 22: Information from Attribute Table Shows on Map



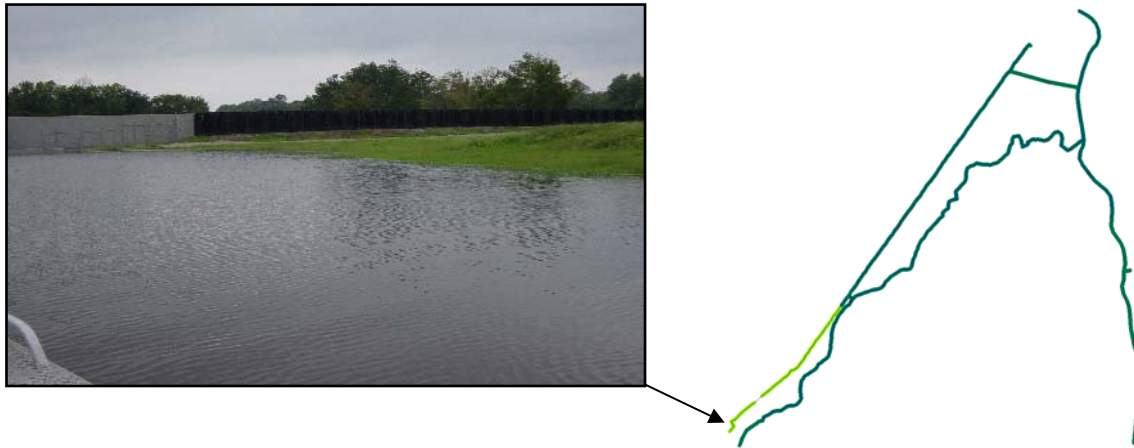
**Figure 23:** LaBranche Wetlands with Route, Sampling Stations and Vegetation Type



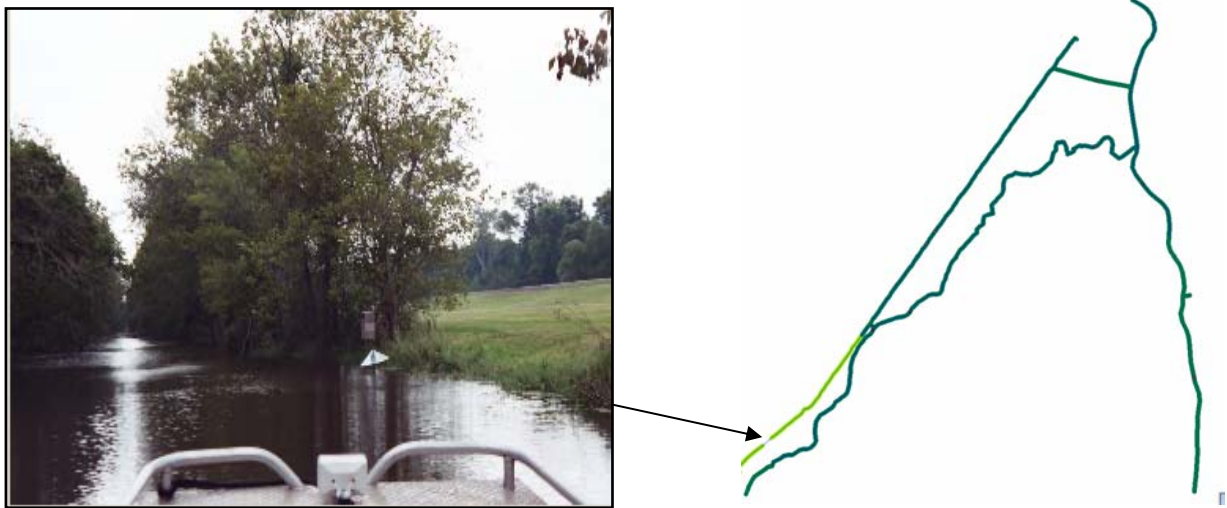
**Figure 24:** Where Largemouth Bass lives

Digital photographs were taken of the study area, and these were used for the vegetation-segmented data (or events). When any line is clicked on the map, a real photograph pops up on the screen in a separate window. Figures 25 through 31 show different views of the Bayou in 2002.

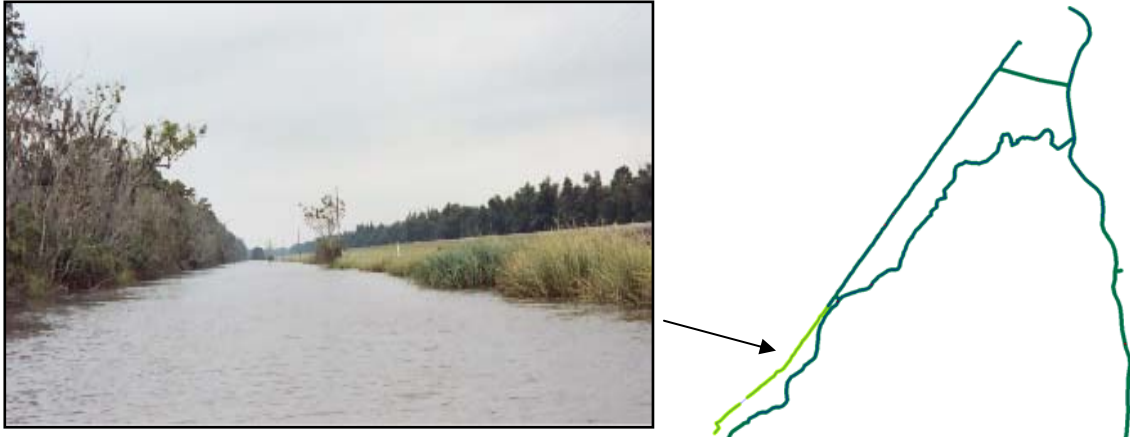
These photographs provide other researchers with a practical perspective of how the study area looks from a boat offshore.



**Figure 25:** West Bank in Engineers Canal, Looking South at the NORCO Wall



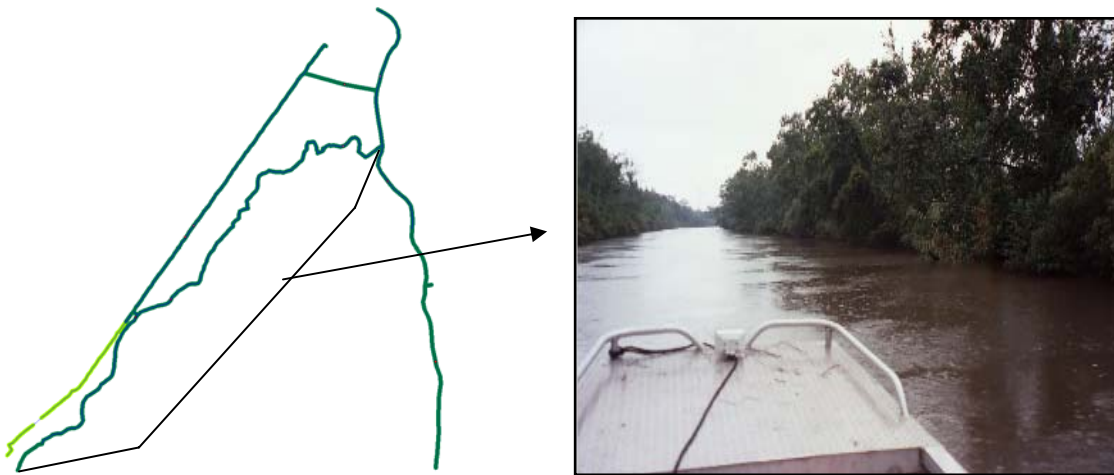
**Figure 26:** Trees Area in Engineers Canal, Looking South



**Figure 27:** Grassy Area in the Engineers Canal, Looking South

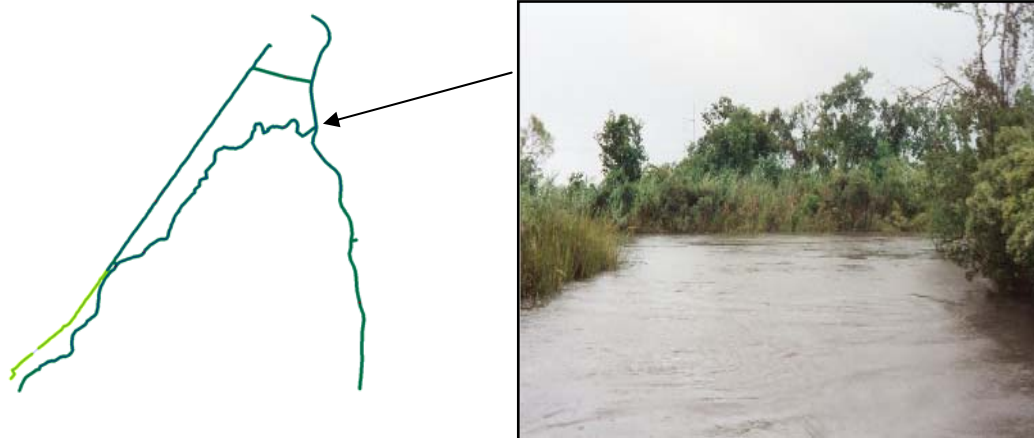


**Figure 28:** East Bank in the Engineers Canal

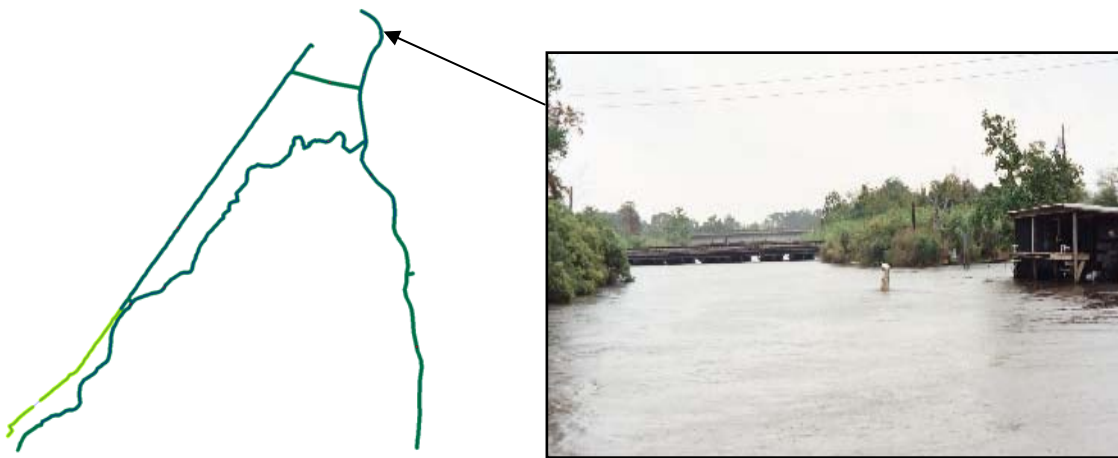


**Figure 29:** Typical View of Bayou Trepagnier, Looking North





**Figure 30:** Between Bayou Trepagnier and Bayou LaBranche



**Figure 31:** Rail Road crossing at Bayou LaBranche Lower, Looking North

## ***CONCLUSION***

Dynamic segmentation is a data structure used for modeling and analyzing linear features. It allows for the association of multiple sets of attributes along any portion of a linear feature. The study showed bayou routes, sampling stations, type of vegetation and the relationship between vegetation and species home ranges. A network route was developed for the purpose of spatial modeling of the bayou. Dynamic segmentation (routes and events) was developed along the bayous, to describe different events along the linear features. Dynamic segmentation was also used to show linear features containing one-to-many relationships, such as six routes along the bayou. Dynamic segmentation was also useful to see what kind of vegetation existed along the bayous and where fish liked to live, such as cypress areas or grassy areas.

Bayou networks were built and created route, sampling stations and types of vegetation. These were shown on map. Digital photographs were taken of the study area, and these were used for the vegetation-

segmented data (or events). When any line was clicked on the map, a real photograph pops up on the screen in a separate window.

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