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CSISS News

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CSISS.org/Spatial Tools/Tobler's Flow Mapper

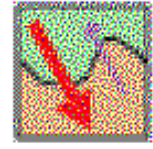


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Search Engines	CSISS Events	Community Center	CSISS presentations, news, personnel, and sitemap. Our Strategic Plan and Annual Reports are also found here.
Try out one of our custom search engines to find spatial analysis resources on the Internet.	Here's where you'll find information and registration for workshops, conferences and specialist meetings.	Join the forums, or if your organization relates to our mission and goals, register as a CSISS affiliate.	

Tobler's Flow Mapper



Background

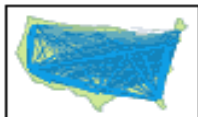
Geographical movement is of crucial importance. This is because much change in the world is due to movement; the movement of people, ideas, disease, money, energy, or material. One way of depicting and analyzing geographical movement is by way of geographical maps. A convenient and rapid method of displaying movement data on such maps is therefore very useful. A flow mapping program is one approach to this objective. For in depth information see csiss.org/Spatial Tools:

- Flow Mapper Tutorial, Tobler 2004 4.1 mb - Updated 6-6-05
- Movement Mapping, Tobler 2003 2.5 MB
- Experiments in Migration Mapping by Computer, Tobler 1987, 500 kb

About Flow Mapper

In 2003 CSISS supported a short effort to produce an interactive flow mapping program. The result is a new Windows-based version of a 1987 program by Waldo Tobler. This original application has been updated by David Jones using Microsoft Visual Basic.Net and Scaleable Vector Graphics for map rendering. It requires as input locational coordinates and information on the interaction between the places. Additional input may include place names and a file of boundary coordinates (for a background map). The user has several menu options for producing a map. The program allows for the production of a total movement maps shown by

Examples



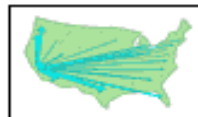
Example 1



Example 2



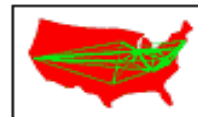
Example 3



Example 4



Example 5



Example 6



Example 7



Example 8



Example 9

Flow Mapper Requirements

- Microsoft Windows 98SE, ME, 2000, XP
- Microsoft Dot.Net Framework installed
- Microsoft Internet Explorer
- Scalable Vector Graphics support for Internet Explorer. Adobe SVG plugin 3.x or higher
- C:\temp folder

Installing Flow Mapper

Remove any existing version of Flow Mapper (*Control Panel > add/remove*).

1. Verify that your operating system is within the requirements.
2. Install Dot.Net Framework, if necessary. Go to *Start > Control Panel*. The .Net Framework Management icon will be visible if it is installed. (You may need to look in *Administrative Tools*). Many Windows XP and 2000 machines come pre-installed with this.

Download and install .Net Framework

3. Make sure that you have Microsoft Internet Explorer installed (required to display maps).
4. Install Adobe SVG plugin. If you are not sure that you have it installed, install it again.

Download and install Adobe SVG Viewer

5. Make sure that the C:\temp folder exists. It's needed for temporary files.
6. Download and install the Flow Mapper program from the CSISS.org web site. Store it to a directory of your choice ("C:\program files\tobler\flow mapper" is suggested). A shortcut to the Flow Mapper program will appear on your desktop. The program is Flow Mapper.exe. Documentation and Data_Sets will also be with the program in this folder. Replace this Data_Sets folder with the newer update from the csiss.org site.

Some nice properties of the program

- Simple and quick flow map preparation - **GIS Not Needed!**
- Extensive color styles available. Black & white too.
- Hovering over a band or arrow gives the magnitude.
- Hovering over a centroid gives its label.
- Two-way, total, or net movement maps.
- Many to many, one to many, or many to one maps.
- Easy threshold choice. Some statistics made available.
- Size dependant only on memory availability.
- Multiple output formats.
- Non-geographic flows within firms, industries, organizations, too.
- Help file included.
- Microsoft Windows compatible.

Flow Mapper Tutorial

Parts I, II, III

To be used in conjunction with the Flow Mapper program developed by Waldo Tobler & David Jones and available for download at CSISS.org/tools

Much of Computer
Cartography is a Dot-to-Dot
Replace the dots by coordinates

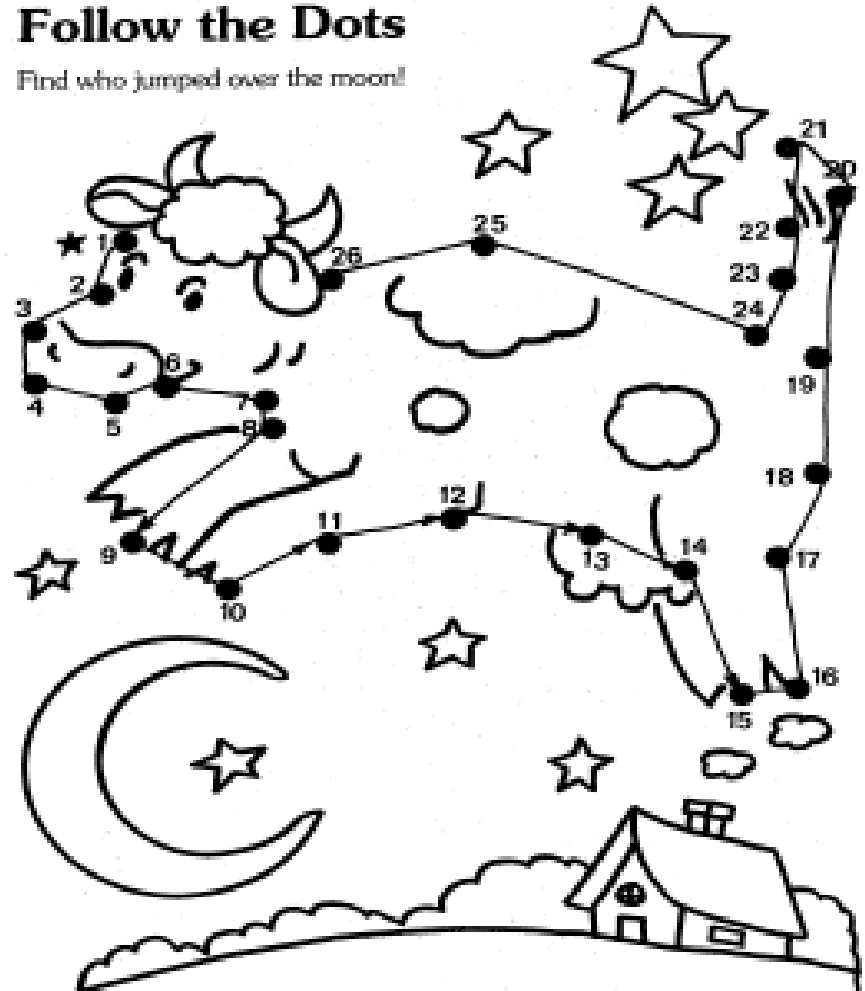
Follow the Dots

Find who jumped over the moon!



Follow the Dots

Find who jumped over the moon!



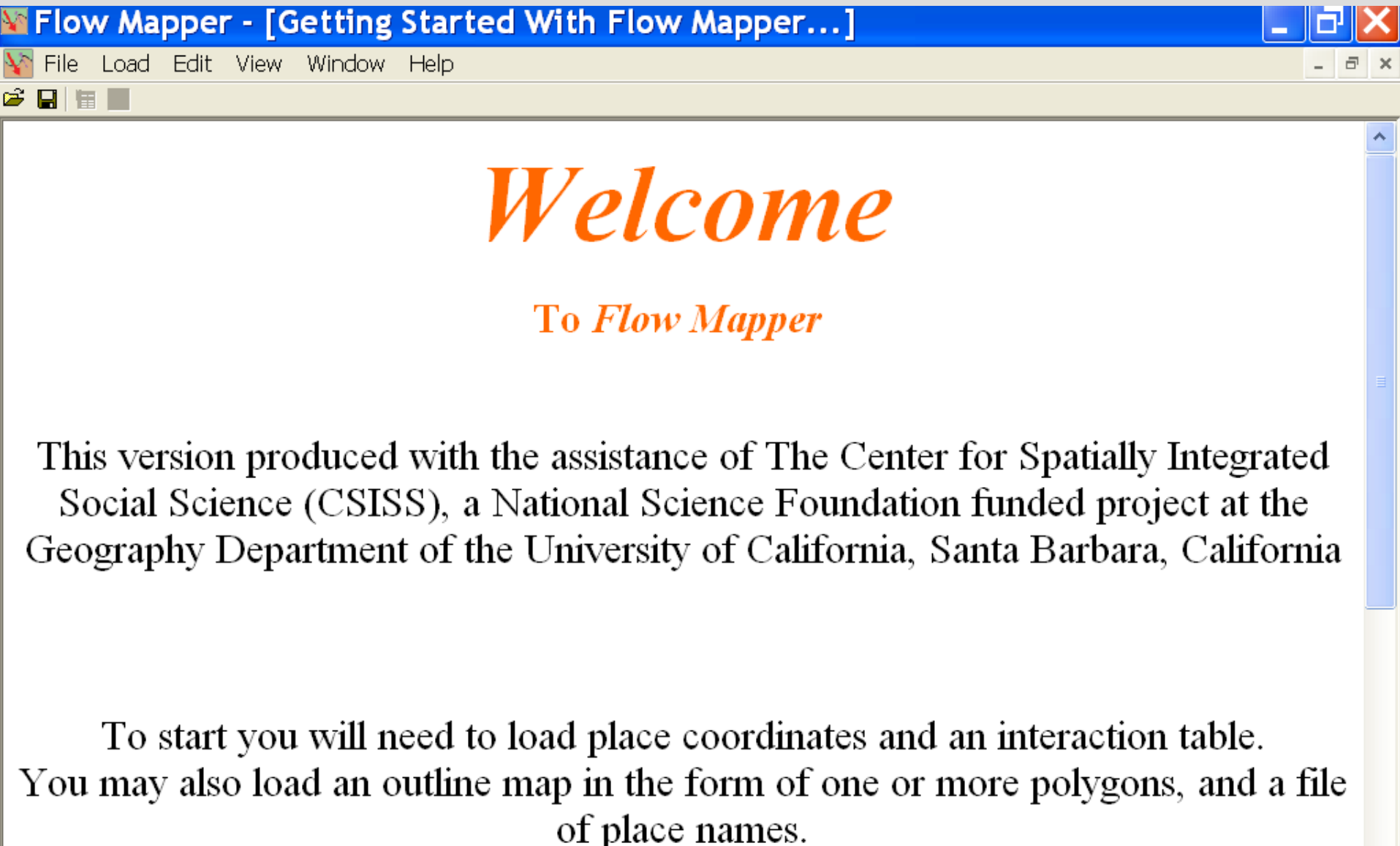
Tutorial Part I

General Instructions

Getting started

The help file also contains instructions

The help file has good instructions & hints. After looking at the help files you can view this Welcome screen. To close it click on the smaller (the lower one) of the two x's in the upper right corner. Then go through this tutorial and start using the program.



The first steps

You will need to have available coordinates.
And an interaction table, or an origin - destination list.

The order in which you load these is not important.

I usually load a background map first to make certain that I am working with the correct area, as in a subsequent view.

Then I load the place names and locations,
then the interaction table.

If you have an origin - destination list instead
of a complete flow table

Then look under

`data_sets\programs\moves\input help programs`

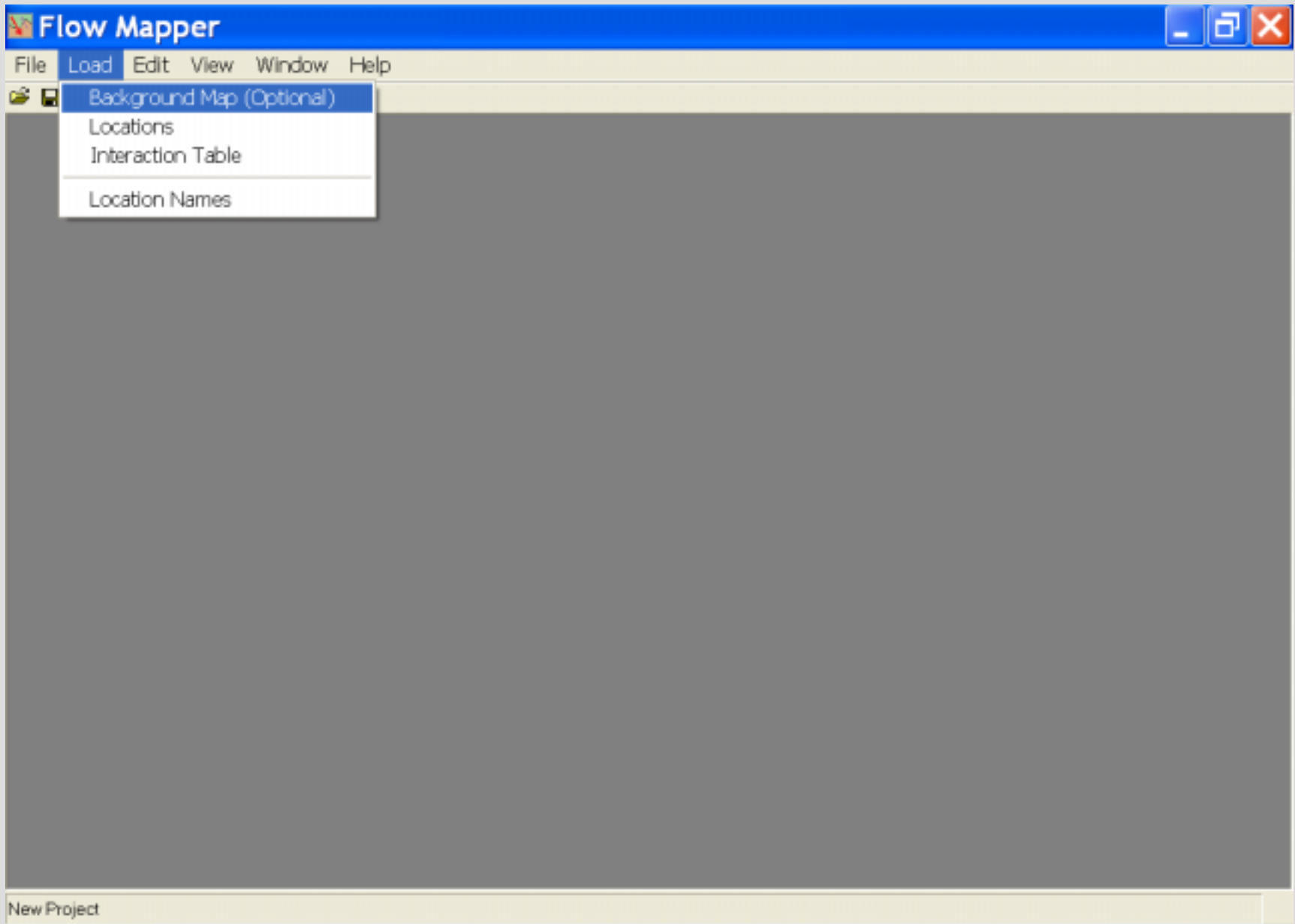
and choose the appropriate program to convert your data.

(do not use tab delimited lists - only comma or space delimited will work)

The program should convert your list to a table in the correct form
for use in Flow Mapper.

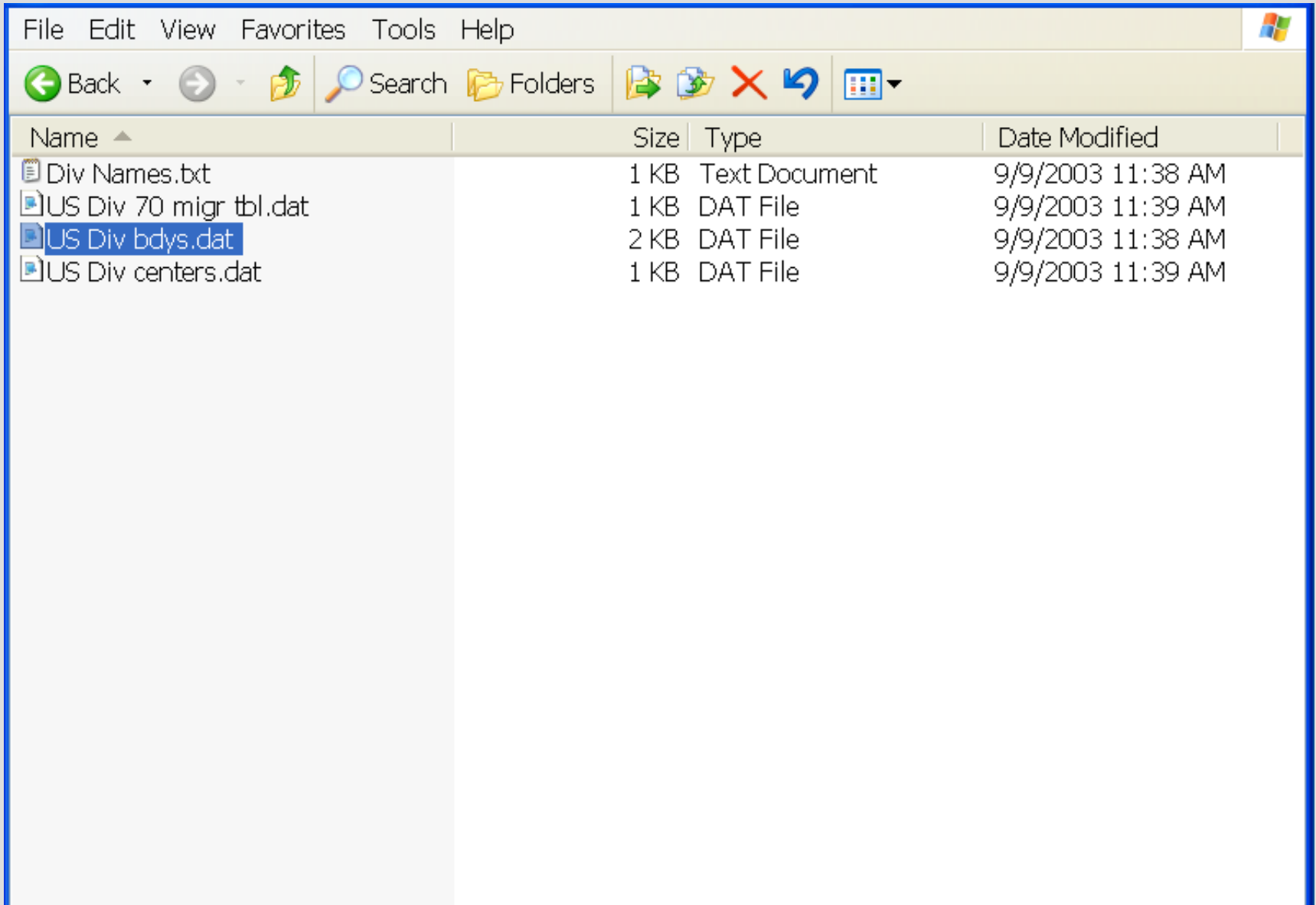
In order to do this you will need to exit the Flow Mapper program,
convert and save the data, and then restart the Flow Mapper
program using the movement table that was created..

Load a background map



Locate the file containing the background map

Then load it. Or look at it to see the simple format.



The image shows a screenshot of a Windows Explorer window. The window title bar is not visible, but the menu bar includes 'File', 'Edit', 'View', 'Favorites', 'Tools', and 'Help'. The toolbar contains icons for 'Back', 'Forward', 'Up', 'Search', 'Folders', 'Copy', 'Paste', 'Delete', 'Refresh', and 'View'. The main area displays a list of files with columns for 'Name', 'Size', 'Type', and 'Date Modified'. The file 'US Div bdys.dat' is selected and highlighted in blue.

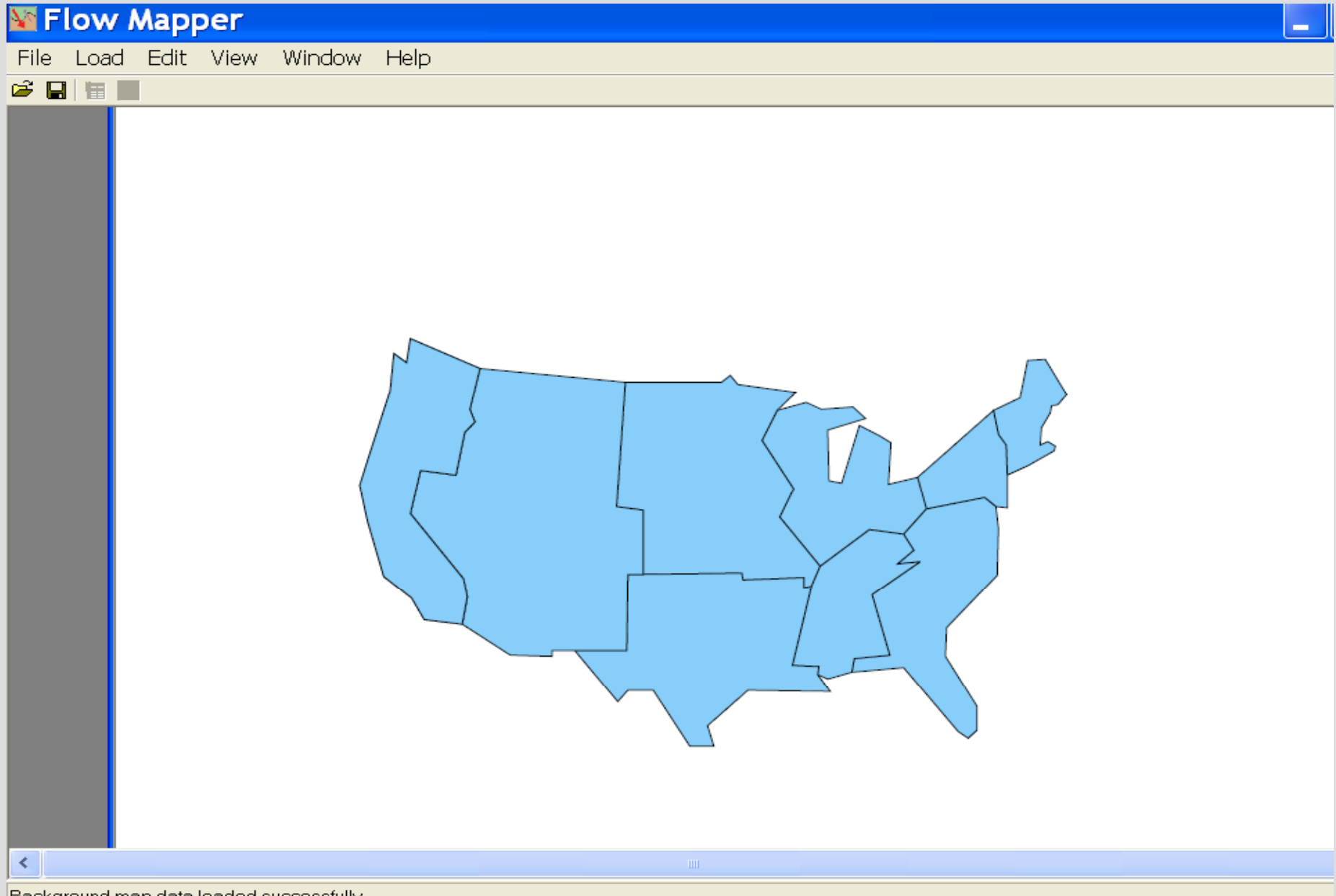
Name ▲	Size	Type	Date Modified
Div Names.txt	1 KB	Text Document	9/9/2003 11:38 AM
US Div 70 migr tbl.dat	1 KB	DAT File	9/9/2003 11:39 AM
US Div bdys.dat	2 KB	DAT File	9/9/2003 11:38 AM
US Div centers.dat	1 KB	DAT File	9/9/2003 11:39 AM

Boundary Coordinates

Number of points, counter-clockwise order, first-last, arbitrary units

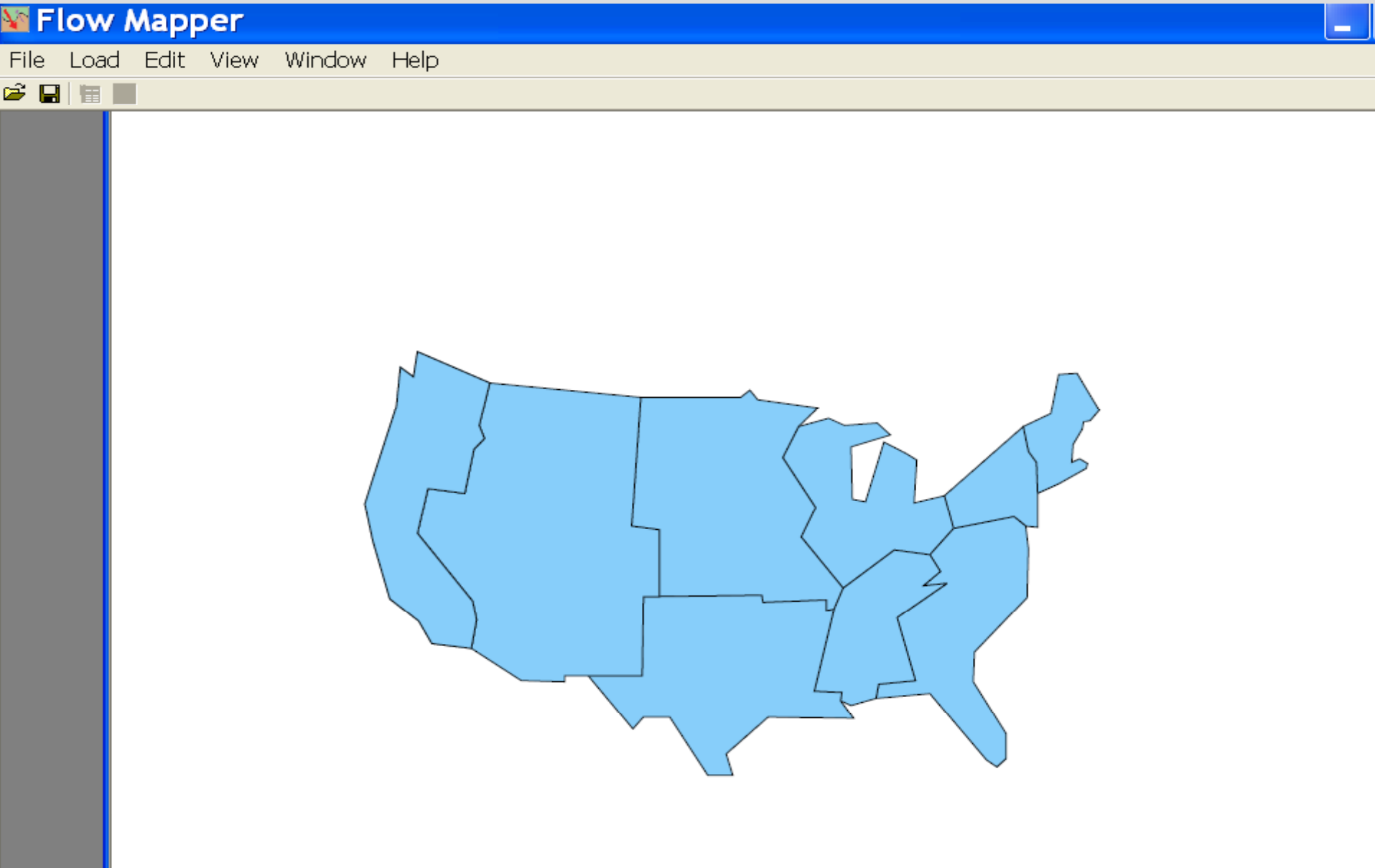
```
US Div bdys.dat - Notepad
File Edit Format View Help
19
65.9 38.5
66.3 36.4
66.9 35.5
67.0 32.9
68.6 33.7
70.7 35.0
70.8 35.4
70.2 35.8
69.6 35.5
69.7 37.0
70.4 38.3
70.5 38.9
71.0 39.0
71.7 39.9
71.2 40.8
70.0 43.0
68.6 42.9
68.0 39.6
65.9 38.5
10
59.9 32.7
60.6 29.9
65.2 30.9
66.1 30.1
67.0 30.0
67.0 32.9
66.9 35.5
```

Background map selected



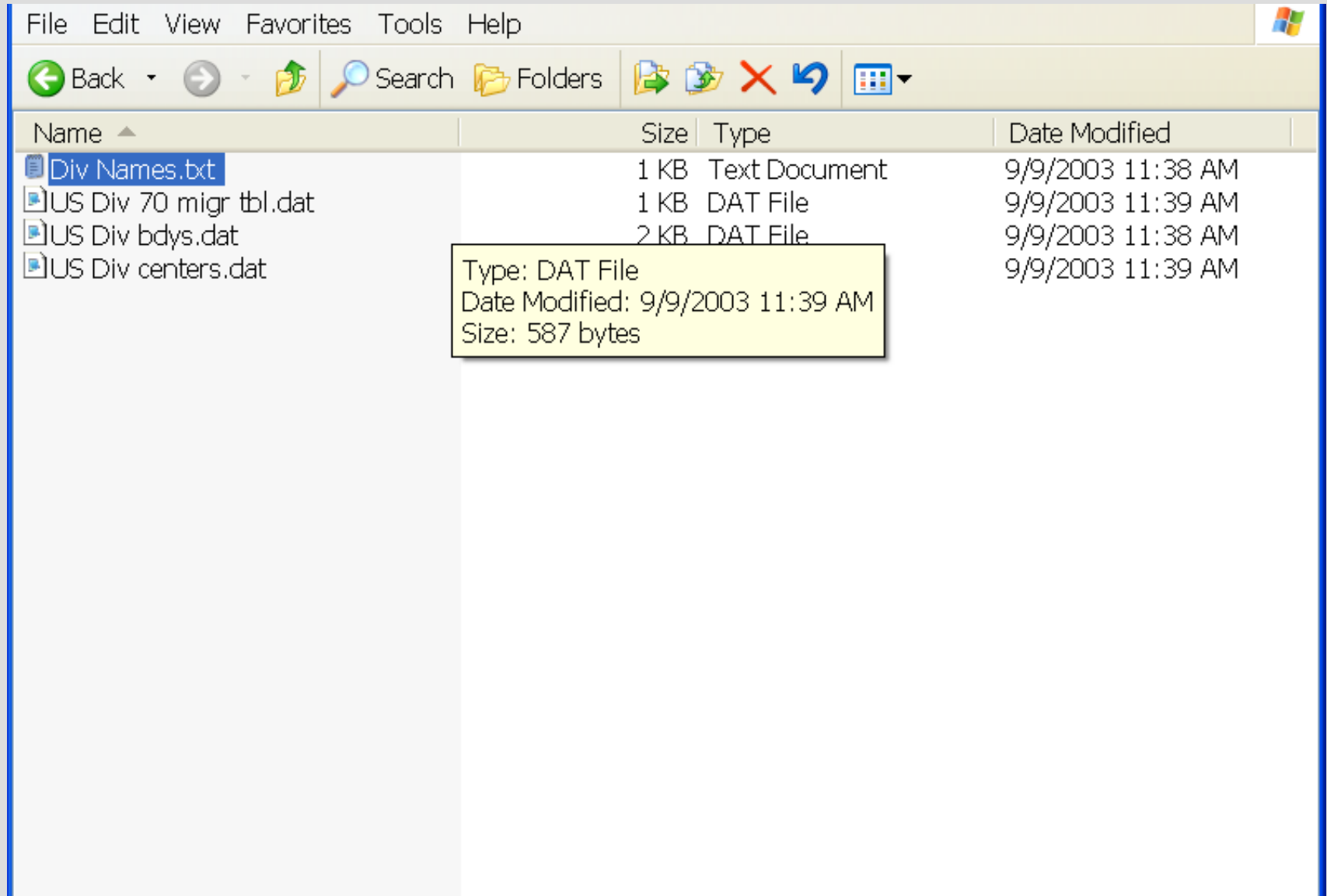
Then load location names

If you have them



Select location names file

Then load it.



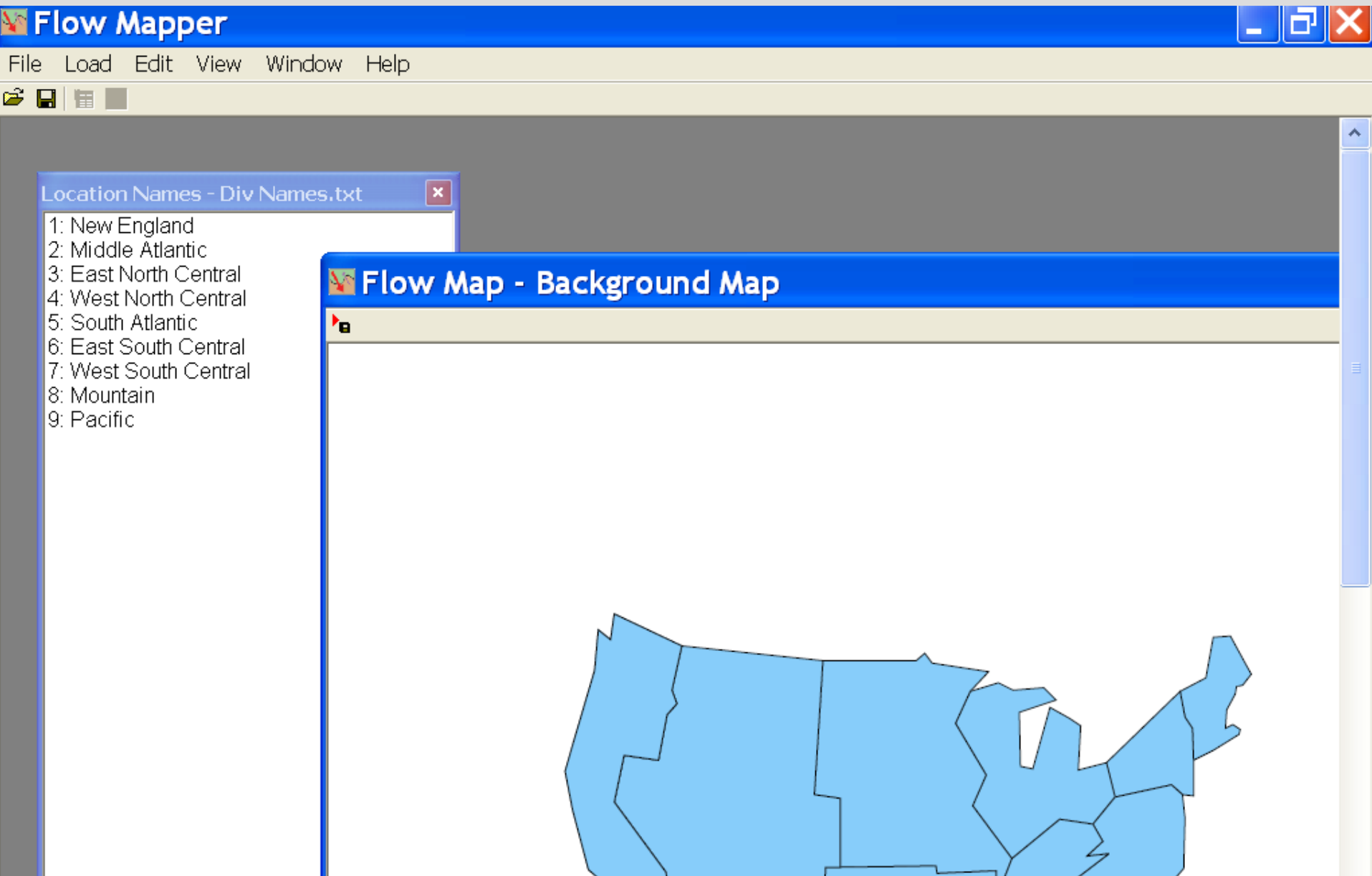
The screenshot shows a Windows Explorer window with the following menu items: File, Edit, View, Favorites, Tools, Help. The toolbar includes Back, Forward, Up, Search, Folders, Copy, Paste, Delete, Undo, and View. The file list is as follows:

Name ▲	Size	Type	Date Modified
Div Names.txt	1 KB	Text Document	9/9/2003 11:38 AM
US Div 70 migr tbl.dat	1 KB	DAT File	9/9/2003 11:39 AM
US Div bdys.dat	2 KB	DAT File	9/9/2003 11:38 AM
US Div centers.dat			9/9/2003 11:39 AM

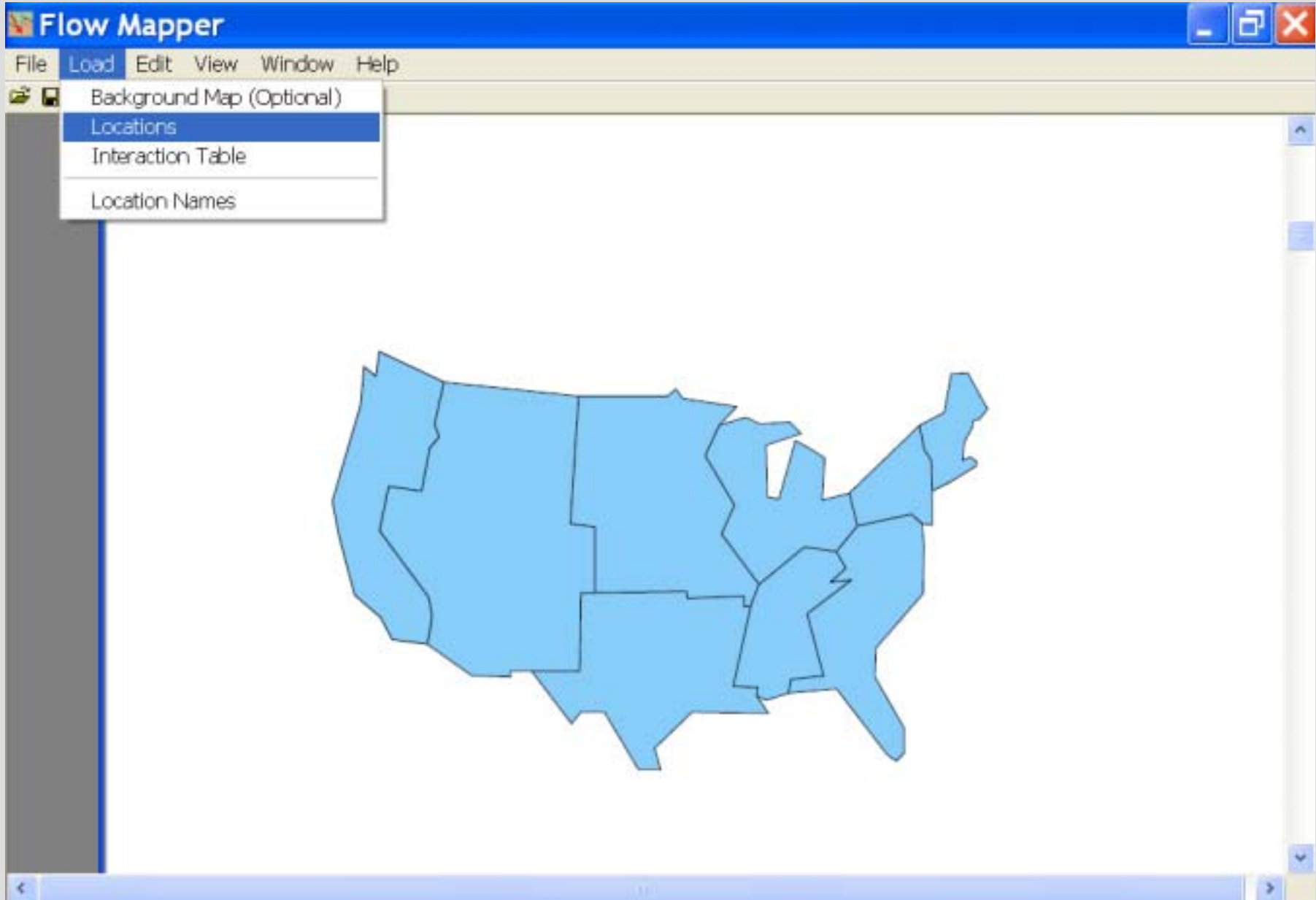
A tooltip is displayed over the 'US Div centers.dat' file, showing the following details:

- Type: DAT File
- Date Modified: 9/9/2003 11:39 AM
- Size: 587 bytes

Location names selected and loaded.

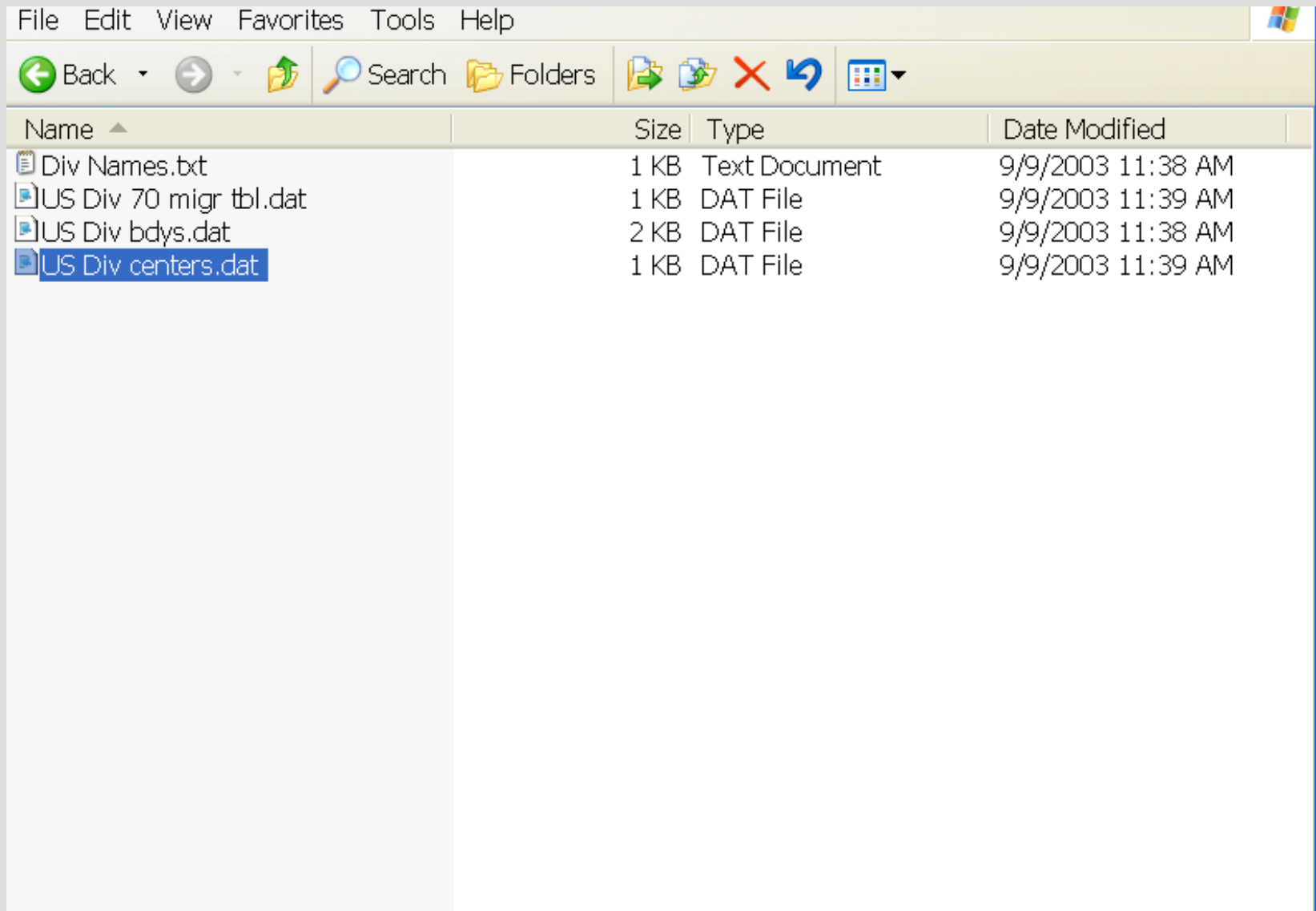


Next: Load locations

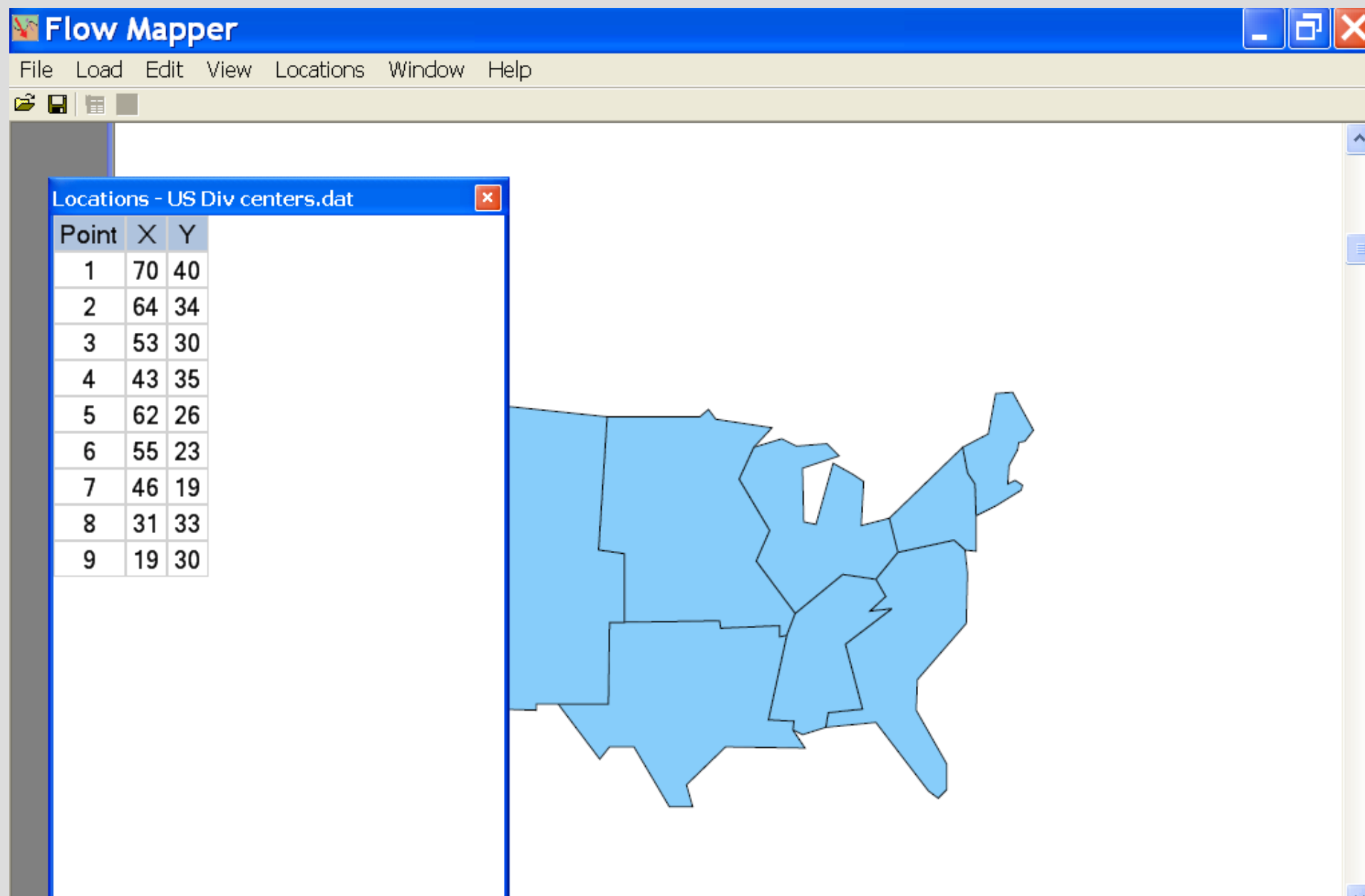


Select the centroid coordinate file

Then load it,



Locations (centroids) loaded



Load interaction table

The screenshot shows the Flow Mapper application interface. The main window displays a map of the United States with state boundaries. A menu is open under the 'Load' tab, with 'Interaction Table' selected. A secondary window titled 'Location Names - Div Names.txt' is open, displaying a list of nine location names. The status bar at the bottom indicates 'Background map data loaded successfully'.

Flow Mapper

File Load Edit View Location Names Window Help

Background Map (Optional)
Locations
Interaction Table
Location Names

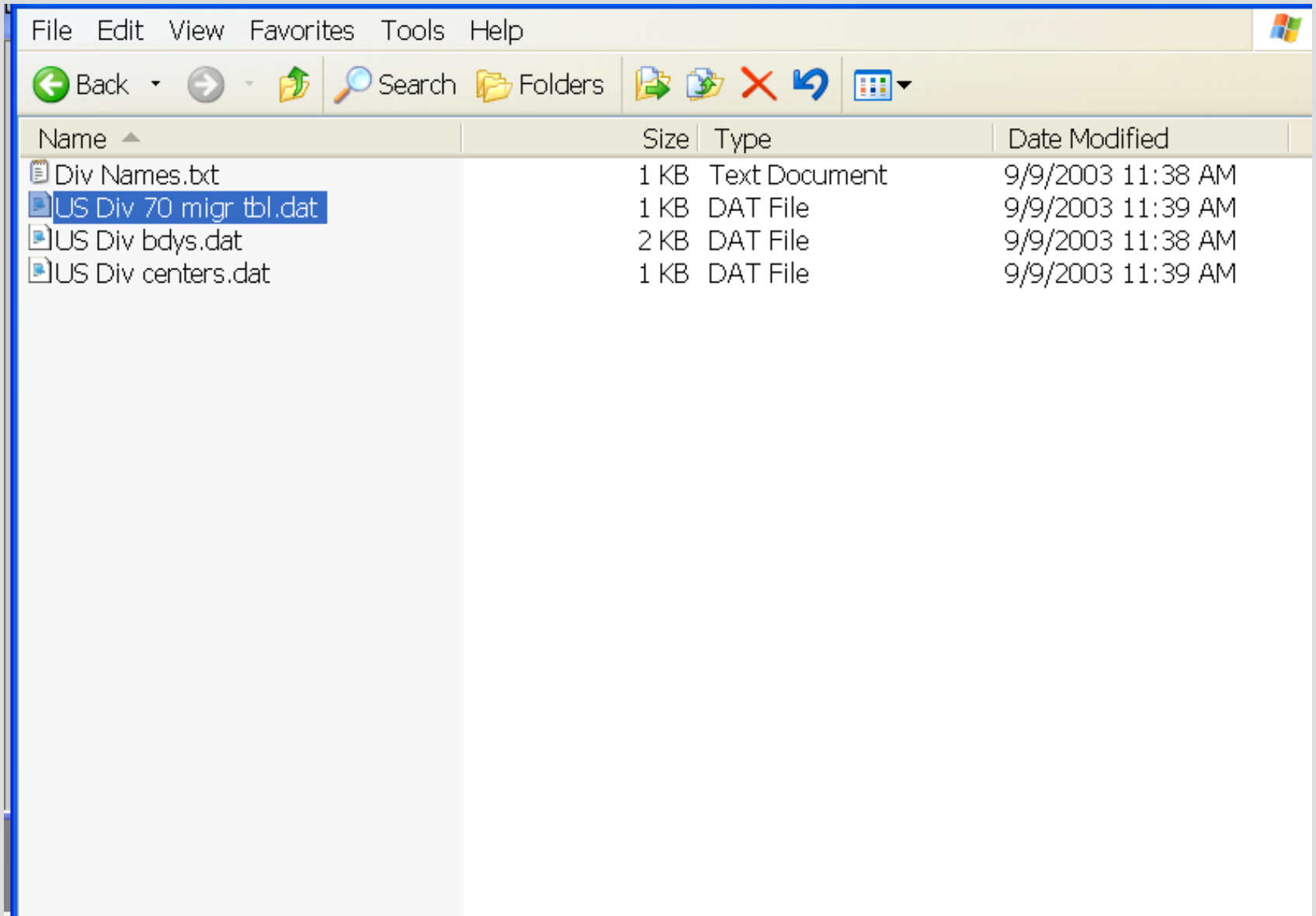
Location Names - Div Names.txt

- 1: New England
- 2: Middle Atlantic
- 3: East North Central
- 4: West North Central
- 5: South Atlantic
- 6: East South Central
- 7: West South Central
- 8: Mountain
- 9: Pacific

Background map data loaded successfully

Select interaction table

Then load it



Interaction table loaded

Flow Mapper [-] [□] [✕]

File Load Edit View Interaction Table Window Help

Interaction Table - US Div 70 migr tbl.dat [✕]

Location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481
4	028977	060681	286580	000000	143860	049892	185618	181868	274629
5	130830	382565	346407	092308	000000	252189	192223	089389	279739
6	021434	053772	287340	049828	316650	000000	141679	027409	087938
7	030287	064645	161645	144980	199466	121366	000000	134229	289880
8	021450	043749	097808	113683	089806	025574	158006	000000	437225
9	072114	133122	229764	165405	266305	066324	252039	342948	000000

Number of Flows: 72 Average: 171019 Maximum: 718673 Sum: 12313401 Percent above Average: 43.0

Background map data loaded successfully

Select EDIT from the menu

The screenshot shows the Flow Mapper application window. The menu bar includes File, Load, Edit, View, Interaction Table, Window, and Help. The 'Edit' menu is open, displaying 'Project Settings' and 'Clear Selections'. A data table titled 'Interaction Table - US Div 70 migr tbl.dat' is open, showing migration data between 9 locations. The table has columns for 'Location' and numbered locations 1 through 9. The data is as follows:

Location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481
4	028977	060681	286580	000000	143860	049892	185618	181868	274629
5	130830	382565	348407	092308	000000	252189	192223	089389	279739
6	021434	053772	287340	049828	316650	000000	141679	027409	087938
7	030287	064645	161645	144980	199466	121366	000000	134229	288880
8	021450	043749	097808	113683	089806	025574	158006	000000	437225
9	072114	133122	229764	165405	266305	066324	252039	342948	000000

Background map data loaded successfully

Project settings menu selected

The screenshot displays the Flow Mapper application interface. The main window has a menu bar with 'File', 'Load', 'Edit', 'View', 'Window', and 'Help'. A toolbar is located below the menu bar. The 'Project Settings' dialog box is open, showing the following options:

- Flow Properties** | **Data Points** | **Map Color** | **Background & Title**
- Flow Type/Width** | **Flow Color** | **Flow Threshold**
- Flow Type**
 - Calculate All Flows
 - Calculate Selected Location Flow

You must select a location via Flow Table or Flow Location Windows to use this option
- Flow Line Width**
 - Fixed
 - Proportional to Flow
- Flow Type**: Gross
- Line Width**: 10 pt
- Flow Line Max Width**: 20 pt
- Sort Flow**: Large Flows On Top

At the bottom of the dialog, a summary bar shows:

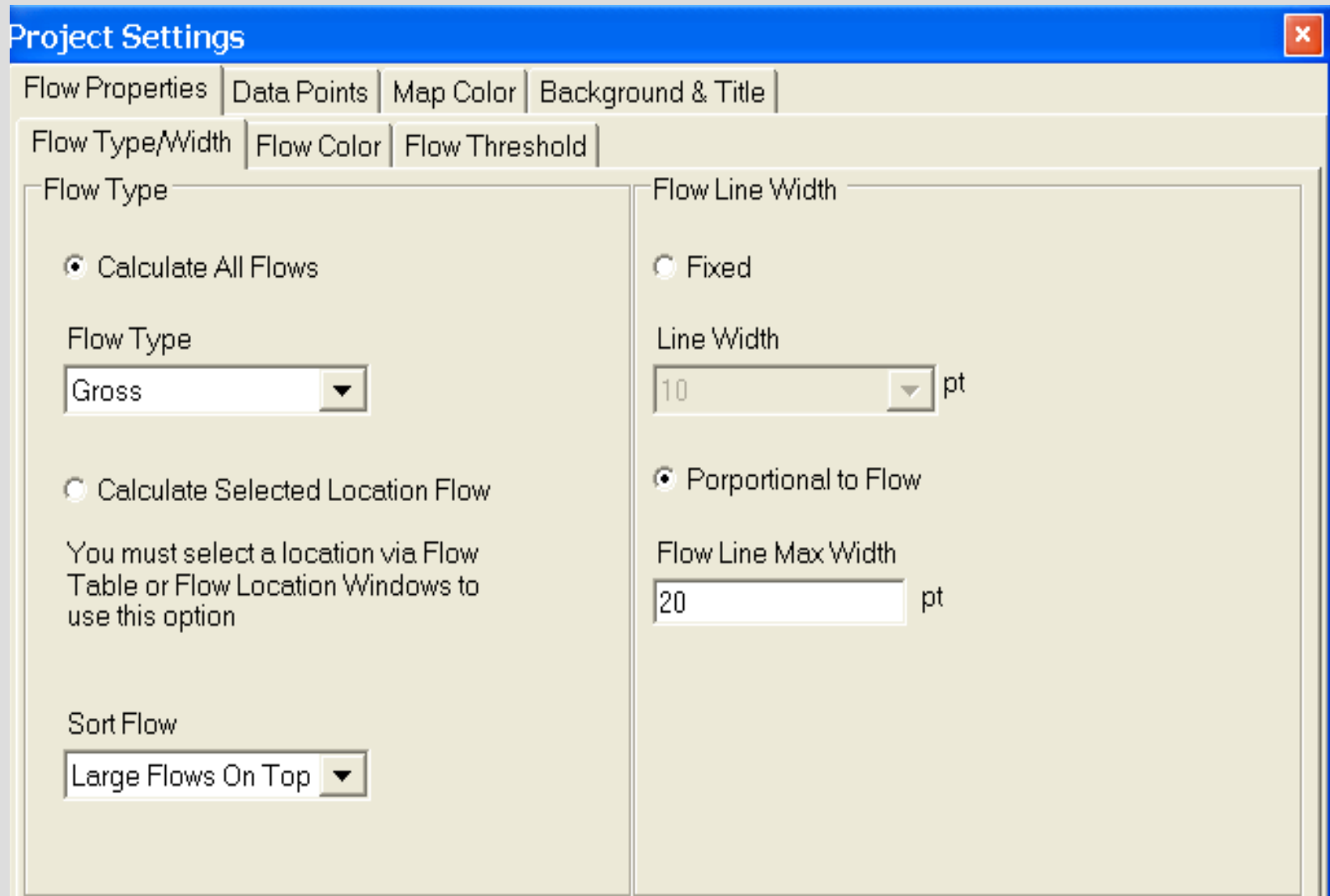
Number of Flows: 72	Average: 171019	Maximum: 718673	Sum: 12313401	Percent above Average: 43.0
---------------------	-----------------	-----------------	---------------	-----------------------------

The status bar at the bottom of the application window displays the message: "Background map data loaded successfully".

Flow types: Gross, net, two-way; single row or column or all

Sort: Large/small on top, large recommended

Line Width: fixed, proportional, maximum size



The image shows a screenshot of a software dialog box titled "Project Settings". The dialog has a blue title bar with a close button (red 'X') in the top right corner. Below the title bar, there are four tabs: "Flow Properties", "Data Points", "Map Color", and "Background & Title". The "Flow Properties" tab is selected. Inside this tab, there are three sub-sections: "Flow Type/Width", "Flow Color", and "Flow Threshold". The "Flow Type/Width" sub-section is active and contains two columns of settings. The left column is titled "Flow Type" and has two radio buttons: "Calculate All Flows" (selected) and "Calculate Selected Location Flow". Below the radio buttons is a "Flow Type" dropdown menu set to "Gross". At the bottom of this column is a "Sort Flow" dropdown menu set to "Large Flows On Top". The right column is titled "Flow Line Width" and has two radio buttons: "Fixed" and "Porportional to Flow" (selected). Below the radio buttons is a "Line Width" dropdown menu set to "10" with "pt" to its right. At the bottom of this column is a "Flow Line Max Width" text input field set to "20" with "pt" to its right.

Project Settings

Flow Properties | Data Points | Map Color | Background & Title

Flow Type/Width | Flow Color | Flow Threshold

Flow Type

Calculate All Flows

Flow Type

Gross

Calculate Selected Location Flow

You must select a location via Flow Table or Flow Location Windows to use this option

Sort Flow

Large Flows On Top

Flow Line Width

Fixed

Line Width

10 pt

Porportional to Flow

Flow Line Max Width

20 pt

Flow band properties

Solid color, gradient, arrowhead style, edge color options


Project Settings [Close]

Flow Properties | Data Points | Map Color | Background & Title

Flow Type/Width | Flow Color | Flow Threshold

Flow Band Color



Flow Band Solid Color



Flow Band - Proportional Gradient

Reversed (Dark to Light)


Red

 TO 

Larger flows rendered darker, smaller flows rendered lighter color

Flow Band Edge

Flow Band Edge Color



Flow Band Edge Width

1 pt

No Flow Band Edge Color

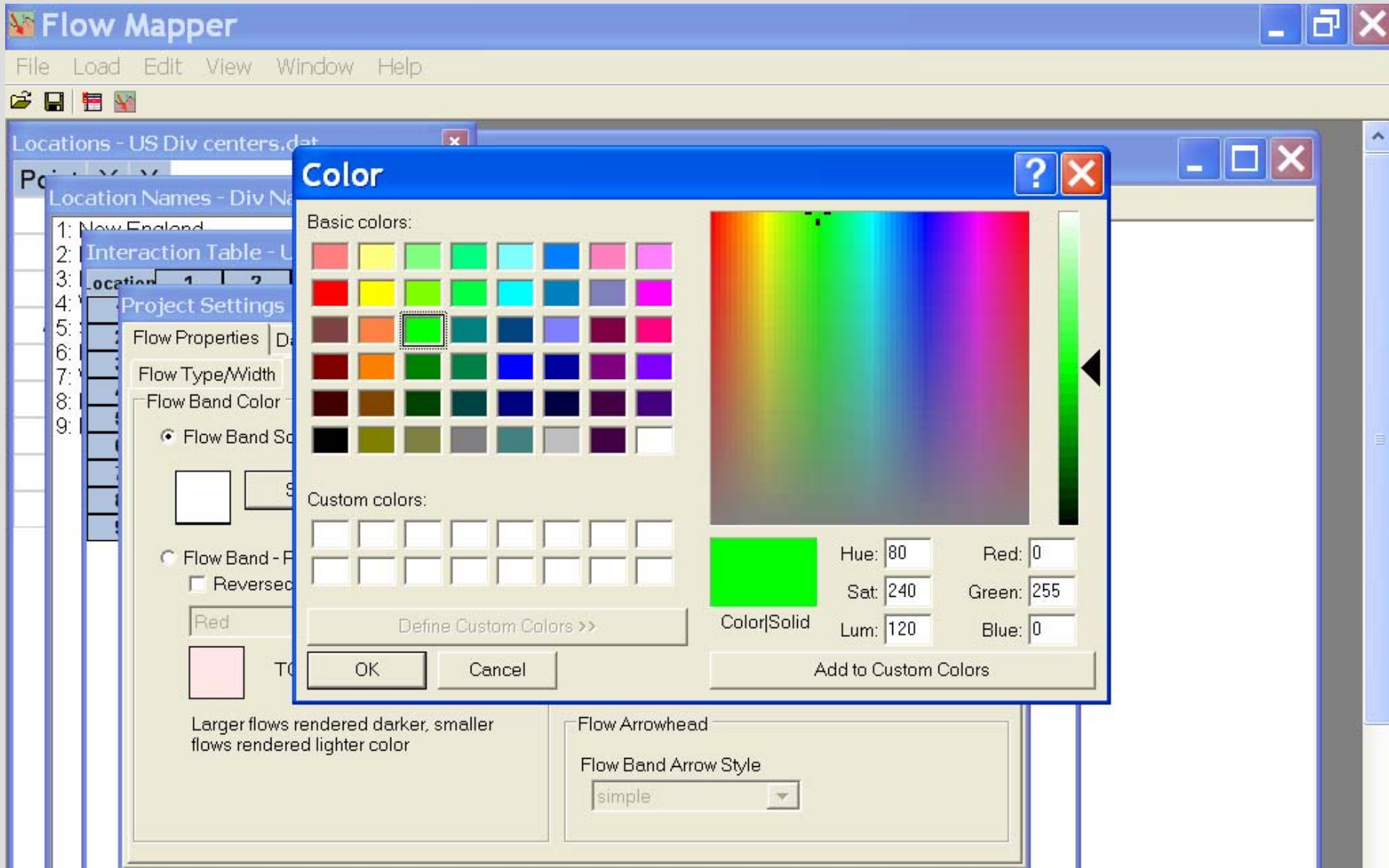
Flow Arrowhead

Flow Band Arrow Style

simple

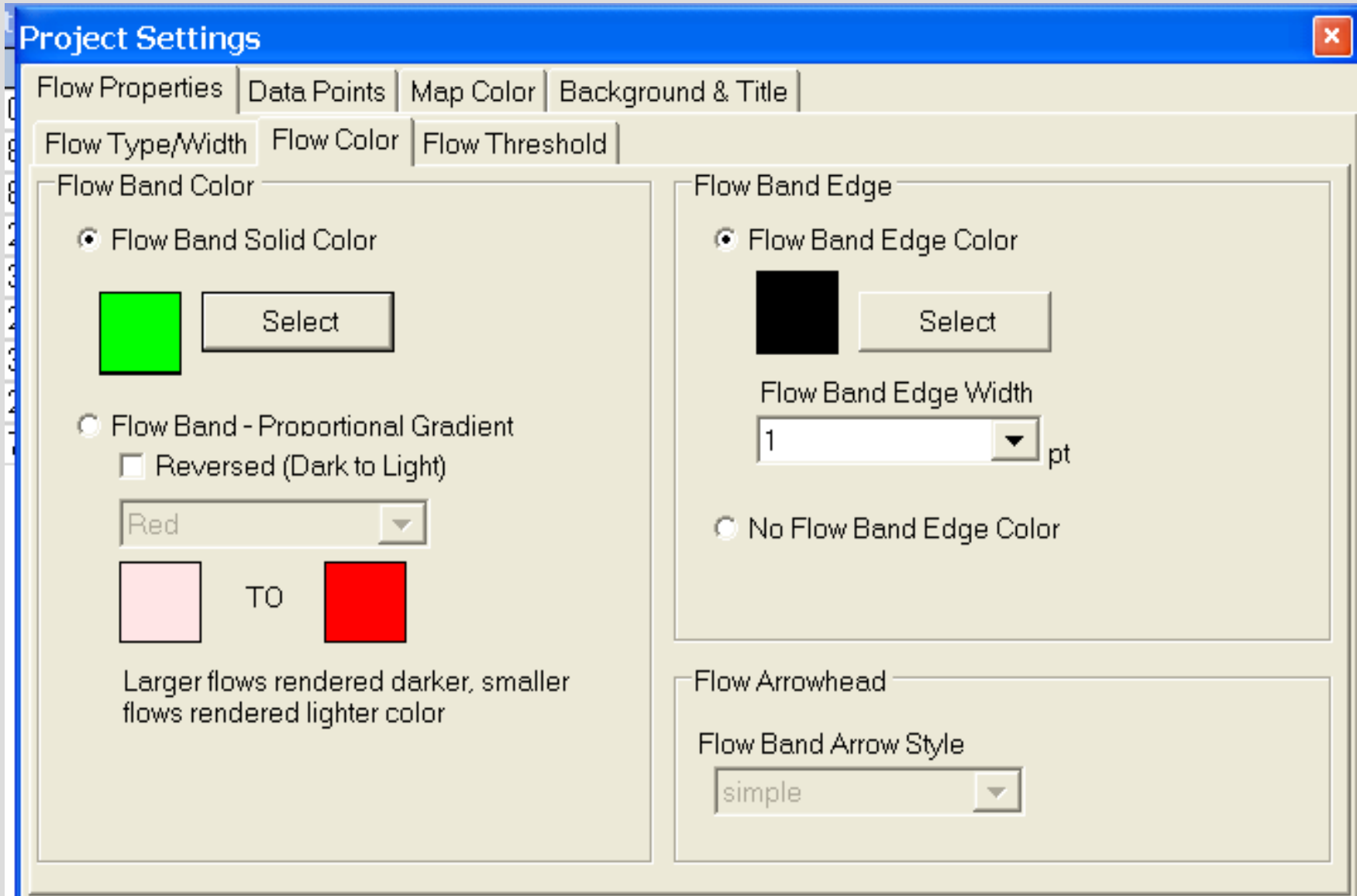
Color selection menu

Note RGB values. Click OK after choosing.



Color appears in the flow band box

Gradient available in three colors. Edge color helpful when overlaps occur.



Threshold

None (all flows), average, percent, specific, maximum expected.

Note that the average calculated from the interaction table is of all array entries and that the gross flows may exceed this and net flows can be much smaller.

Project Settings ✕

Flow Properties | Data Points | Map Color | Background & Title

Flow Type/Width | Flow Color | Flow Threshold

Display Threshold

Show flows above percentage only

Percentage

Show flows above average only

Note: Average calculated from Interaction Table Flow Values

Show flows above flow value only

Flow Value

Show all flows

Expected Maximum Flow

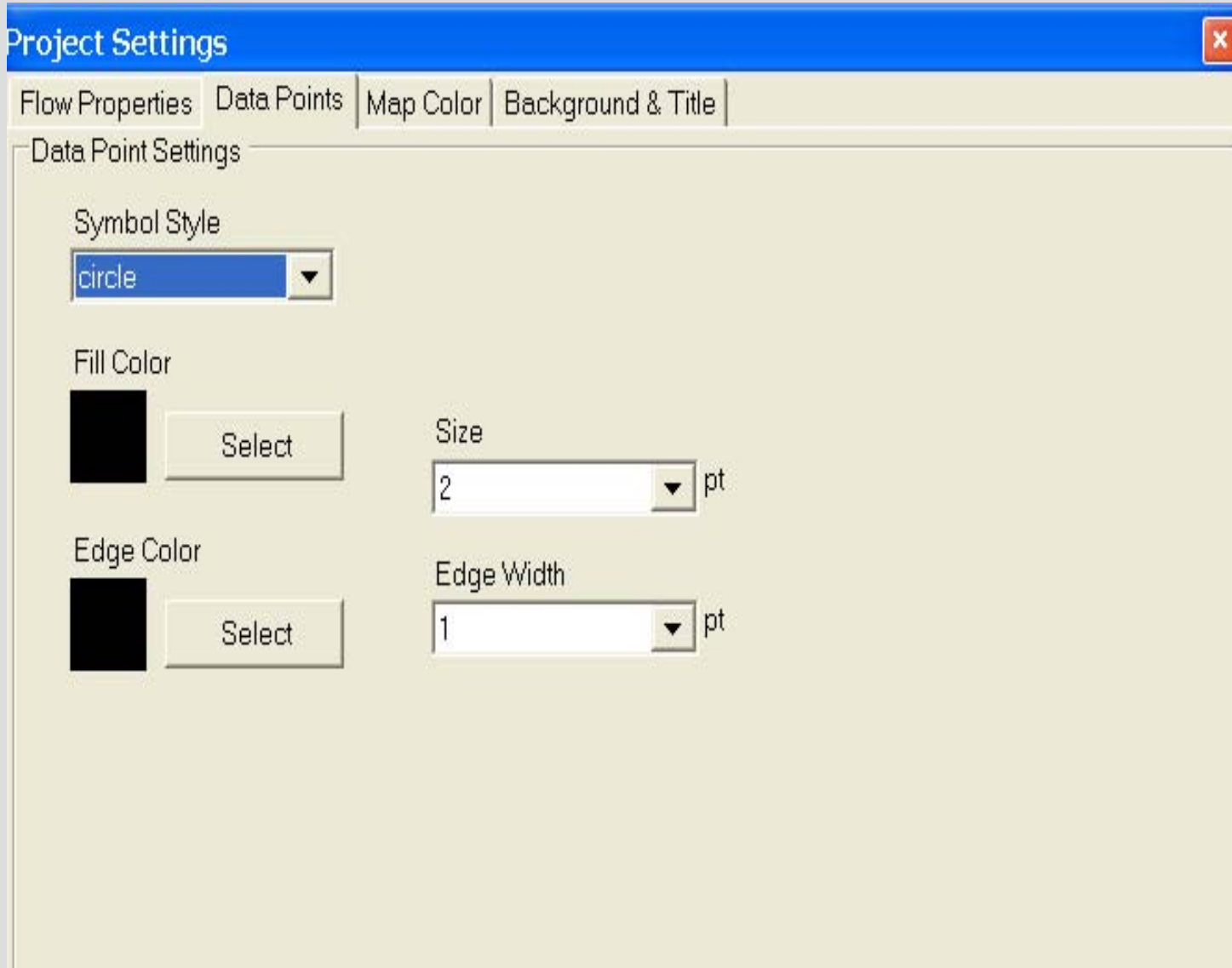
Use Expected Maximum Flow

Expected Maximum Flow

Centroid point display

None, circle, square, triangle; color, size, edge

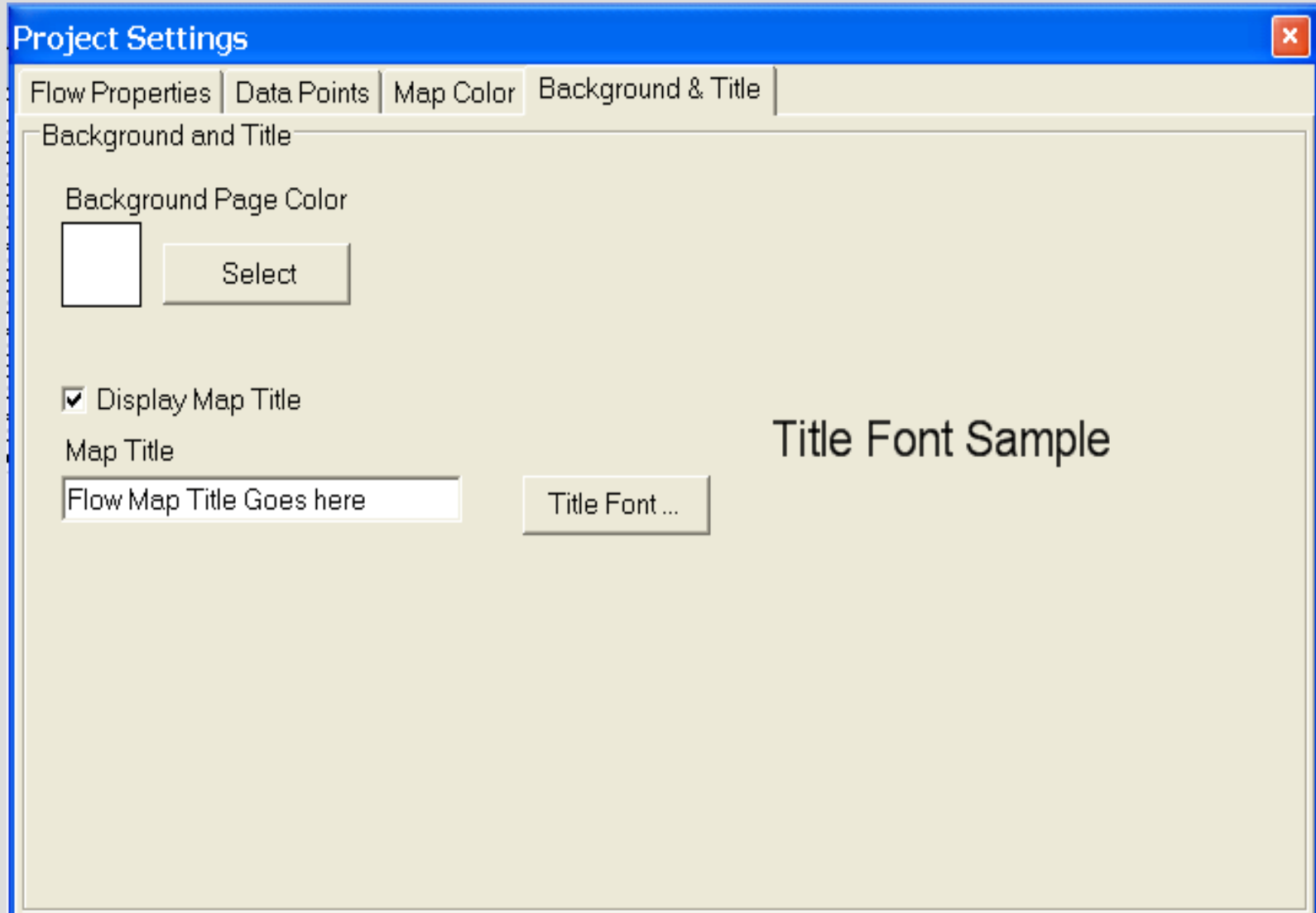
A centroid must be displayed for it to be identified when the mouse hovers on it



Background color and title

One or two line title moves with FGVT keys when mouse is the on map.

Back-slash separates title lines



To make a map click on the rightmost icon on the second line in the upper left.

The screenshot displays the Flow Mapper application window. The title bar reads "Flow Mapper" and the menu bar includes "File", "Load", "Edit", "View", "Window", and "Help". A toolbar with icons for file operations is visible below the menu bar. A "Create Flow Map" button is located in the upper left area of the main workspace.

An "Interaction Table - US Div 70 migr tbl.dat" window is open, showing a table with the following data:

location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481

A "Project Settings" dialog box is open, showing the "Flow Properties" tab. The "Flow Type/Width" sub-tab is active. The "Flow Type" is set to "Net". The "Flow Line Width" is set to "Proportional to Flow" with a "Line Width" of 10 pt and a "Flow Line Max Width" of 20 pt. The "Sort Flow" is set to "Large Flows On Top".

At the bottom right of the dialog, a status bar indicates "Percent above Average: 43.1".

Here is a map on the screen

Ctrl & Alt keys and right mouse can modify it to make it fit. Use right scroll bar too.

The screenshot shows the Flow Mapper application interface. The main window displays a map of the United States with a network of green lines representing flow paths. The map is titled "Flow Map 2 - Gross Flow Where Flow > 17101...". The sidebar contains a table of locations and a list of location names.

Point	X
1	70
2	64
3	53

Location Names - Div Name

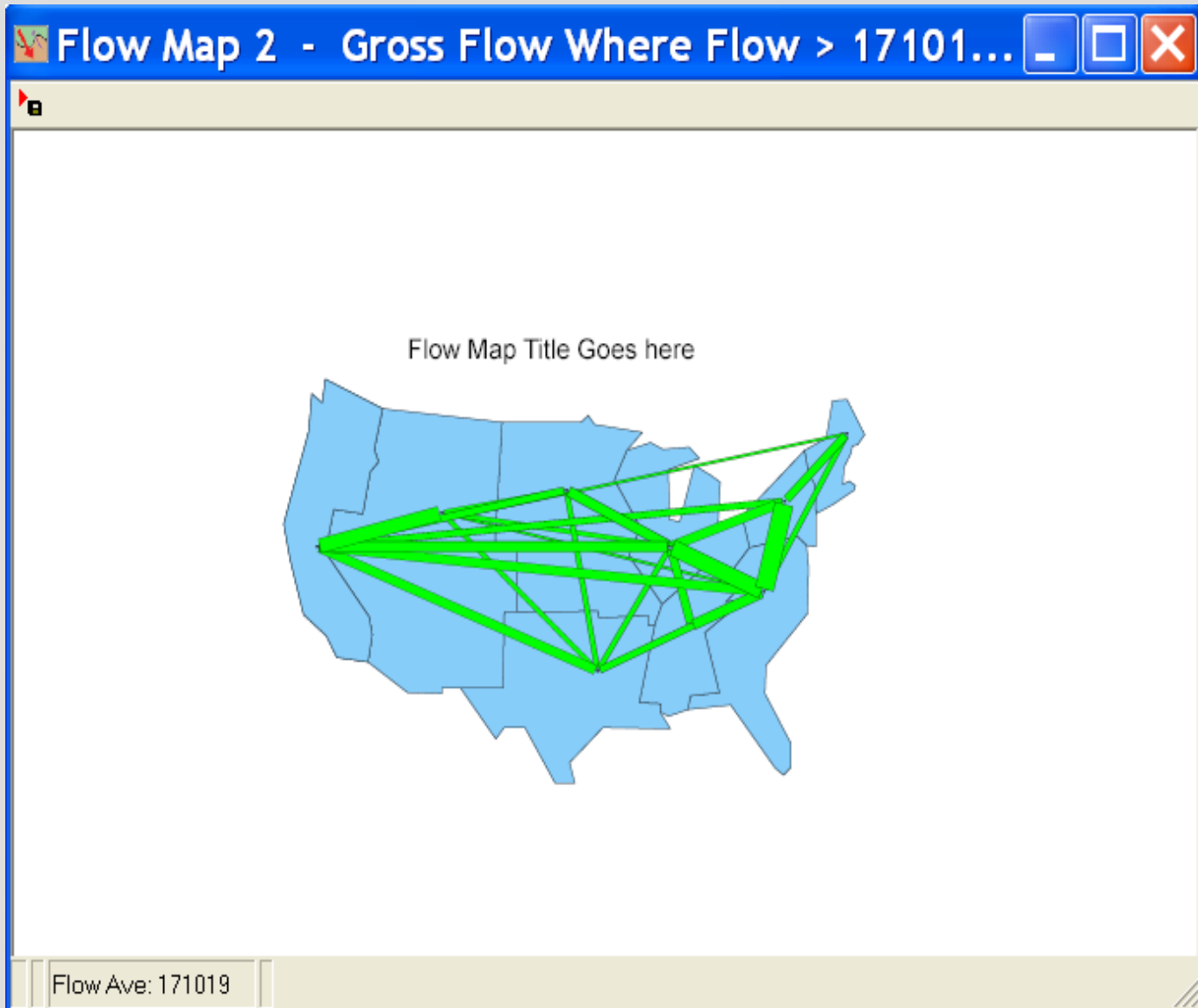
- 1: New England
- 2: Middle Atlantic
- 3: East North Central
- 4: West North Central
- 5: South Atlantic
- 6: East South Central
- 7: West South Central
- 8: Mountain
- 9: Pacific

Flow Ave: 171019

087838
nonoon

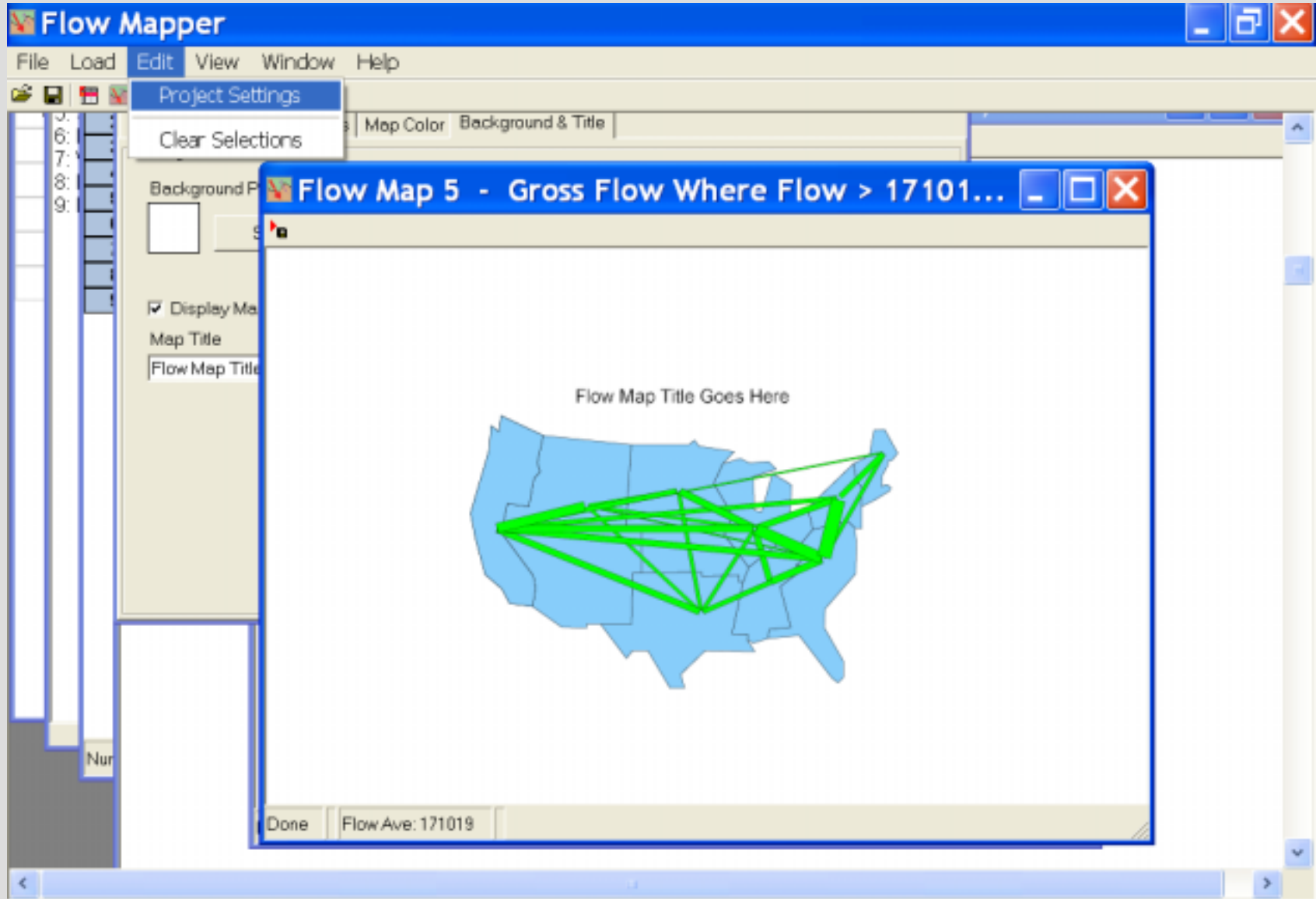
To save the map

Use the little flagged box at the upper left corner; name it with with an extension.
All of the map must be on view on the screen! Later cropping may be desirable.



For a new map click the Edit option again.

This brings up the Project Setting menu. Change the settings as desired for a new map.



To move back to first menu click on flow properties

Upper left just below 'Project Settings'

The screenshot shows the Flow Mapper application window. The main window title is "Flow Mapper" and it has a menu bar with "File", "Load", "Edit", "View", "Window", and "Help". Below the menu bar are several icons. A dialog box titled "Project Settings" is open, showing the "Data Points" tab. The "Data Point Settings" section includes:

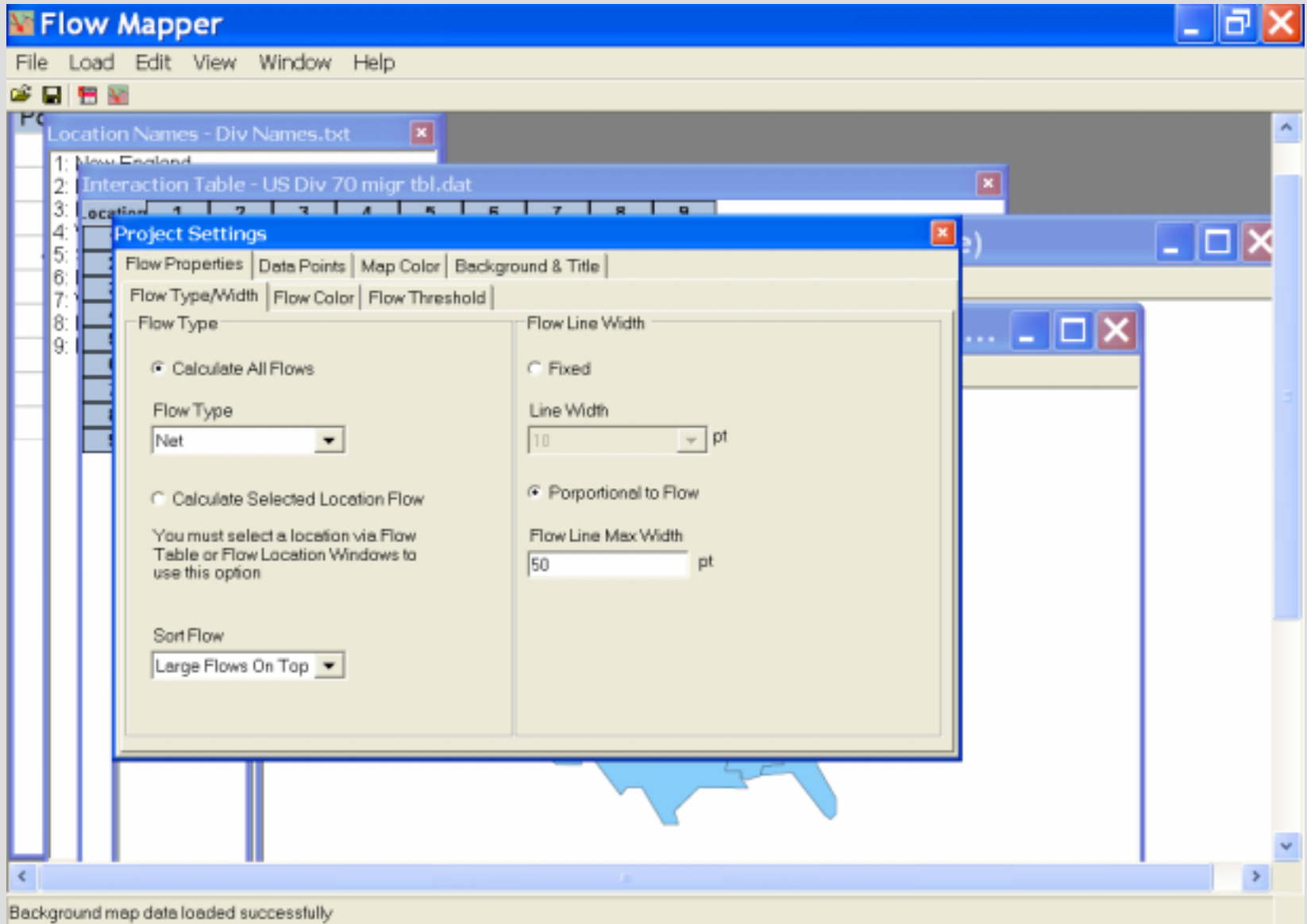
- Symbol Style: none
- Fill Color: [Black color swatch] [Select button]
- Size: 2 pt
- Edge Color: [Black color swatch] [Select button]
- Edge Width: 1 pt

In the background, an "Interaction Table - US Div 70 mgr tbl.dat" is visible, containing the following data:

Location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	087280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481

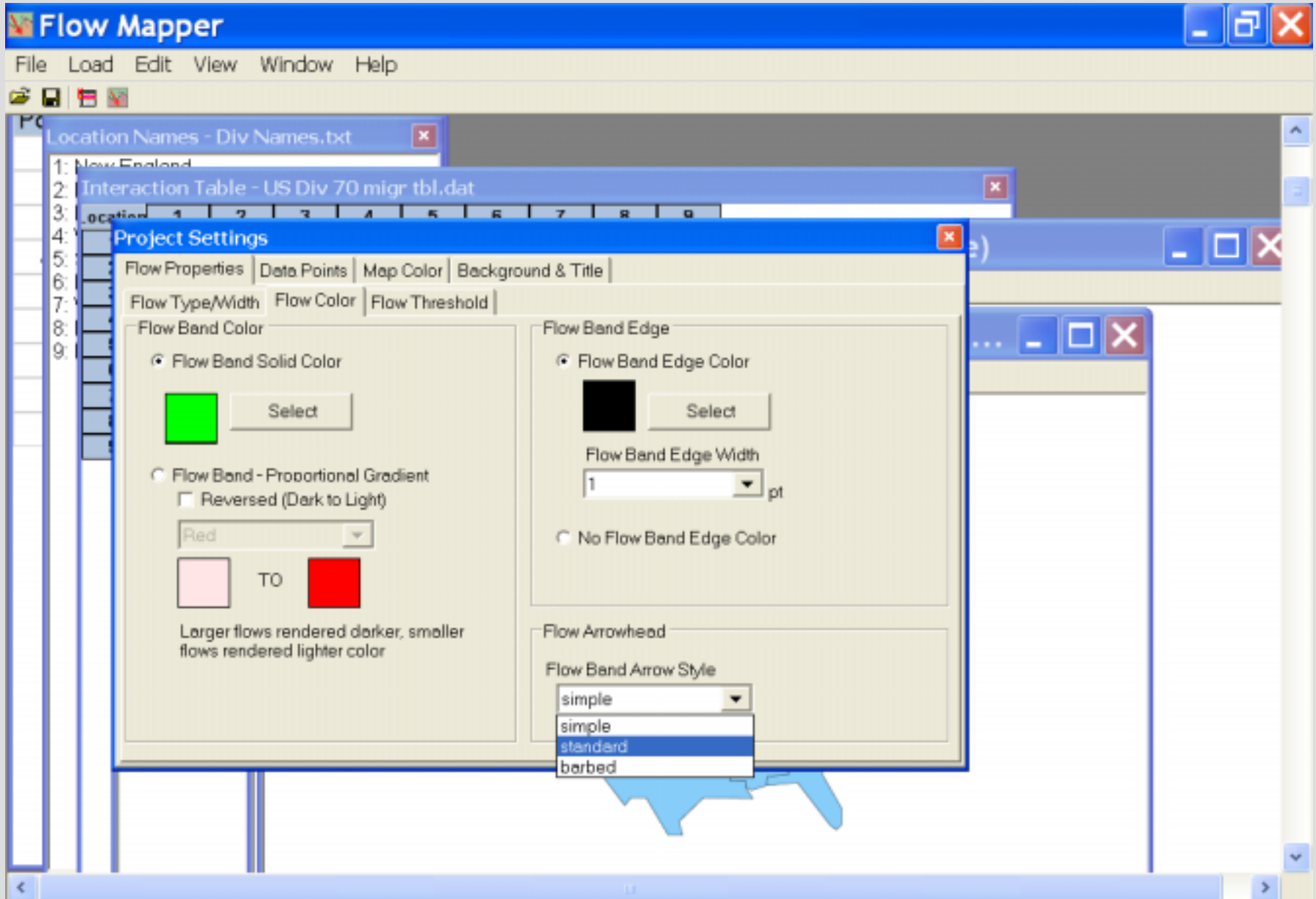
At the bottom right of the main window, a status bar displays "Percent above Average: 43.0".

Settings changed for a net flow map with changed symbol width

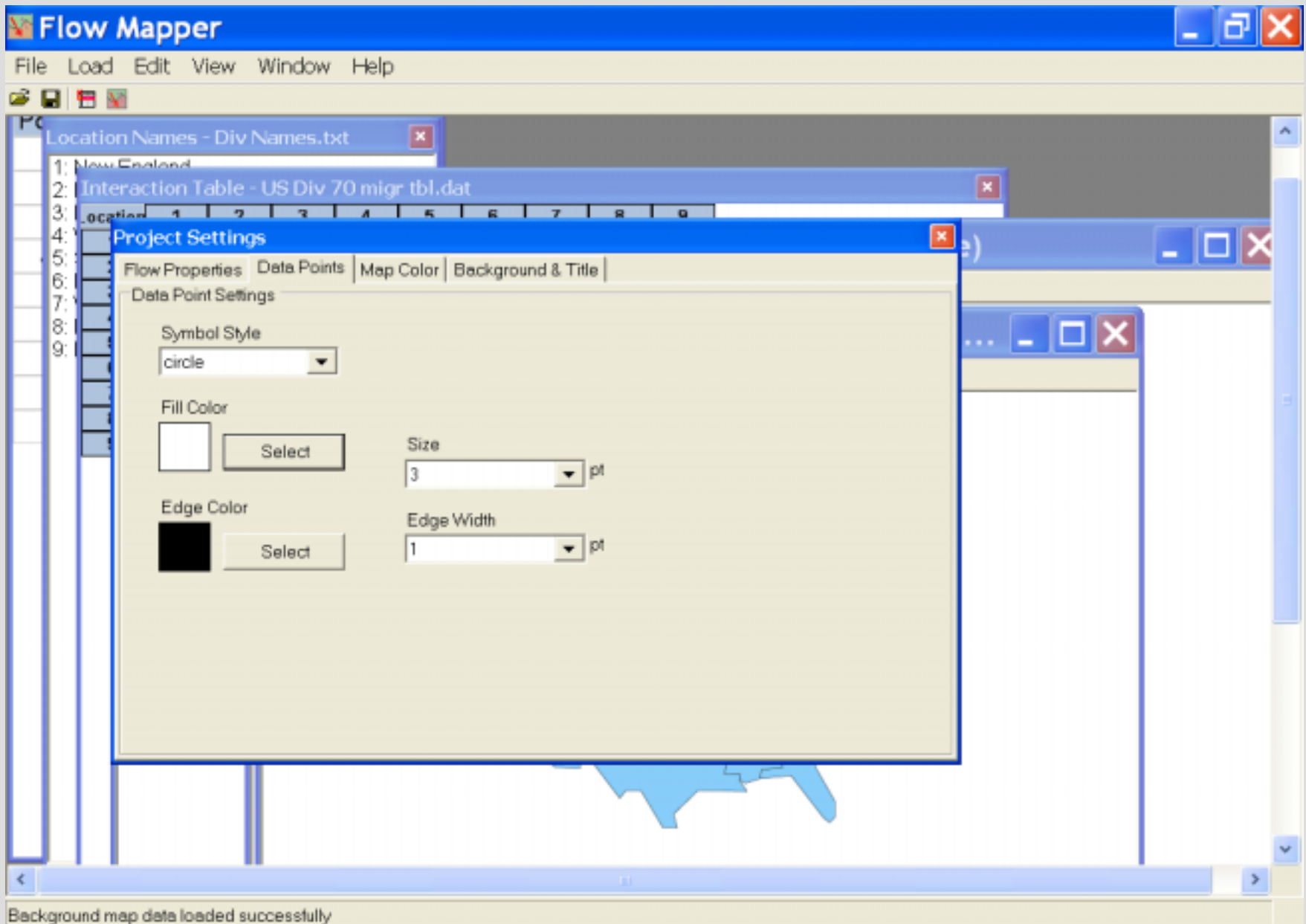


Arrow style changed

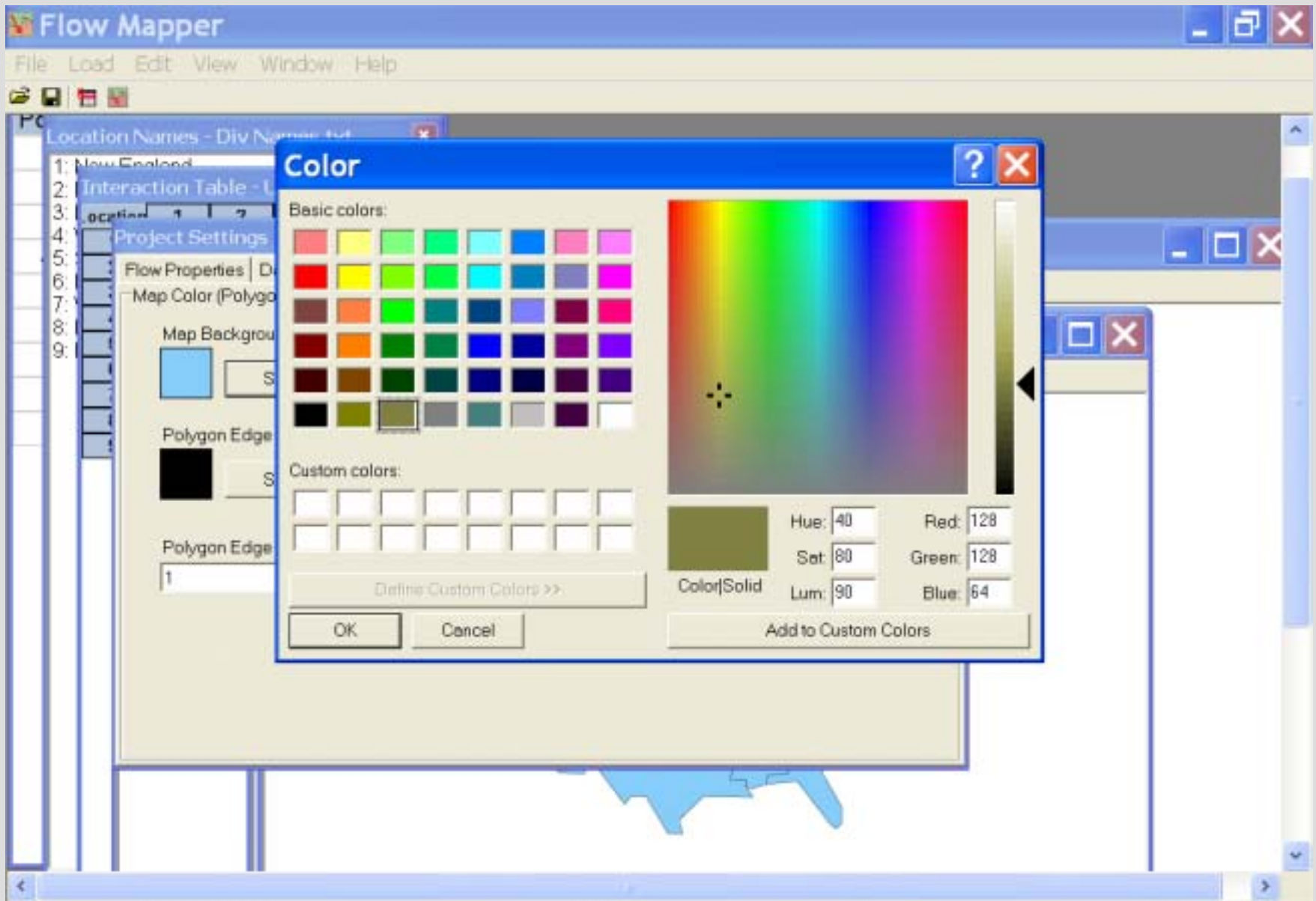
simple, standard, barbed



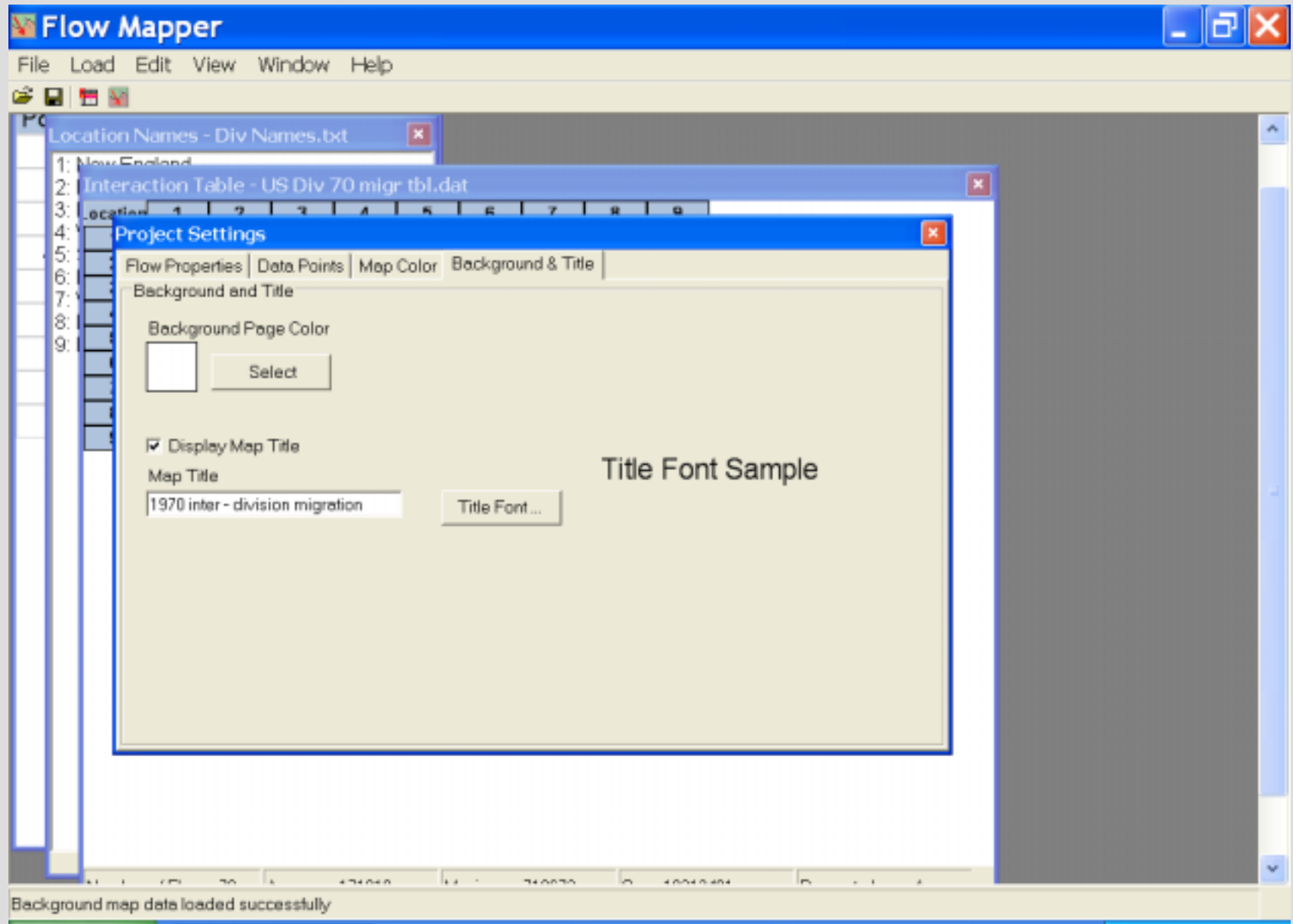
Displaying locations with a white circle.



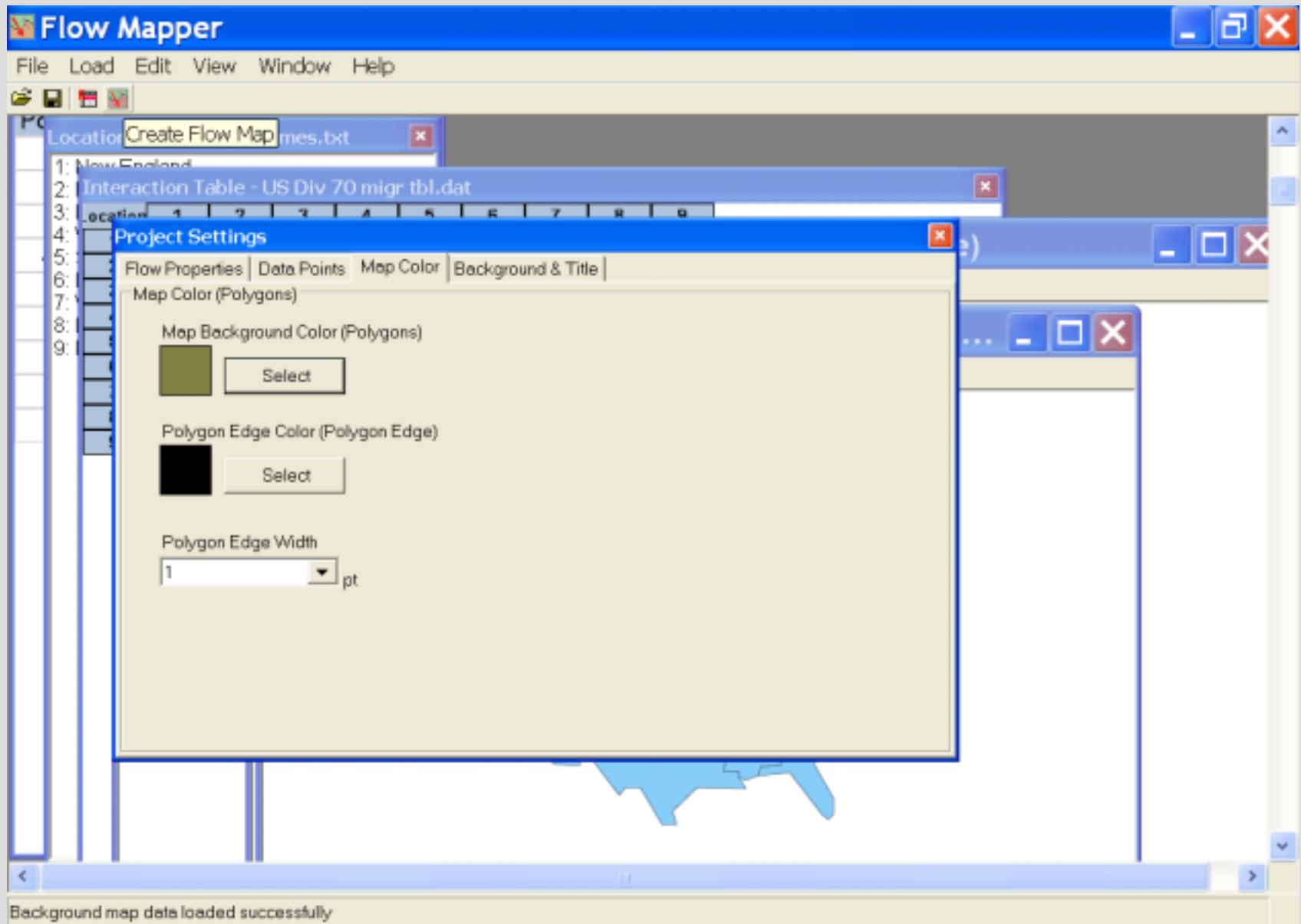
Changing map color



Changing title



Creating new map.



New map displayed

Save it if it looks good

The screenshot shows the Flow Mapper software interface. The main window, titled "Flow Map 9 - Net Flow Where All Displayed", displays a map of the United States with green lines representing migration flows between states. The map is titled "1970 inter - division migration". A "Project Settings" dialog box is open, showing options for "Flow Properties", "Background and Title", and "Display Map Title". The "Map Title" field contains the text "1970 inter - division migration". The status bar at the bottom indicates "Flow Ave: 171019".

Flow Mapper

File Load Edit View Window Help

Location Names - Div Names.txt

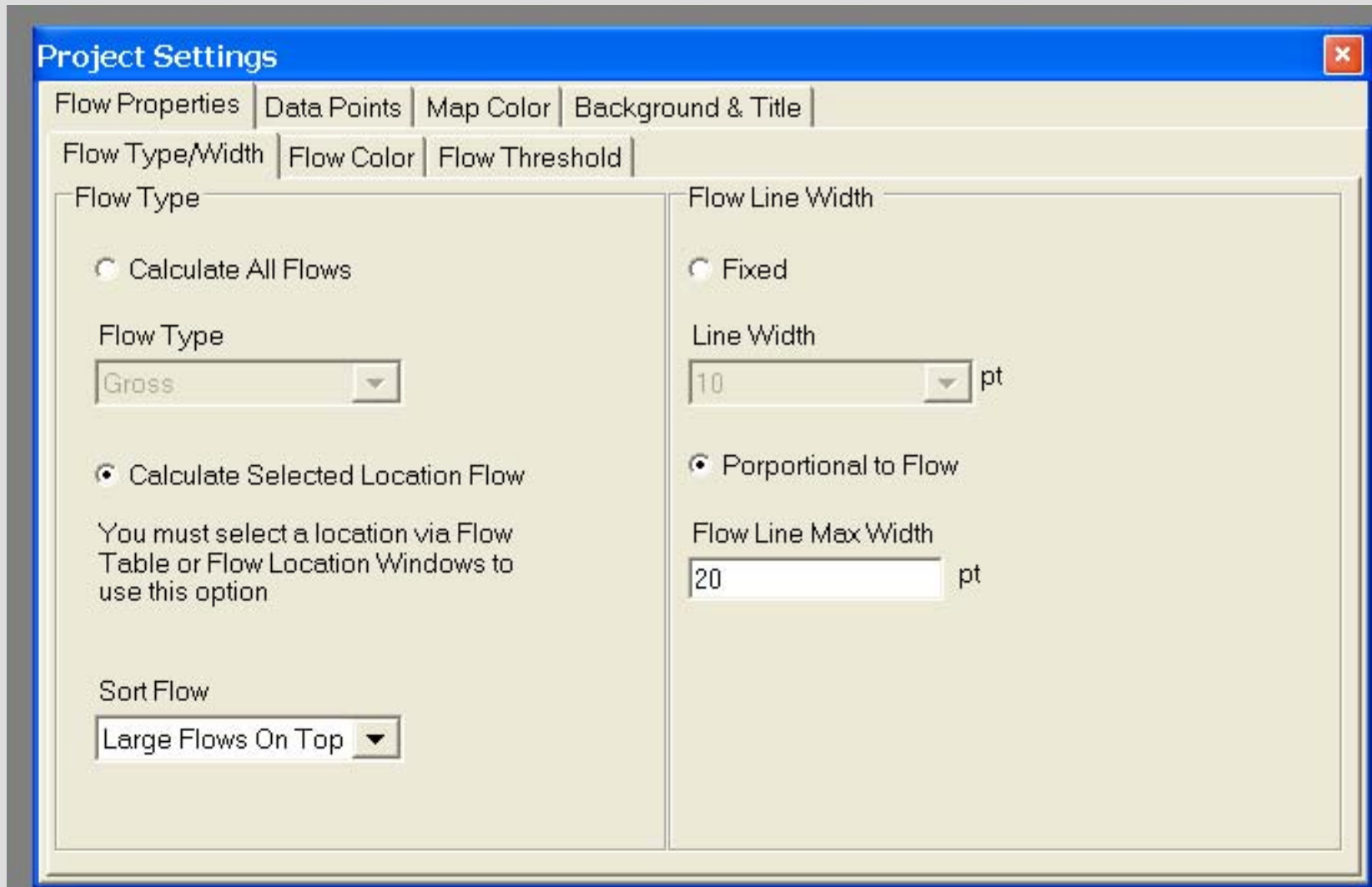
1: New England
2: Interaction Table - U
3: Location 1 2
4: Project Settings

Flow Properties | De
Background and Tit
Background Page
Select
 Display Map T
Map Title
1970 inter - divisid

Flow Ave: 171019

Background map data loaded successfully

To get moves from (or to) only one place use the
‘Calculate Selected Location Flow’ on the
‘Flow Type’ menu



Next highlight a row (for ‘from’ a place) or a column (for ‘to’ a place) on the interaction table.

Or click on the place in the location table. One click gets you the ‘to’ place, two gets the ‘from’ place. If you cannot see the interaction table use the ‘view’ tab in the top line. The map that you get will be of the net flow, so chose an arrowhead style.

The screenshot displays two windows from a software application. The left window, titled 'Locations - US Div centers.dat', contains a list of nine regions: 1: New England, 2: Middle Atlantic, 3: East North Central, 4: West North Central, 5: South Atlantic, 6: East South Central, 7: West South Central, 8: Mountain, and 9: Pacific. The '9: Pacific' entry is highlighted in blue. The right window, titled 'Interaction Table - US Div 70 migr tbl.dat', shows a table with columns for 'location' and regions 1 through 9. The row for '9' is highlighted in yellow. The data in the table is as follows:

location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481
4	028977	060681	286580	000000	143860	049892	185618	181868	274629
5	130830	382565	346407	092308	000000	252189	192223	089389	279739
6	021434	053772	287340	049828	316650	000000	141679	027409	087938
7	030287	064645	161645	144980	199466	121366	000000	134229	289880
8	021450	043749	097808	113683	089806	025574	158006	000000	437225
9	072114	133122	229764	165405	266305	066324	252039	342948	000000

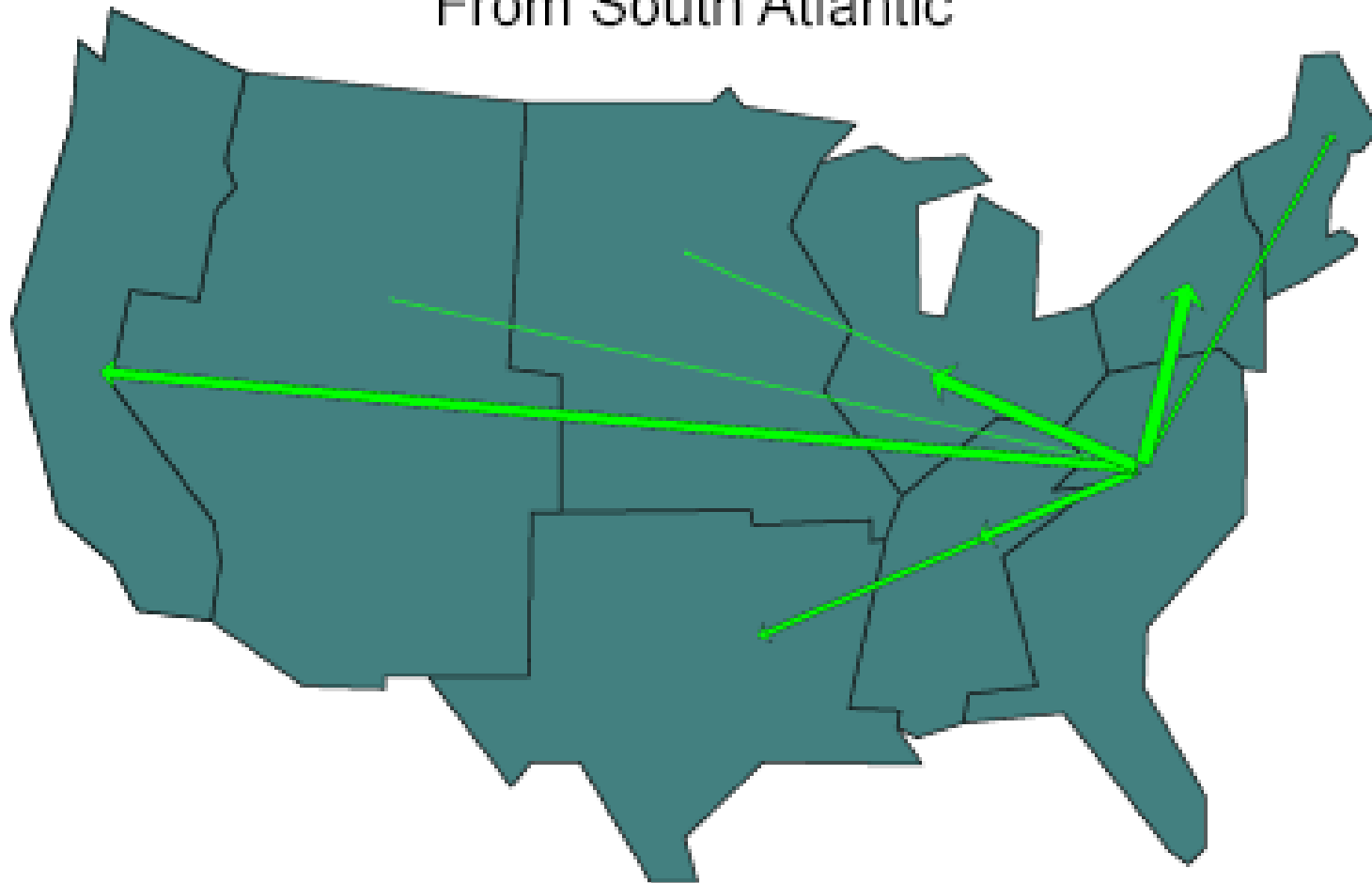
Or view the interaction table and click on a row

The screenshot displays the Flow Mapper application interface. At the top is a blue title bar with the text "Flow Mapper". Below it is a menu bar with "File", "Load", "Edit", "View", "Window", and "Help". A toolbar with several icons is visible below the menu bar. The main window contains two panes. The top pane, titled "Interaction Table - US Div 70 migr tbl.dat", displays a table with 10 columns labeled "location", "1", "2", "3", "4", "5", "6", "7", "8", and "9". The row for "location 5" is highlighted in yellow. The bottom pane, titled "Project Settings", has tabs for "Flow Properties", "Data Points", "Map Color", and "Background & Title". Under "Flow Properties", there are sub-tabs for "Flow Type/Width", "Flow Color", and "Flow Threshold". The "Flow Type" section has two radio buttons: "Calculate All Flows" (unselected) and "Calculate Selected Location Flow" (selected). Below the selected radio button is a text box containing "Net" and a dropdown arrow. A note below reads: "You must select a location via Flow Table or Flow Location Windows to use this option". The "Flow Line Width" section has two radio buttons: "Fixed" (unselected) and "Proportional to Flow" (selected). Below the selected radio button is a text box containing "20" and a dropdown arrow, followed by "pt". At the bottom left of the settings pane is a "Sort Flow" section with a dropdown menu showing "Large Flows On Top".

location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481
4	028977	060681	286580	000000	143860	049892	185618	181868	274629
5	130830	382585	346407	092308	000000	252189	192223	089389	279739
6	021434	053772	287340	049828	318650	000000	141679	027409	087938
7	030287	064645	161645	144980	199466	121366	000000	134229	289880
8	021450	043749	097808	113683	089806	025574	158006	000000	437225
9	072114	133122	229764	165405	266305	066324	252039	342948	000000

The moves from the South Atlantic Division

Migration 1995-2000
From South Atlantic



Or moves to the South Atlantic Division

Notice choice of arrowhead type

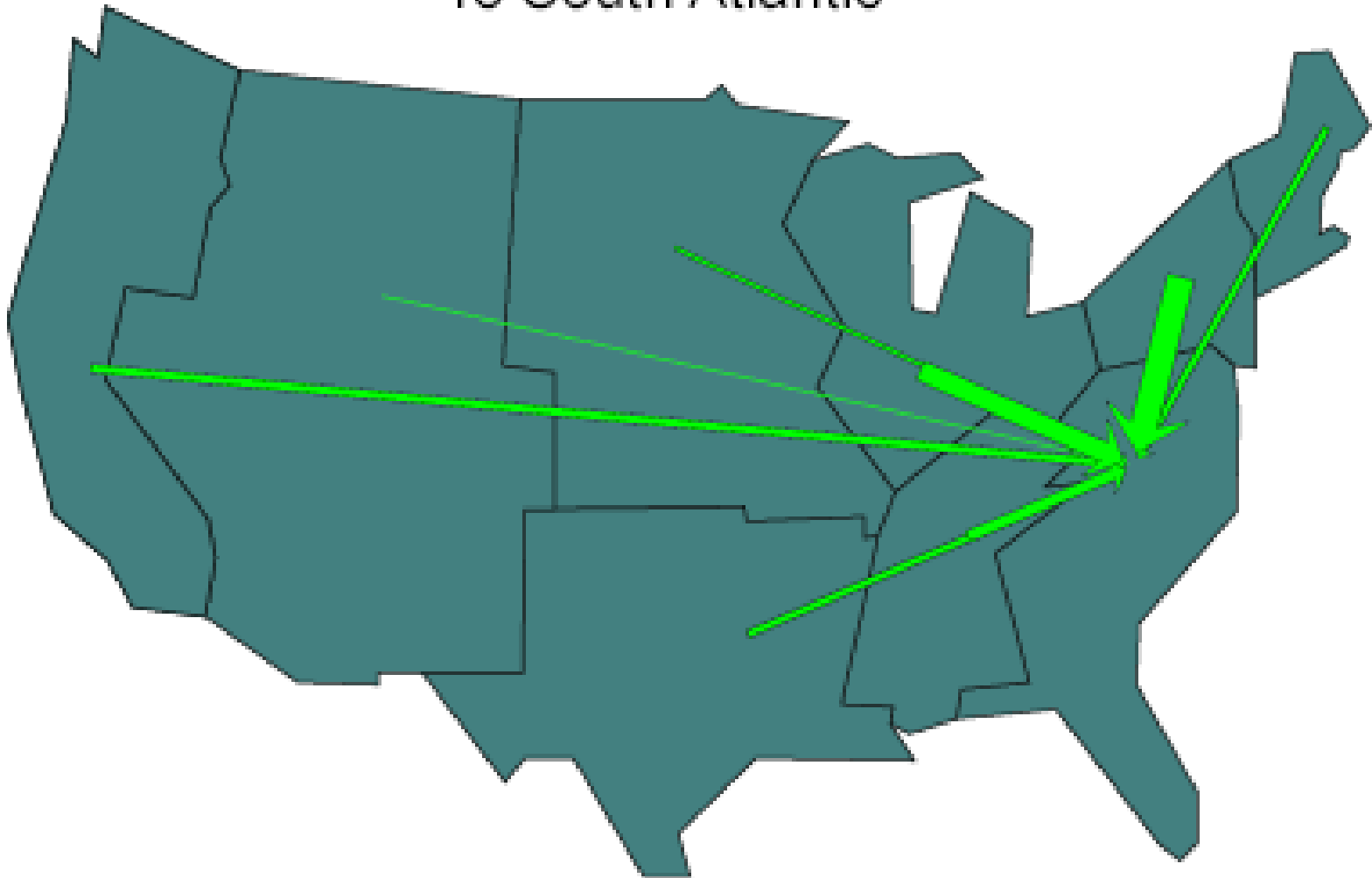
The screenshot displays the Flow Mapper software interface. At the top is a menu bar with 'File', 'Load', 'Edit', 'View', 'Window', and 'Help'. Below the menu bar is a toolbar with several icons. The main window shows an 'Interaction Table - US Div 70 migr tbl.dat' with a grid of data. The table has columns labeled 'Location' and '1' through '9'. The data is as follows:

Location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481
4	028977	060881	286580	000000	143860	049892	185618	181868	274629
5	130830	382565	346407	092308	000000	252189	192223	089389	279739
6	021434	053772	287340	049828	316650	000000	141679	027409	087938
7	030287	064645	161645	144980	199466	121366	000000	134229	289880
8	021450	043749	097808	113883	089806	025574	158006	000000	437225
9	072114	133122	229764	165405	266305	066324	252039	342948	000000

Below the table is a 'Project Settings' dialog box. It has tabs for 'Flow Properties', 'Data Points', 'Map Color', and 'Background & Title'. The 'Flow Properties' tab is active, showing sub-tabs for 'Flow Type/Width', 'Flow Color', and 'Flow Threshold'. Under 'Flow Band Color', the 'Flow Band Solid Color' option is selected, with a green color swatch and a 'Select' button. The 'Flow Band - Proportional Gradient' option is unselected, with a 'Reversed (Dark to Light)' checkbox and a 'Red' color swatch. Below this, there are two color swatches, one light pink and one red, with 'TD' between them. A note reads: 'Larger flows rendered darker, smaller flows rendered lighter color'. Under 'Flow Band Edge', the 'Flow Band Edge Color' option is selected, with a black color swatch and a 'Select' button. The 'Flow Band Edge Width' is set to '1' pt. The 'No Flow Band Edge Color' option is unselected. Under 'Flow Arrowhead', the 'Flow Band Arrow Style' is set to 'barbed'.

The moves to the South Atlantic Division

Migration 1995-2000
To South Atlantic



The Flow Mapper program can be downloaded from CSISS.org/Spatial tools.

Included are examples and references.

Comments and questions can be directed to

W. Tobler.

<http://www.geog.ucsb.edu/~tobler>

Program conceived by Waldo Tobler, design & programming by David Jones

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End of part 1 of the tutorial

Now experiment with your own data or try some of the files that came with the program in the Data_Sets folder, or continue with part 2 of the tutorial.

Tutorial Part II

An example of using Flow Mapper

by Waldo Tobler

The life history of a flow mapping project

Locate an interaction table.

Locate a map.

Digitize the map.

Enter the table and coordinates.

Use the flow map program.

Use a model to estimate the movement.

Compare the observed with the estimate.

Study area in Pennsylvania

Ten counties containing five parks

324

JOURNAL OF REGIONAL SCIENCE, VOL. 19, NO. 3, 1979

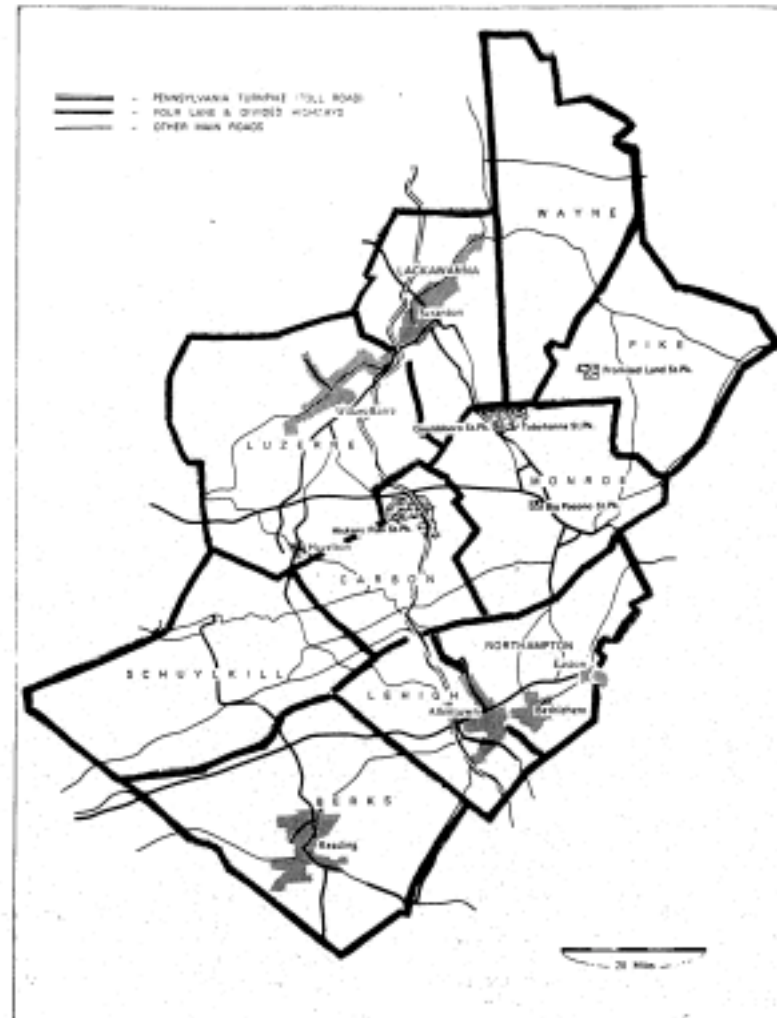


FIGURE 1: Map of the Study Area.

My recording of coordinates

						PA THAVS
1	339	60	39	85	270	
2	390	100	40	220	160	
3	425	140	41	207	159	
4	460	180	42	205	140	
5	490	220	4	338	80	
6	515	260				
7	546	315				
8	588	365				
9	572	415				
10	600	340				
11	600	465				
12	635	490				
13	665	550				
14	694	570				
15	680	600				
16	615	620				
17	586	660				
18	580	739				
19	561	745				
20	579	760				
21	542	780				
22	517	778				
23	514	816				
24	507	817				
25	493	835				
26	455	835				
27	450	688	460			
28	382	689				
29	351	604				
30	284	585				
31	215	585				
32	200	585				
33	210	585				
34	210	570				
35	210	480				
36	230	305				
37	197	339				
38	85	240				

Boundary outline coordinates

X and Y stored in an ASCII file

```
338 60
390 100
435 190
460 180
490 220
545 260
546 315
588 365
562 415
600 440
600 465
635 490
665 550
694 570
680 600
615 620
586 660
580 739
561 745
579 760
542 780
517 778
514 816
501 817
493 835
455 835
460 688
382 689
351 604
285 585
215 585
200 550
200 510
213 480
227 480
230 405
197 339
85 290
85 270
220 160
249 159
245 140
338 60
```

Fifteen centroid coordinates

Ten counties and five parks

X and Y also stored in an ASCII file

```
310 158  
380 370  
410 610  
455 245  
330 535  
510 460  
265 490  
590 565  
240 310  
520 660  
500 440  
465 510  
400 440  
540 550  
480 515
```

County, then park, names

Berks

Carbon

Lackawanna

Lehigh

Lucerne

Monroe

Northampton

Pike

Schuylkill

Wayne

Big Pocono Park

Gouldsboro Park

Hickory Run Park

Promised Land Park

Tobyhanna Park

Movement table

From 10 counties to 5 parks

Table 1: Observed Movements

To Park From County	1 Big Pocono	2 Gouldsboro	3 Hickory Run	4 Promised Land	5 Tobyhanna	OutSum O_i
Berks	46	35	333	84	69	567
Carbon	50	33	1670	71	91	1915
Lackawanna	230	6970	141	977	1917	10235
Lehigh	307	520	1458	315	387	2987
Lucerne	255	3366	4586	303	595	9105
Monroe	376	313	253	150	848	1940
Northampton	385	1121	1263	499	981	4249
Pike	17	7	26	87	6	143
Schuylkill	63	101	1886	48	40	2138
Wayne	8	20	12	124	18	183
InSum I_i	1737	12486	11628	2658	4952	33461

Source: Cesario (1973), Table 5, p. 245.

This represents a rather different situation. Given is a ten by five table of interaction relating the residents of ten counties and their attendance at five parks. The table is thus rectangular. But the flow mapping program expects square arrays. A simple short computer program is used to convert the small table into a fifteen by fifteen table, with the original 10 by 5 in the upper right corner ('Original.tbl') and zeros in the rest of the table.

The location list contains fifteen entries, the first ten being the coordinates for the counties and the last five the coordinates of the parks ('XYS.dat'). The name list is also in this order ('Names.txt'). The parks are all located in Pennsylvania in the area between Wilkes Barre-Scranton-Lackawanna and Berks-Allentown-Bethlehem. A map of the study area showing details is given in M. Baxter, G. Ewing, 1979, "Calibration of Production Constrained Trip Distribution Models and the Effect of Intervening Opportunities", *Journal of Regional Science*, 19(3): 319-330.

A map outline of 43 points is given in a text file ('Boundary.dat'). The units are arbitrary from a piece of graph paper.

Since the information represents the movements from the counties to the parks it is appropriate to use the net flow map ('Observed.tif').

The map of observed movements is then compared to a map ('Estimated.tif') made from the estimated movements computed from the table marginals using a model ('Estimated.tbl'). The model in this instance is the so-called 'Quadratic Transportation Problem'. The absolute value of the difference between these two sets of data ('Difference.tbl') is also represented on a map ('Difference.tif'). The correlation (r -squared) between the model estimate and the observed movements is 0.85.

The model, and the data, are completely described in W. Tobler, 1988, "The Quadratic Transportation Problem as a Model of Spatial Interaction Patterns", pp. 75-88 of W. Coffey, ed., *Geographical Systems and Systems of Geography: Essays in Honor of William Warntz*, University of Western Ontario, London".

Having found an interaction matrix, the next step is to get it into the computer

If the table is small you can enter it by typing it into notepad.

Larger tables can be entered using a spreadsheet.

Excel tables can be used by converting them to space or comma delimited ASCII files (do not use tab delimited).

The 15 by 15 observed movement table.

The 10 by 5 table has been forced into a square format.

The movement from the 10 counties to the 5 parks is one directional only.

0	0	0	0	0	0	0	0	0	0	46	35	333	84	69
0	0	0	0	0	0	0	0	0	0	50	33	1670	71	91
0	0	0	0	0	0	0	0	0	0	230	6970	141	977	1917
0	0	0	0	0	0	0	0	0	0	307	520	1458	315	387
0	0	0	0	0	0	0	0	0	0	255	3366	4586	303	595
0	0	0	0	0	0	0	0	0	0	376	313	253	150	848
0	0	0	0	0	0	0	0	0	0	385	1121	1263	499	981
0	0	0	0	0	0	0	0	0	0	17	7	26	87	6
0	0	0	0	0	0	0	0	0	0	63	101	1886	48	40
0	0	0	0	0	0	0	0	0	0	8	20	12	124	18
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The next step is to produce the map, as in the previous tutorial

There are visitors from 10 counties to 5 parks

The moves indicated are from the counties to the parks.

This yields a rectangular table.

The flow program expects a square table.

The rectangular table needs to be converted to a square table.

This is done by constructing a 15 by 15 table, of mostly zeros.

An 'input help program' does this conversion.

Conversion from origin-destination lists is also available.

The rectangular 10 by 5 table shows up in the upper right hand corner.

The full table could show moves between counties & between parks.

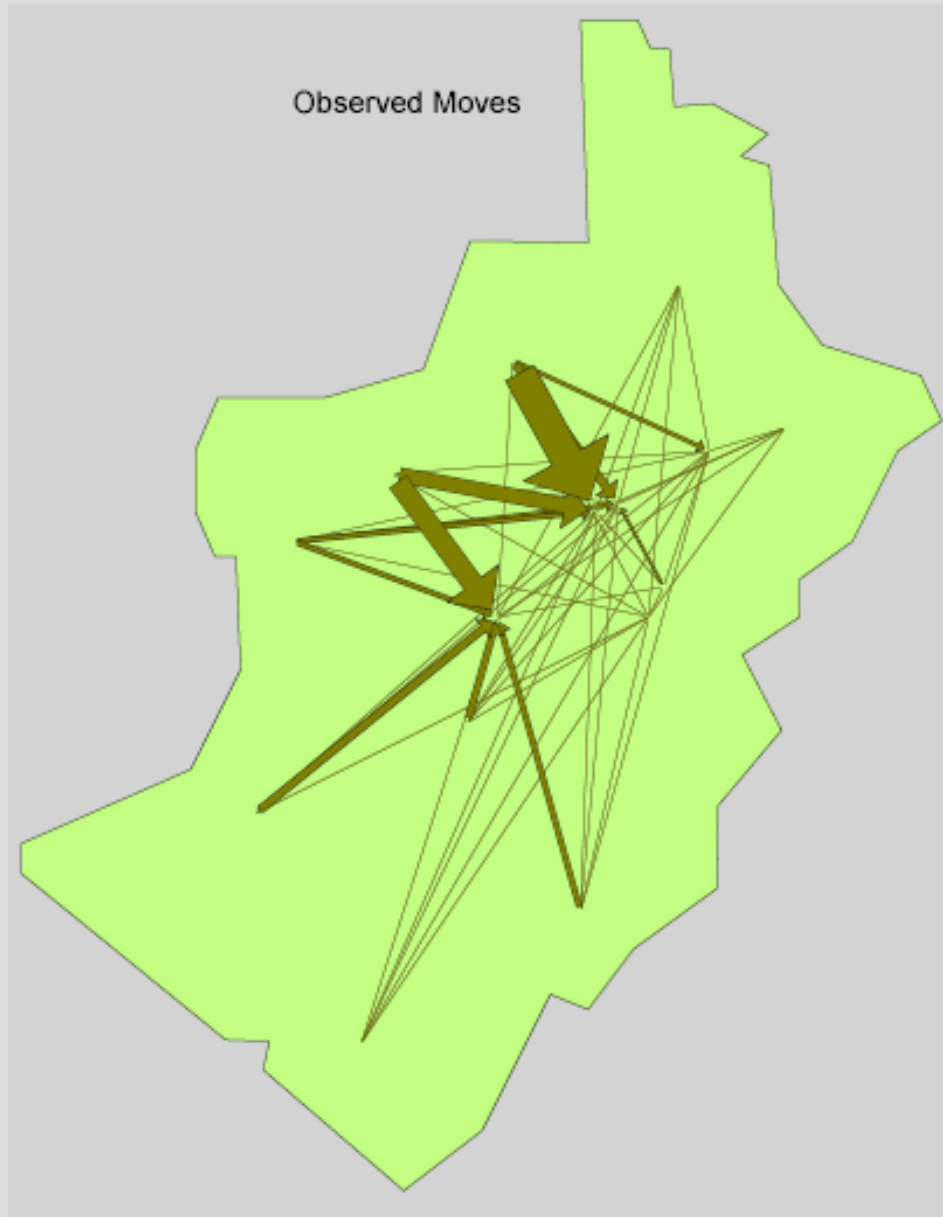
But these moves are not recorded.

Return moves are implicit but not depicted.

The lower left corner could be used for these, as the transposed table,

a 5 by 10 table.

Visits by county residents to parks



Distance from parks to counties

Needed for model estimates. The model also uses the table marginals.
These values must also be in a computer file.

Table 2: Distance from counties to parks (C_{ij}) in miles

To Parks From County	Big Pocono	Gouldsboro	Hickory Run	Promised Land	Tobyhanna
Berks	95	101	89	115	96
Carbon	40	52	30	71	44
Lackawanna	45	21	46	35	29
Lehigh	47	62	57	70	62
Lucerne	55	45	25	65	49
Monroe	17	26	45	26	24
Northampton	41	56	64	60	52
Pike	49	53	80	35	47
Schuylkill	70	77	57	85	71
Wayne	53	37	72	22	37

Source: Cesario (1973), Table 5, p. 245

Movement table

From 10 counties to 5 parks
with marginals: Insums and Outsums noted

Table 1: Observed Movements

To Park From County	1 Big Pocono	2 Gouldsboro	3 Hickory Run	4 Promised Land	5 Tobyhanna	OutSum O_i
Berks	46	35	333	84	69	567
Carbon	50	33	1670	71	91	1915
Lackawanna	230	6970	141	977	1917	10235
Lehigh	307	520	1458	315	387	2987
Lucerne	255	3366	4586	303	595	9105
Monroe	376	313	253	150	848	1940
Northhampton	385	1121	1263	499	981	4249
Pike	17	7	26	87	6	143
Schuylkill	63	101	1886	48	40	2138
Wayne	8	20	12	124	18	183
InSum I_i	1737	12486	11628	2658	4952	33461

Source: Cesario (1973), Table 5, p. 245.

Estimated table using the QTP model

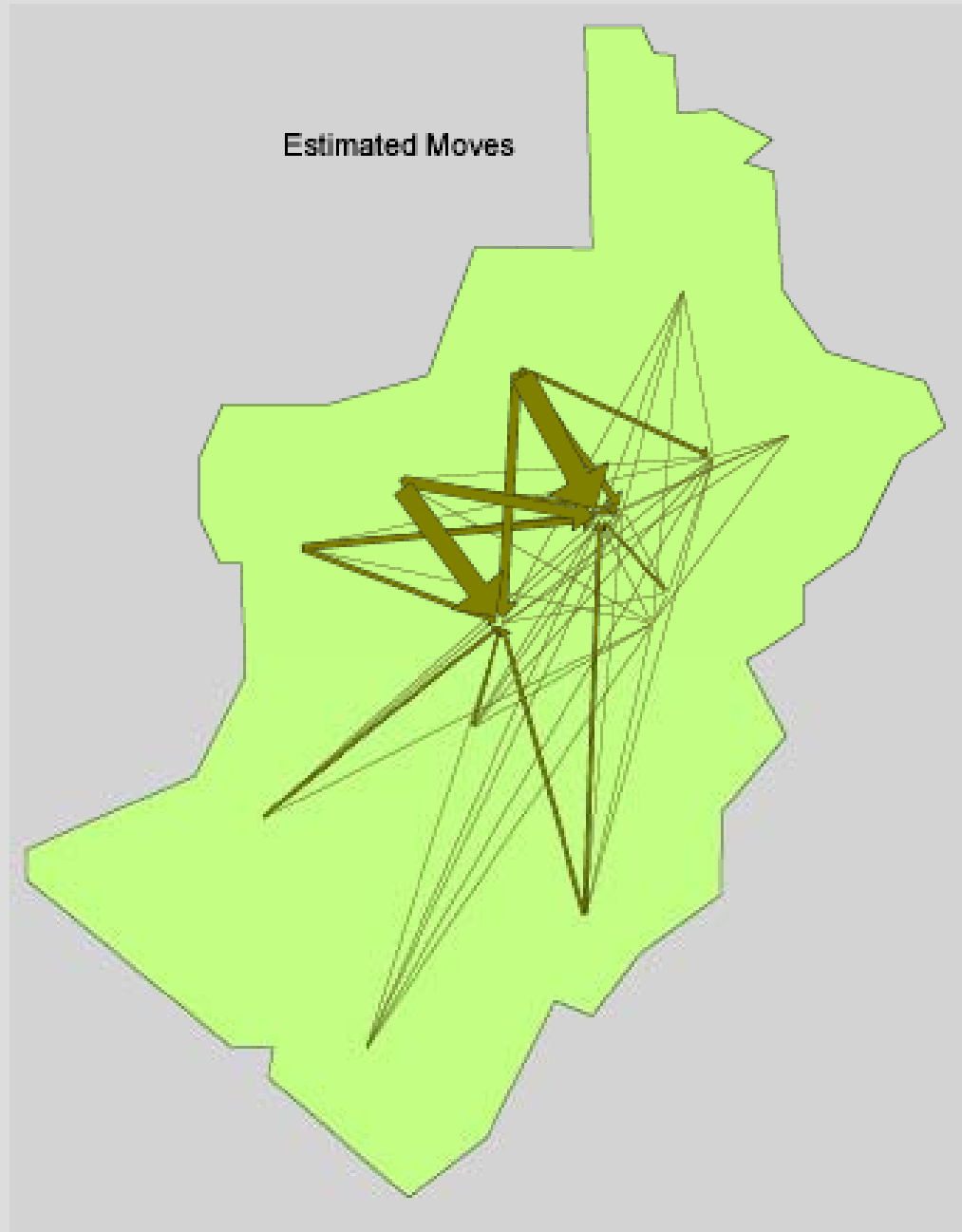
See QTP.doc under reprints on my web site for a description of the model.

Table 3: Results from model

To Park From County	Big Pocono	Gouldsboro	Hickory Run	Promised Land	Tobyhanna	Pushes
Berks	31	197	211	42	86	4.04E-3
Carbon	110	531	889	109	275	7.30E-4
Lackawanna	394	5019	2242	929	1650	6.78E-5
Lehigh	208	1033	1071	237	438	1.85E-3
Lucerne	347	2614	4559	523	1062	4.86E-4
Monroe	191	737	417	23	364	0
Northhampton	325	1546	1292	377	709	1.68E-3
Pike	9	53	34	21	26	1.59E-3
Schuylkill	113	682	876	156	311	2.35E-3
Wayne	8	72	36	34	32	7.75E-4
Pulls	1.93E-3	1.58E-3	1.67E-3	2.32E-3	1.82E-3	

Correlation between observed and estimated: $r^2 = 0.85$, $n=50$

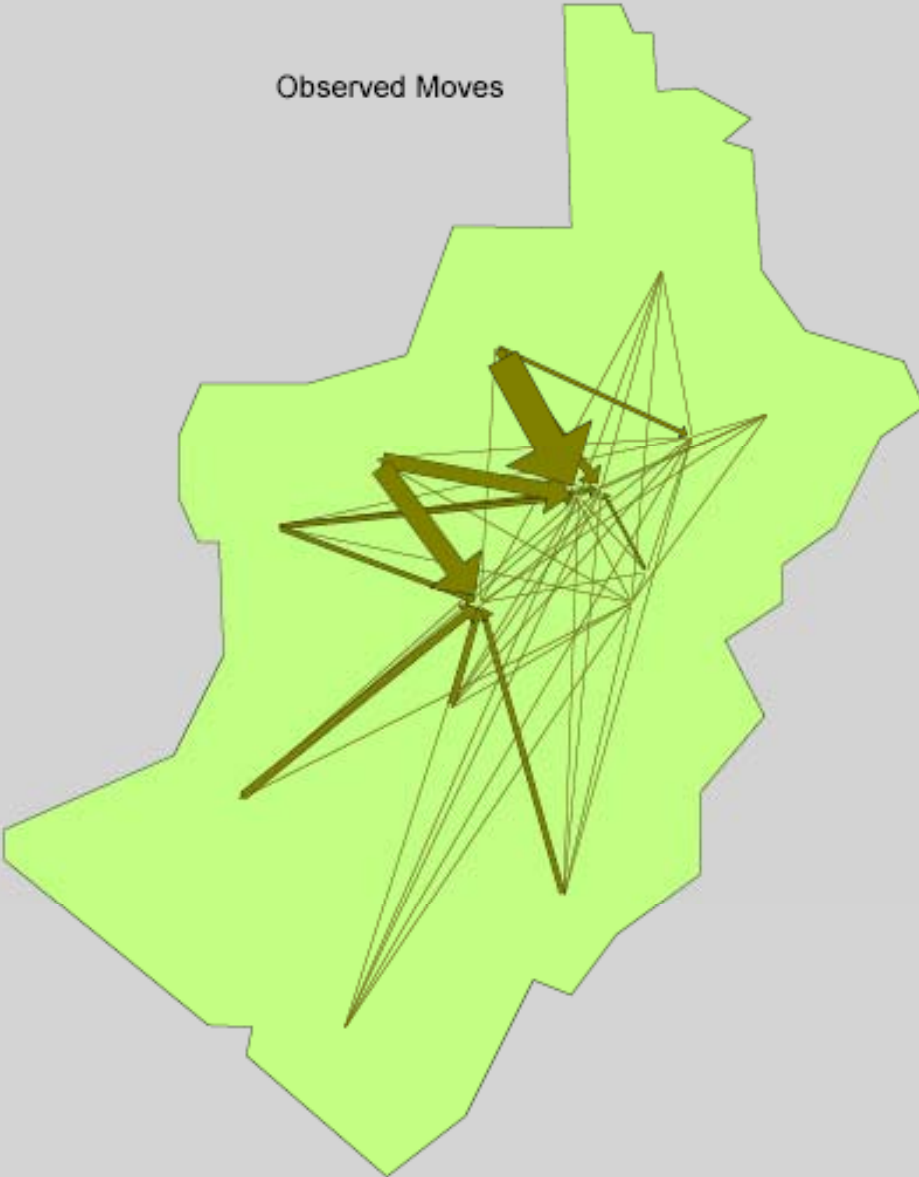
Estimated Moves



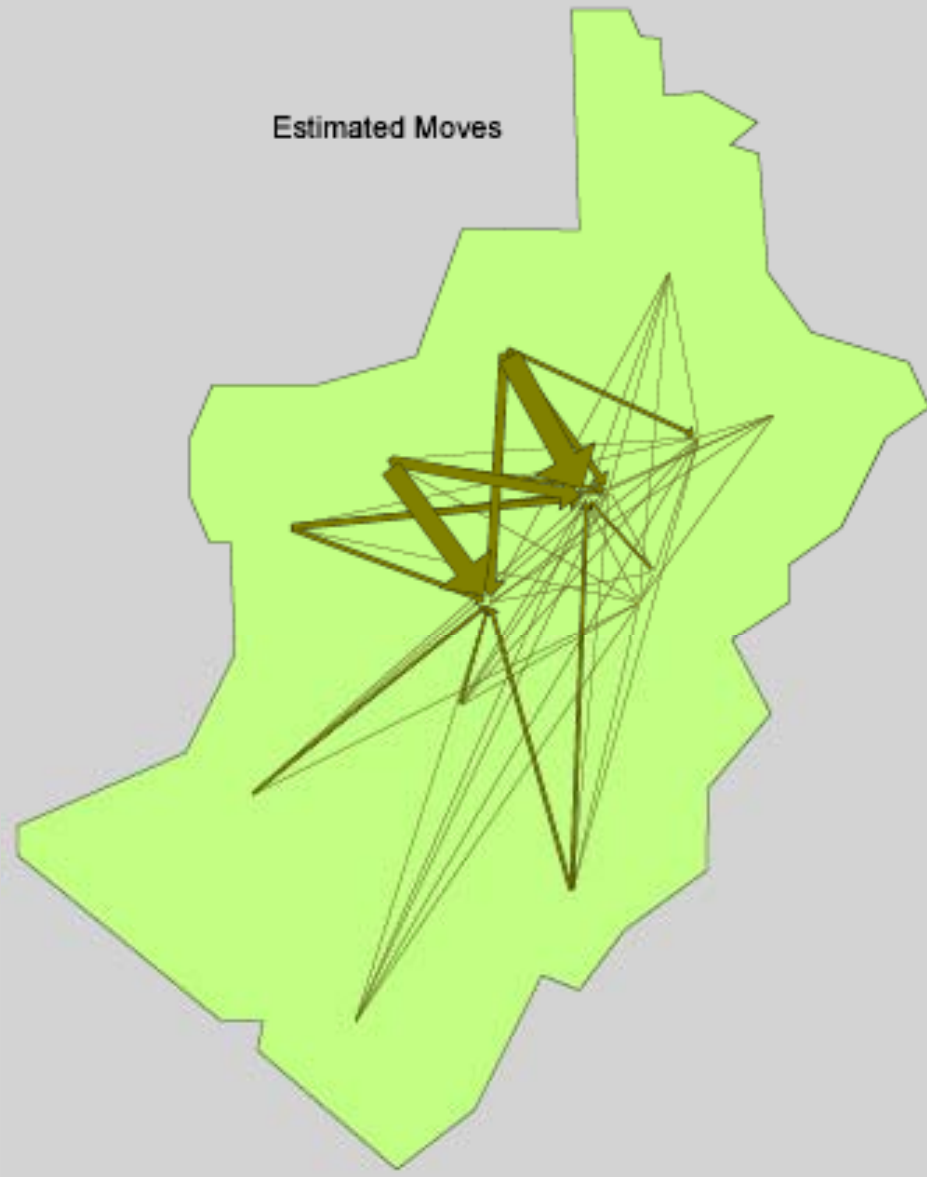
Observed Moves versus QTP Estimated Moves

Park attendance

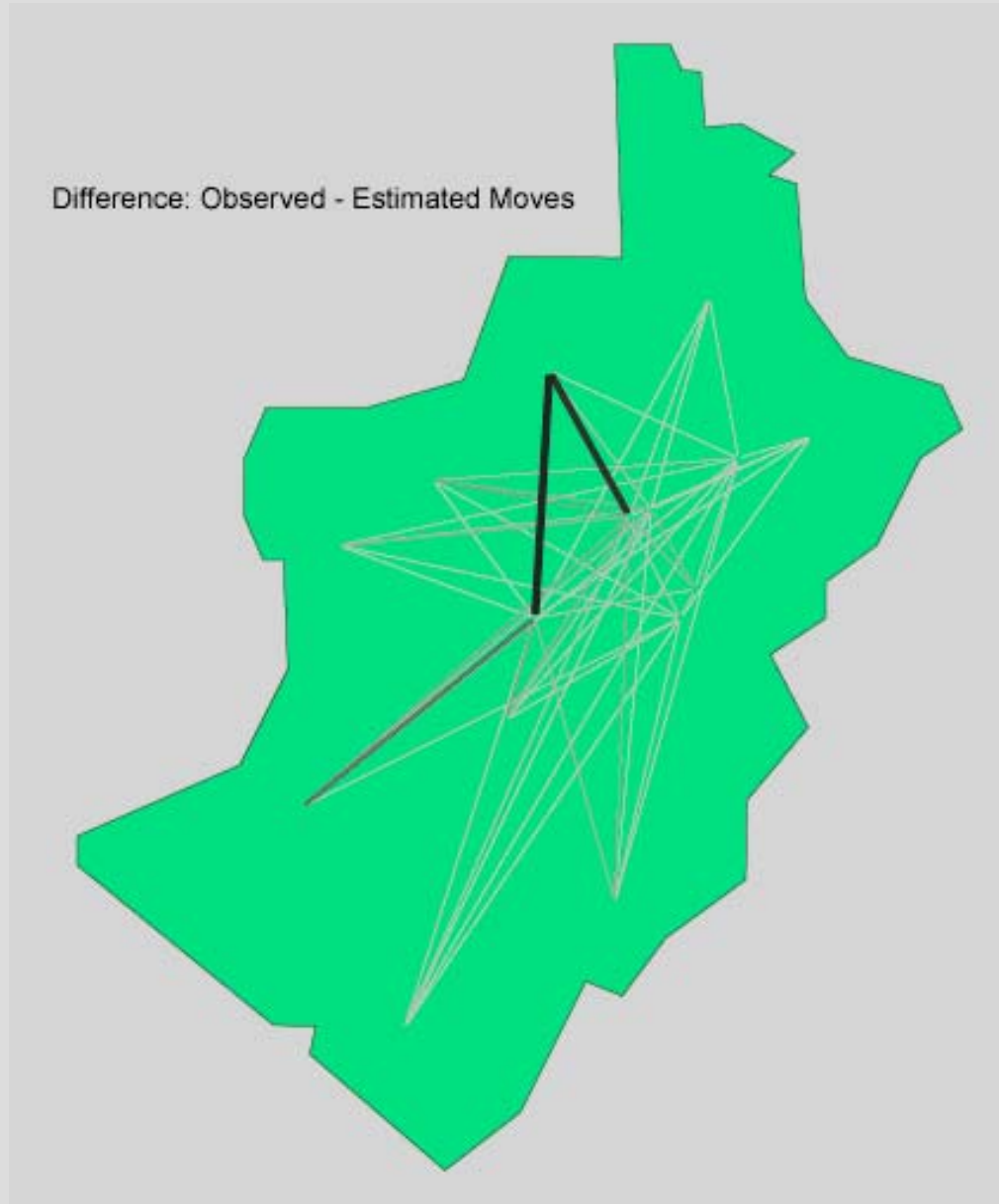
Observed Moves



Estimated Moves



Difference: Observed minus Estimated Quadratic transportation model



Thank you for your attention

Questions can be addressed to:

Waldo Tobler
Professor Emeritus
Geography Department
University of California
Santa Barbara, CA 93016-4060
<http://www.geog.ucsb.edu/~tobler>

End of part 2 of the tutorial

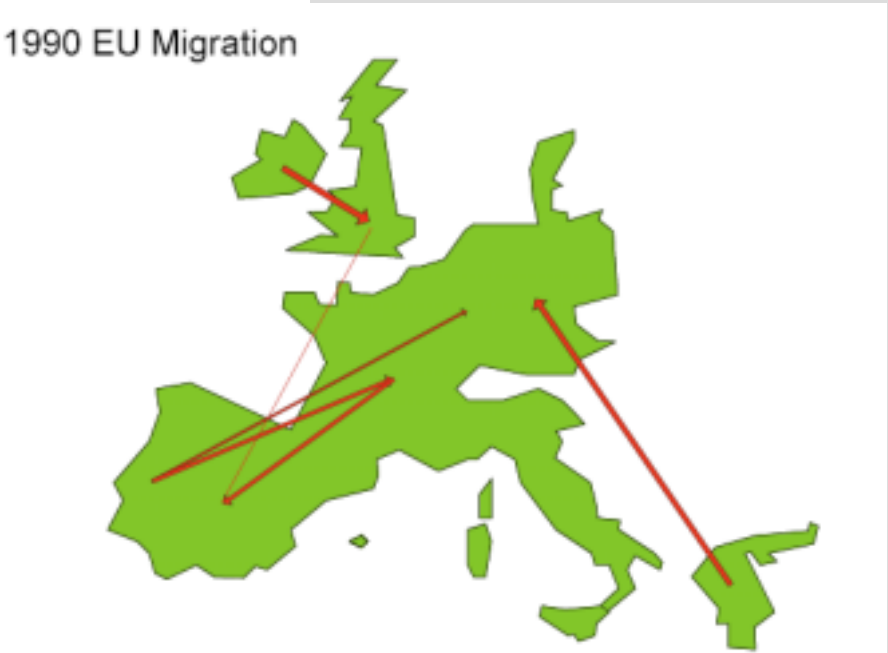
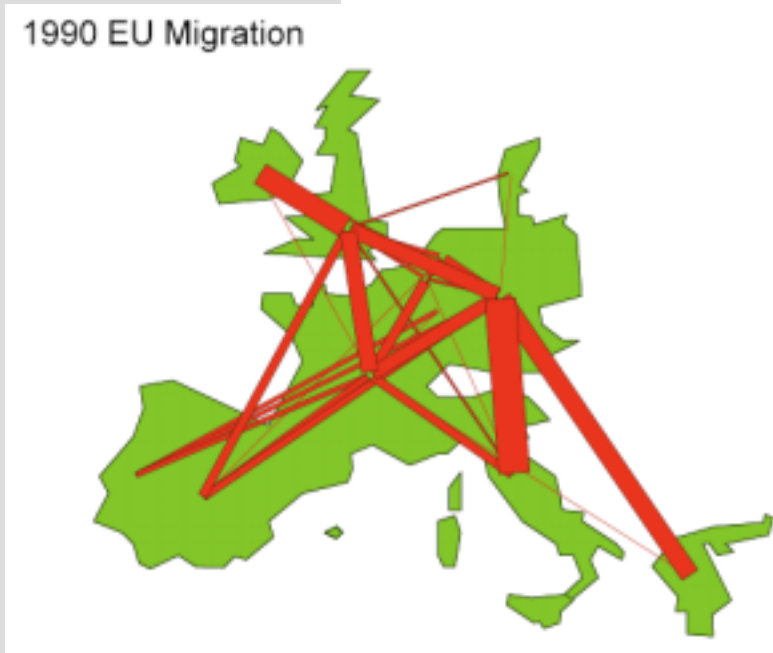
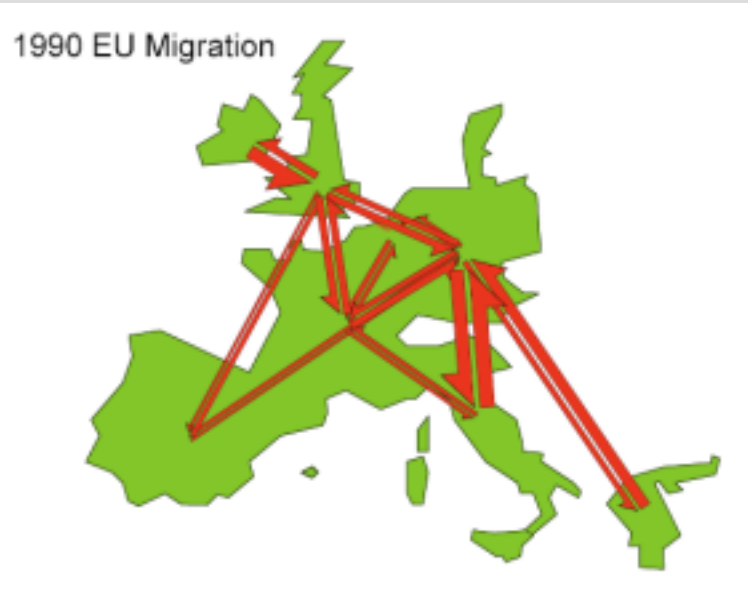
Now experiment with your own data or try some of the files that came with the program in the Data Sets folder, or continue with part 3 of the tutorial

Tutorial Part III

Examples produced using the Flow Mapper program.

by Waldo Tobler

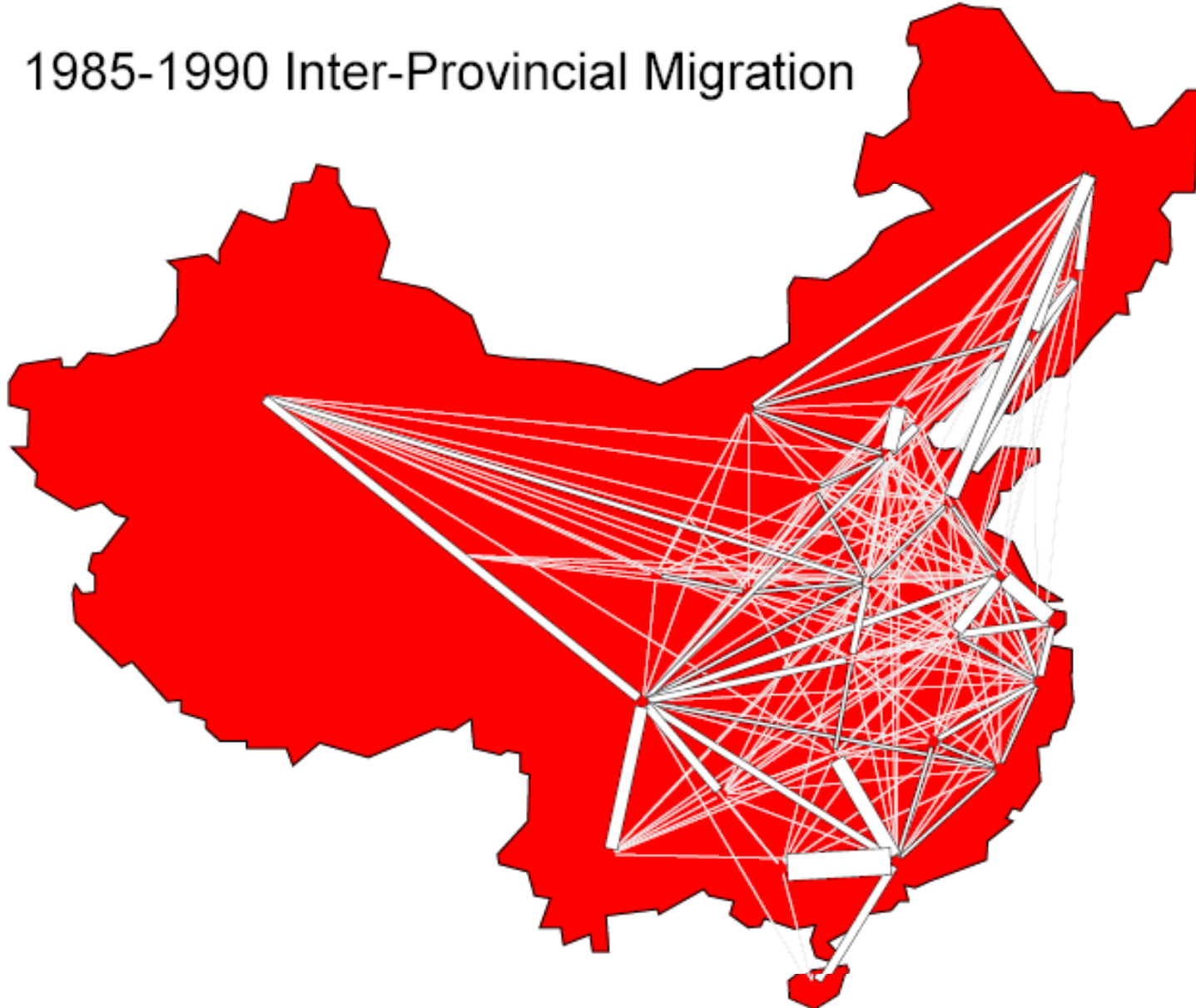
Two-way, Total (Gross), and Net Migration



Showing the majority of inter-provincial moves in China

Using the flow mapper program

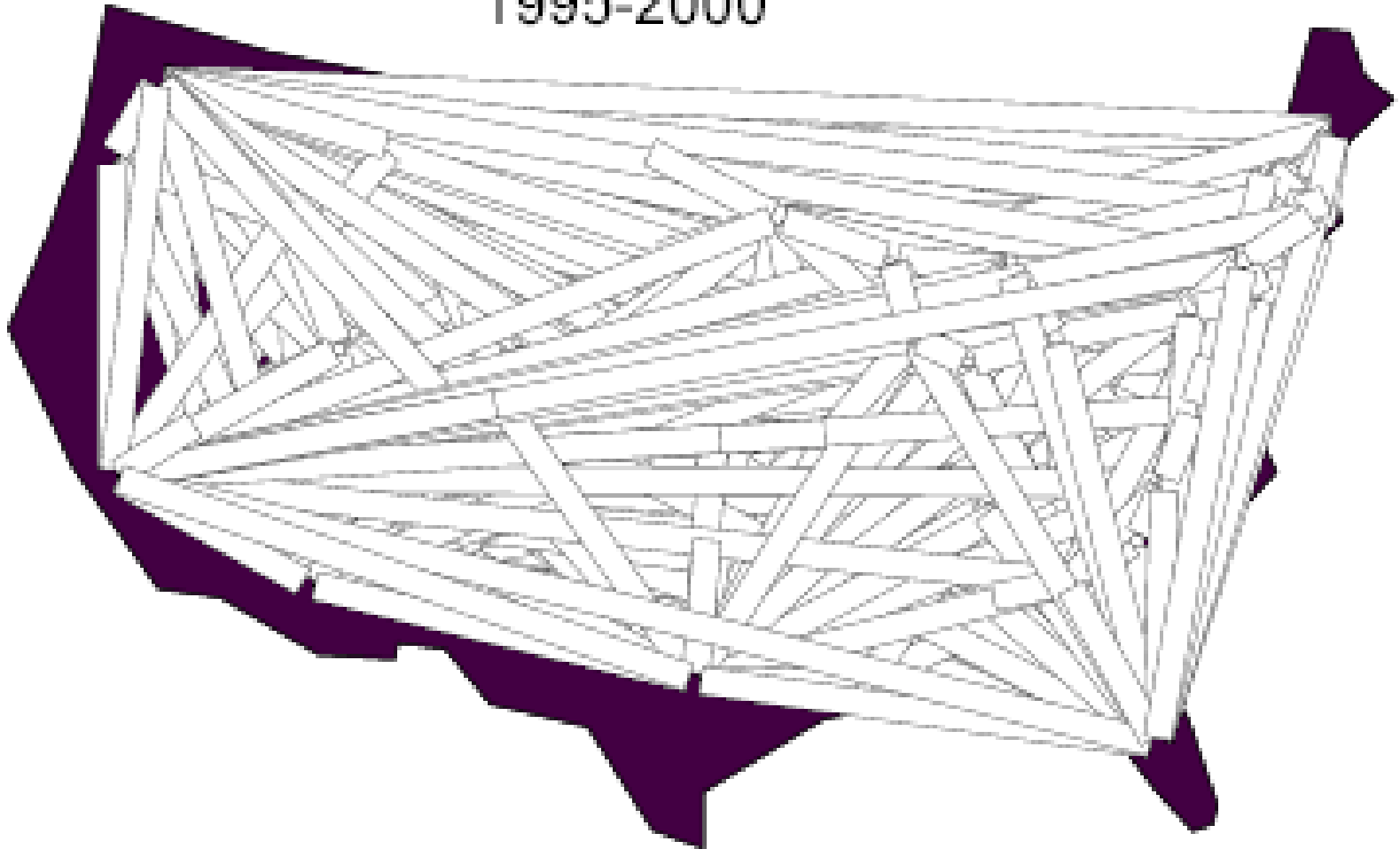
1985-1990 Inter-Provincial Migration



Showing 2256 flows

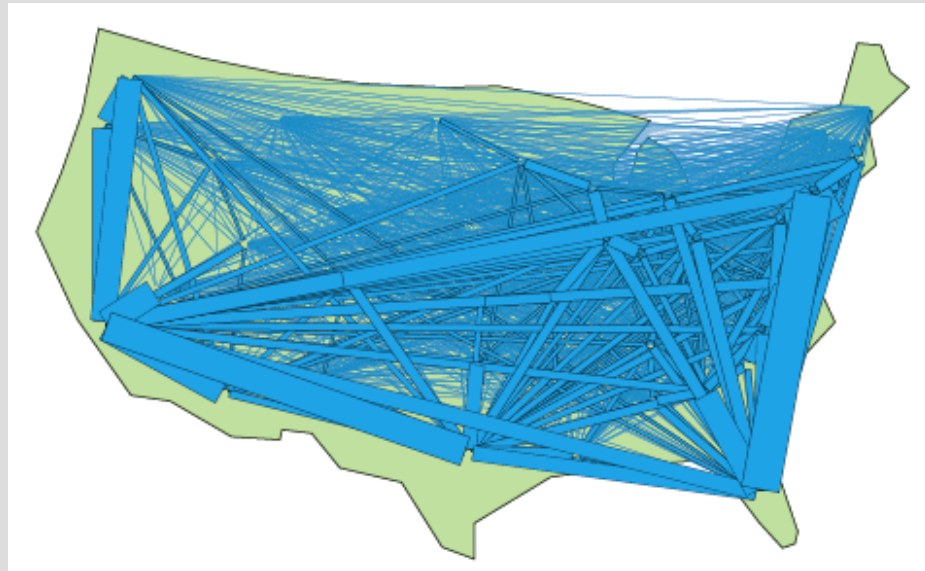
from 48 by 48 table, with constant width bands. Not very useful.

All migrations shown
1995-2000



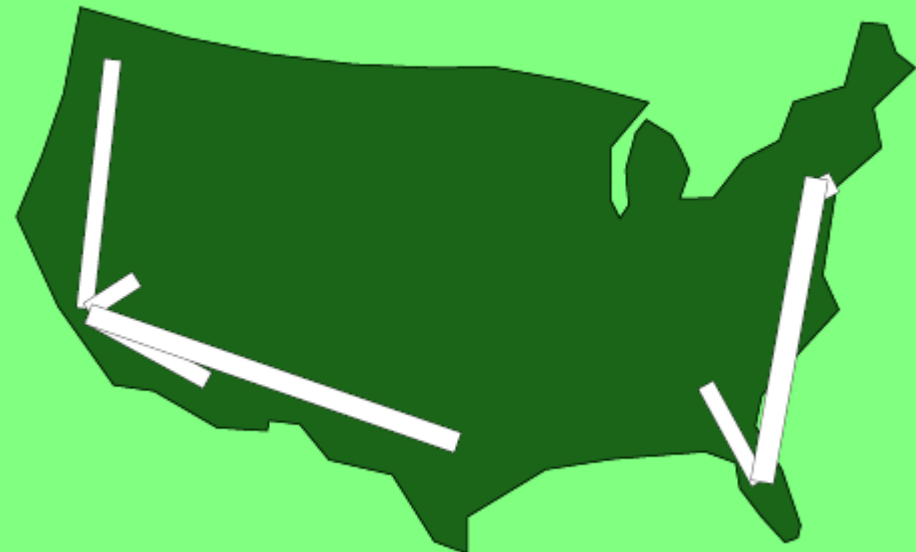
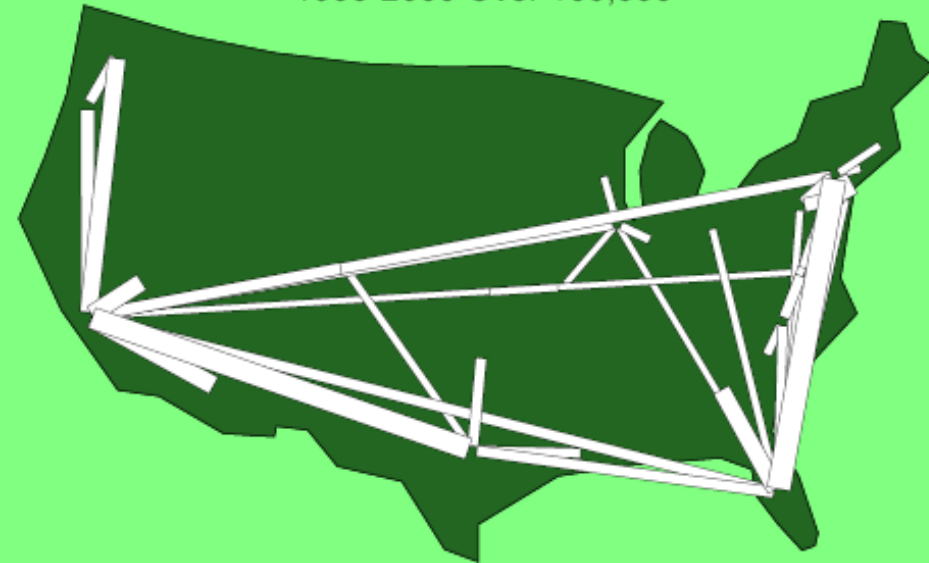
1995-2000 Total Migration

Variable width bands, and parsing by quantity.



1995-2000 Over 100,000

1995-2000 Over 200,000

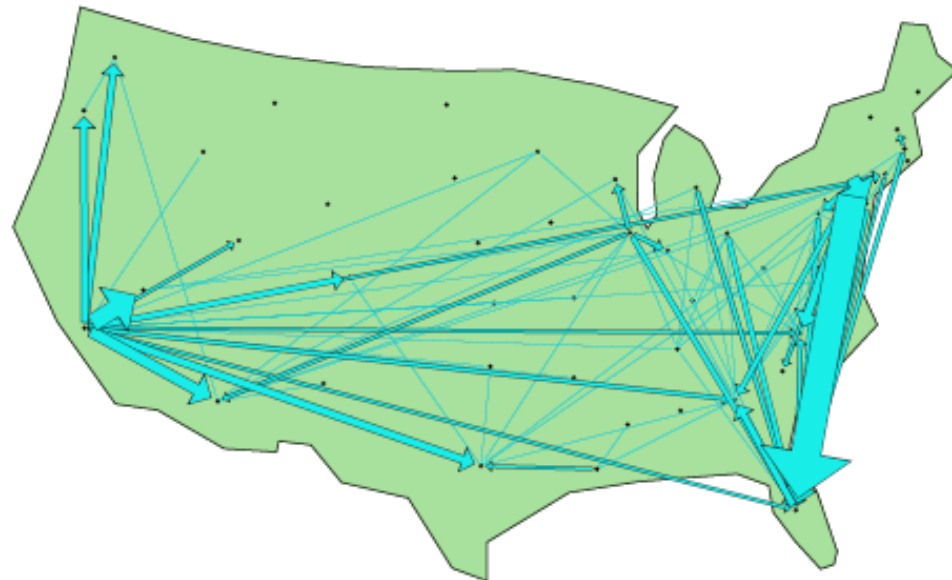
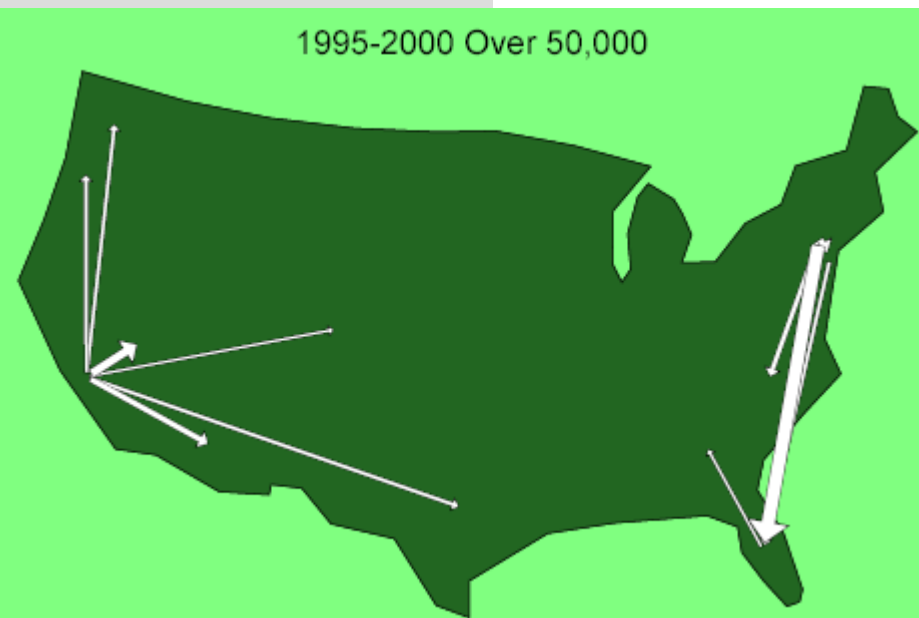


1995-2000 Net Migration

Complete and simplified.

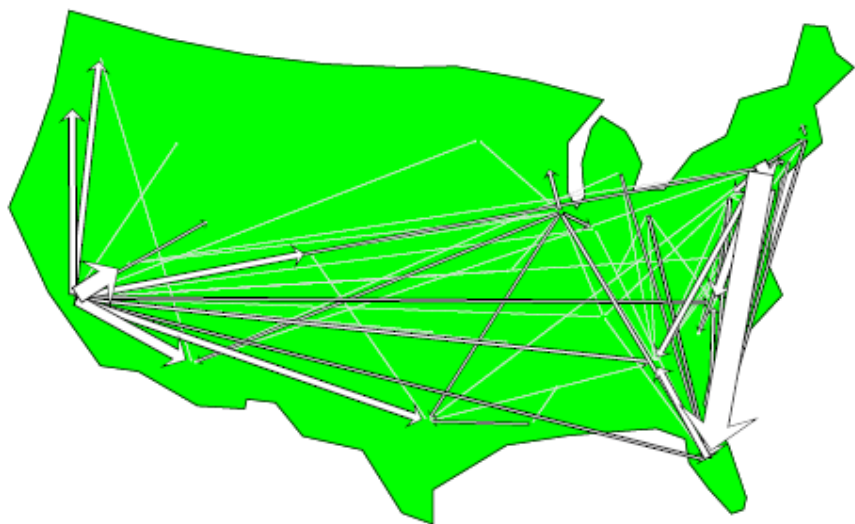


1995-2000 Over 50,000

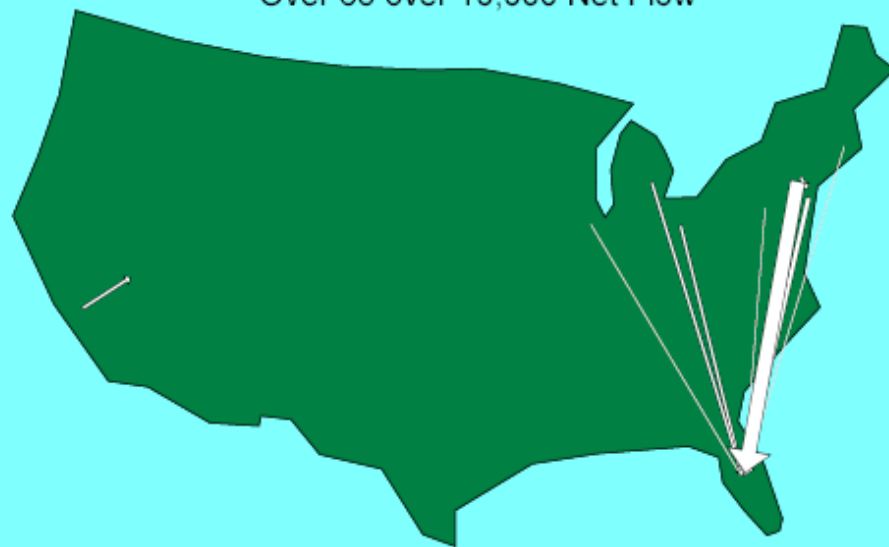


1995-2000 Net Migration by two age groups, and movement size.

Ages 5-64, Over 10,000 people moving



Over 65 over 10,000 Net Flow



Two Variants

Same Data



People over age 65 migrating
95% of moves, 1995-2000



Map of migration, 1995-2000
95% of persons aged 65 and over

Migration Patterns Persist the Netherlands

1984

1994

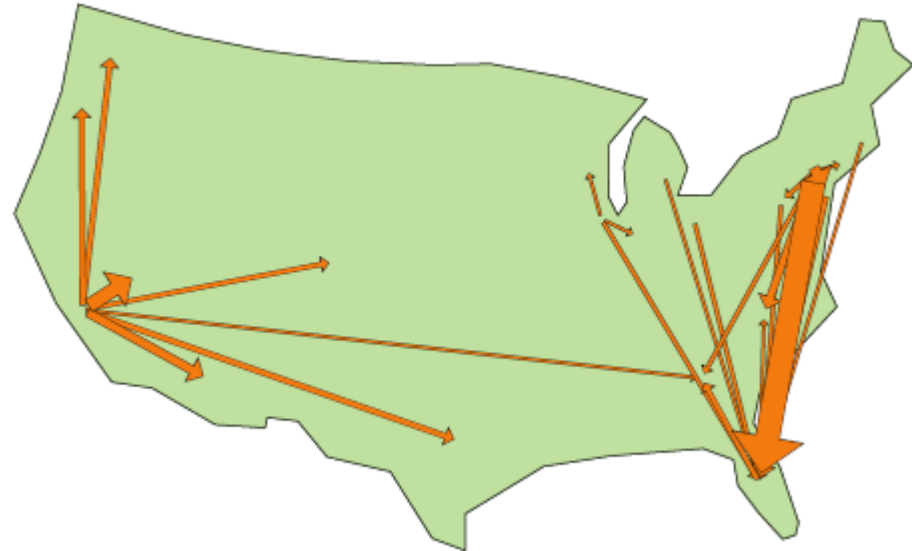
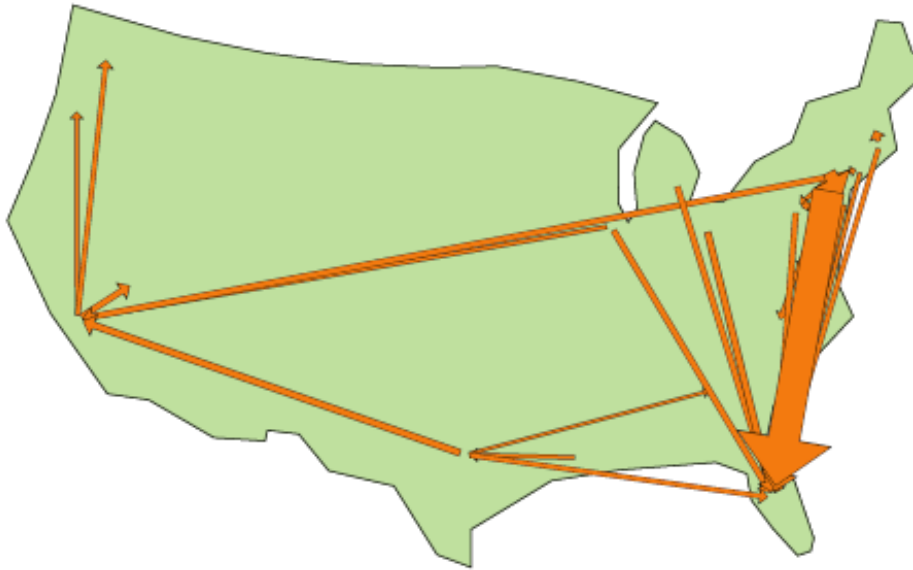


Net Migration in the United States

US Census Data

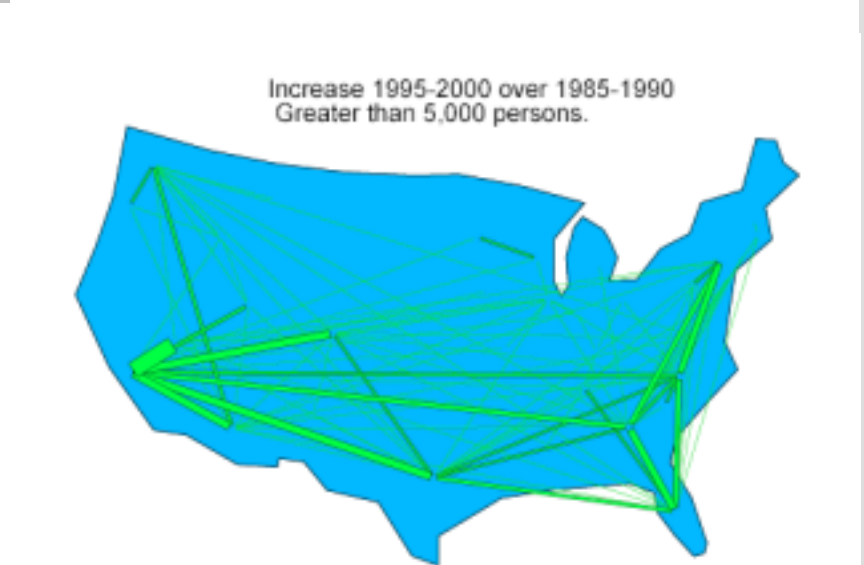
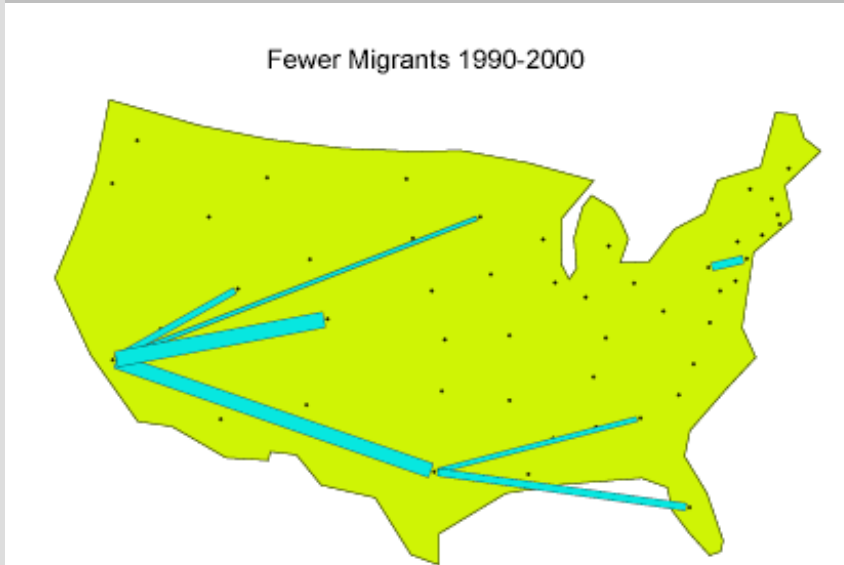
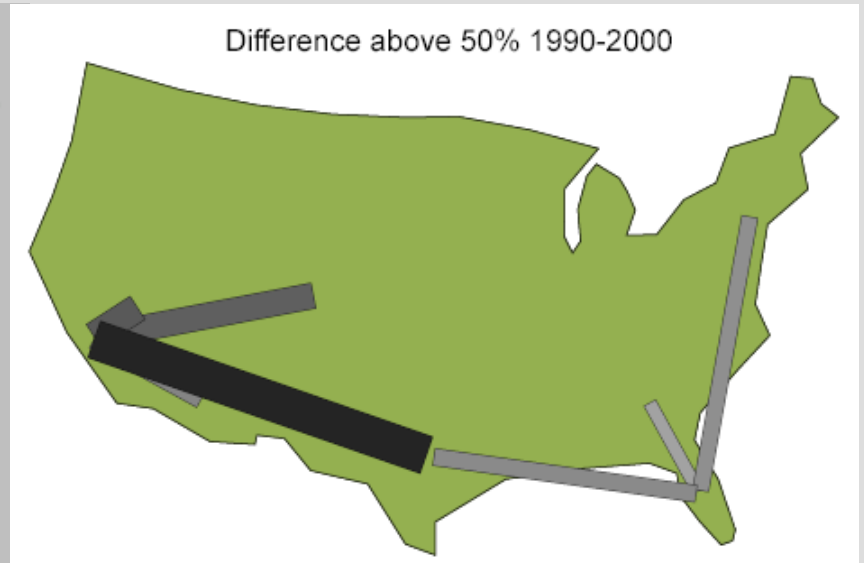
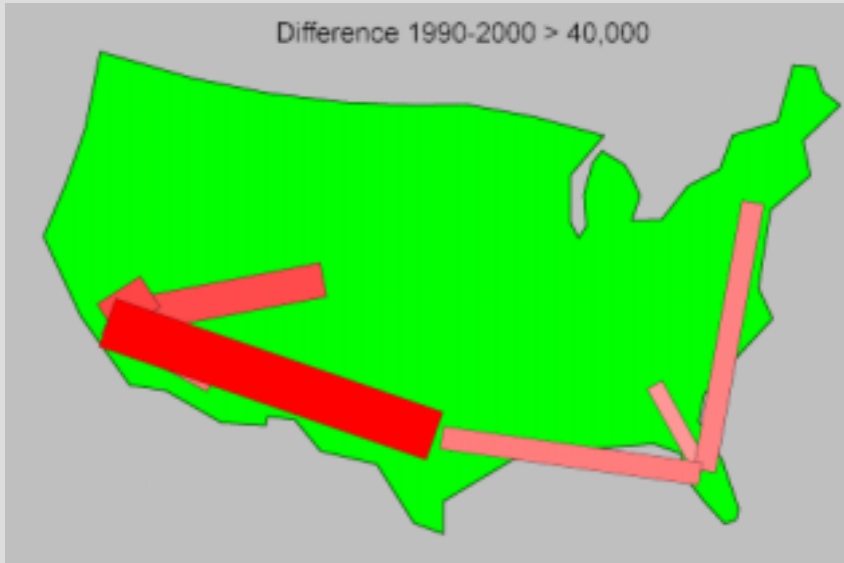
1985-1990

1995-2000



Difference between 1985-1990 and 1995-2000 Migration

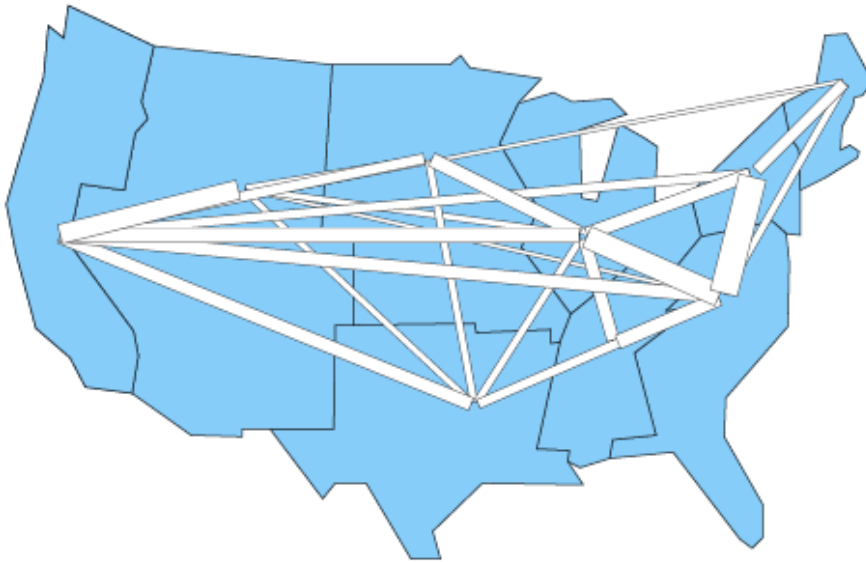
US Census information



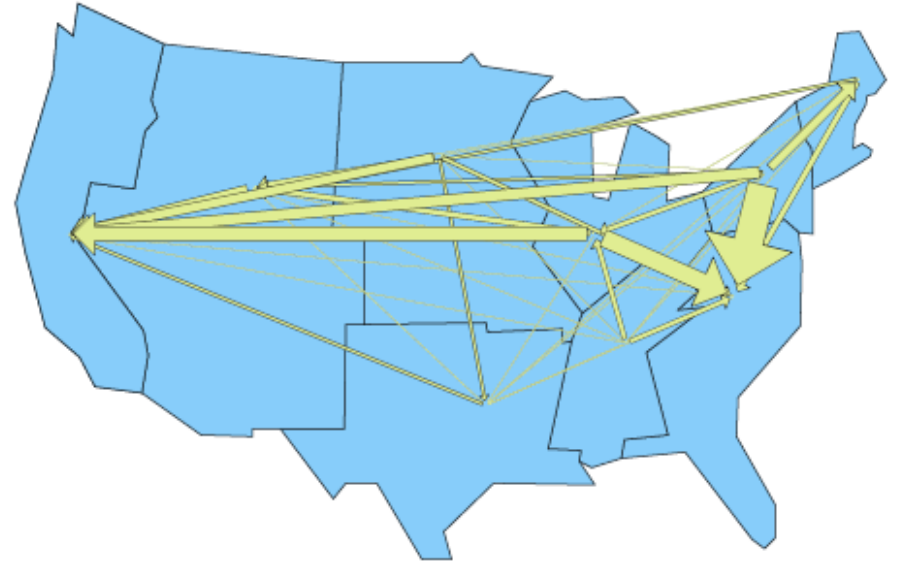
Migration by Census Divisions

Top: 1965-1970 Migration, Total and Net

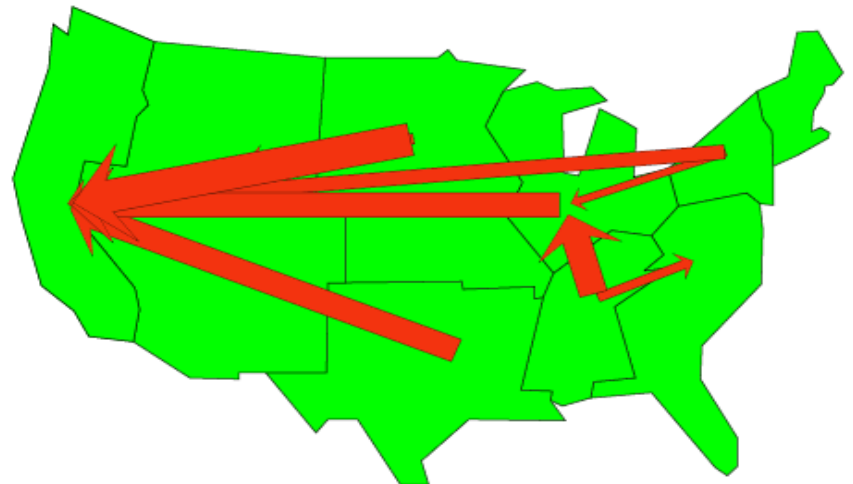
Bottom: Birth to 1970 Residence, Total and Net



Flow: Birth to 1970 Residence



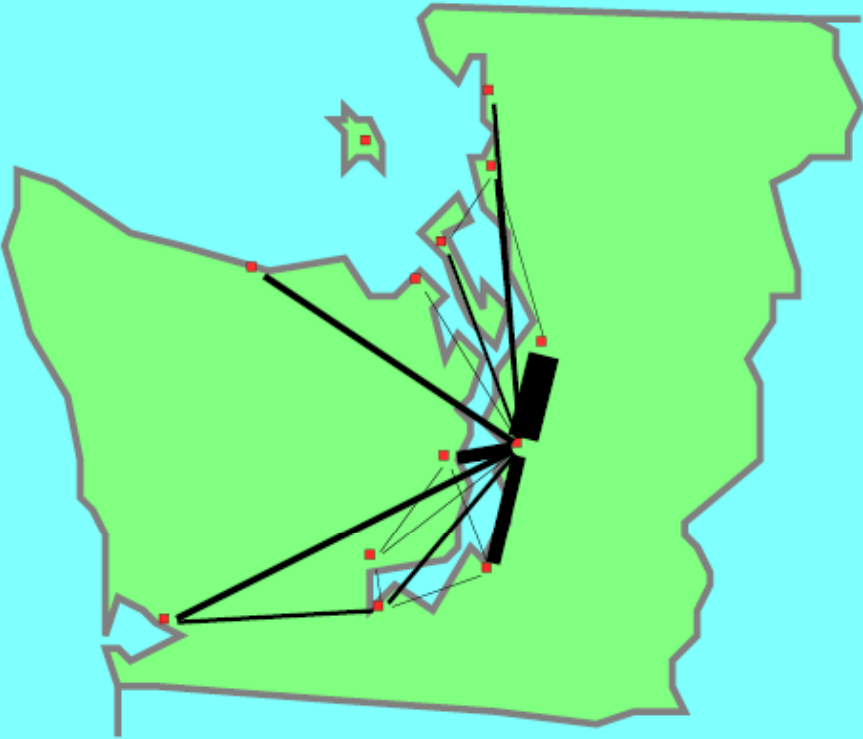
Flow Map: Birth to 1970 Residence



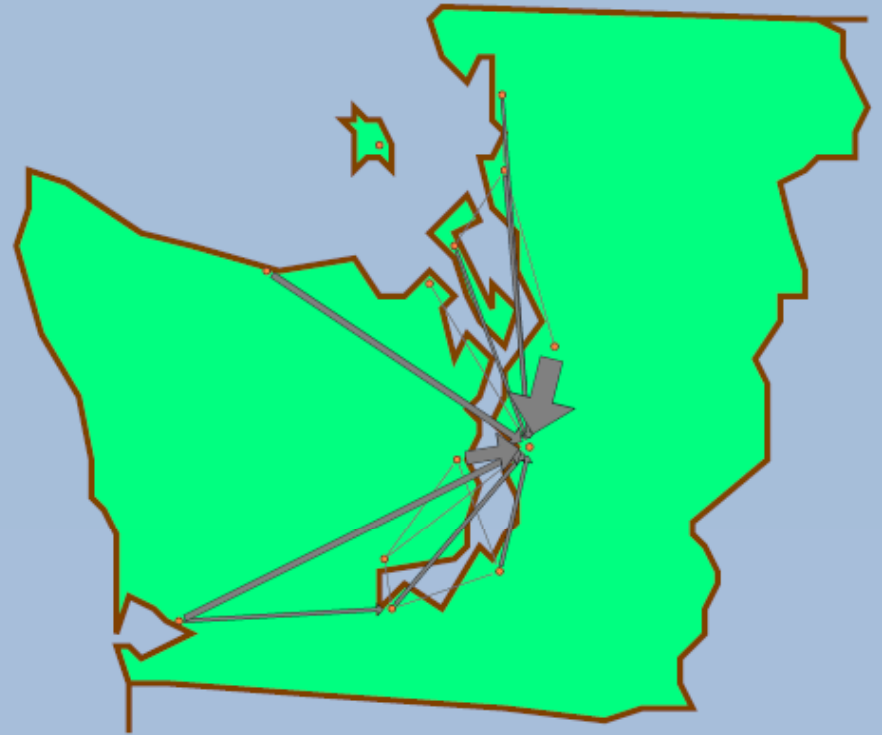
Gross and Net Moves

$M_{ij} + M_{ji}$ and $|M_{ij} - M_{ji}|$
in Western Washington state.

74-78 Cancer Treatment Flows > 200



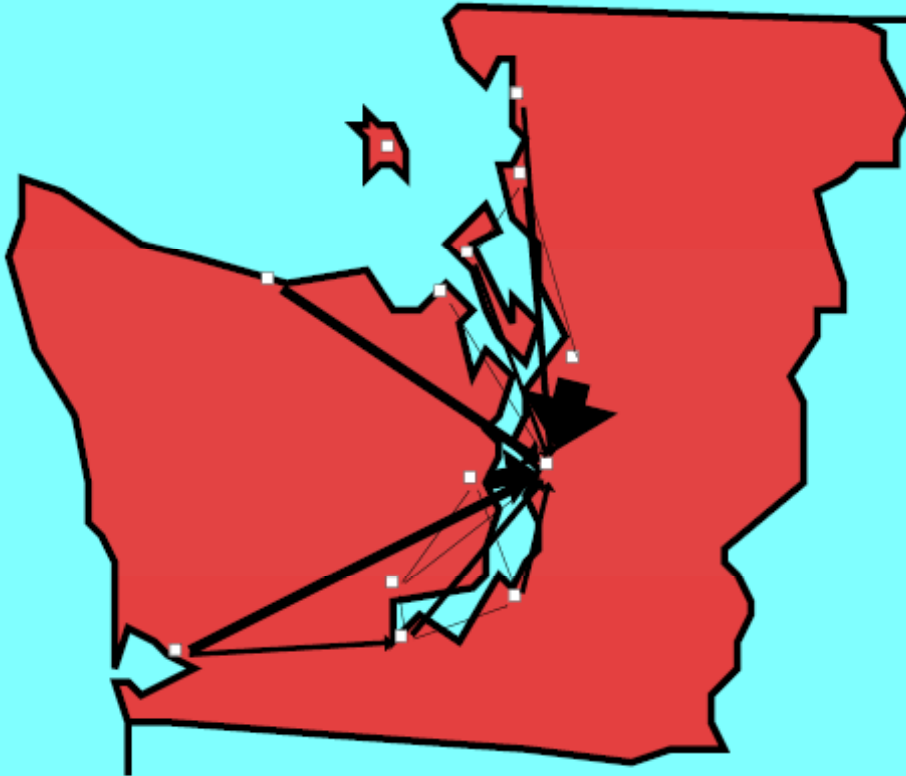
74-78 Cancer Treatment Flow



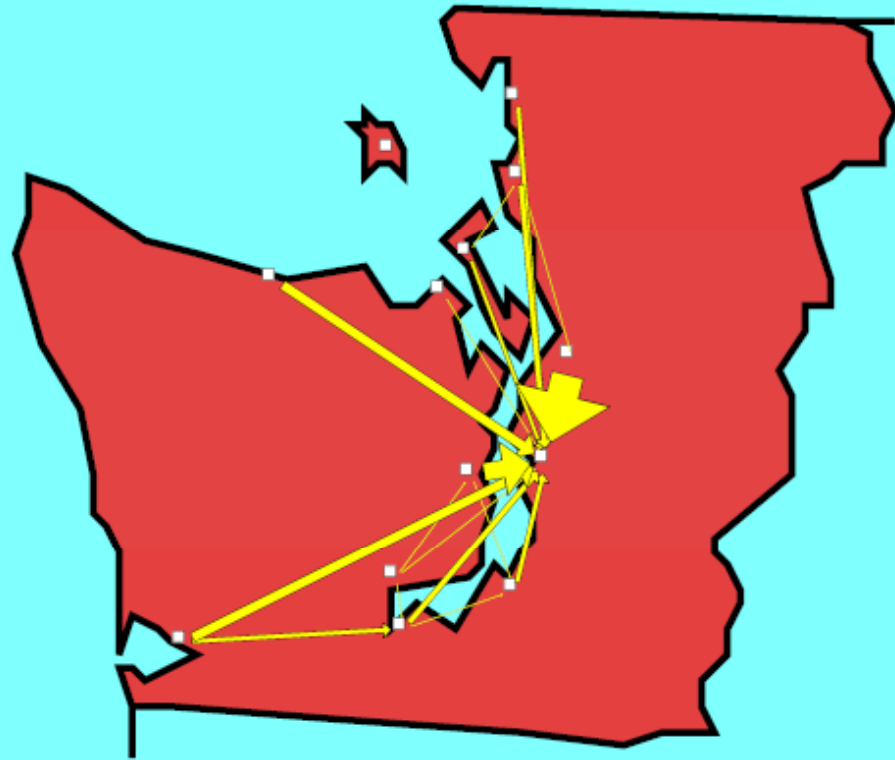
Variations in style

With islands, showing centroids, and title.

74-78 Cancer Treatment Flows > 200

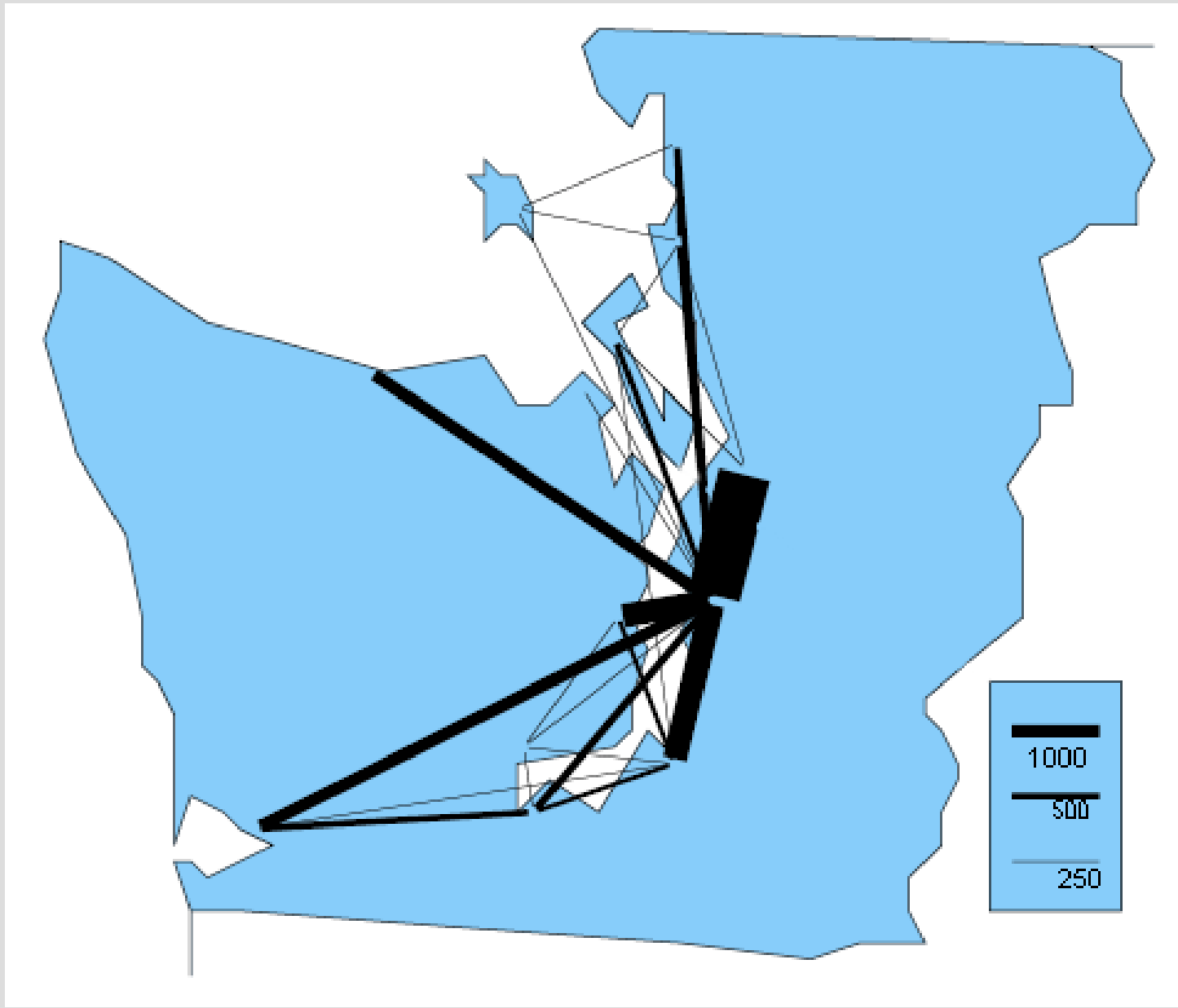


74-78 Cancer Treatment Flows > 200

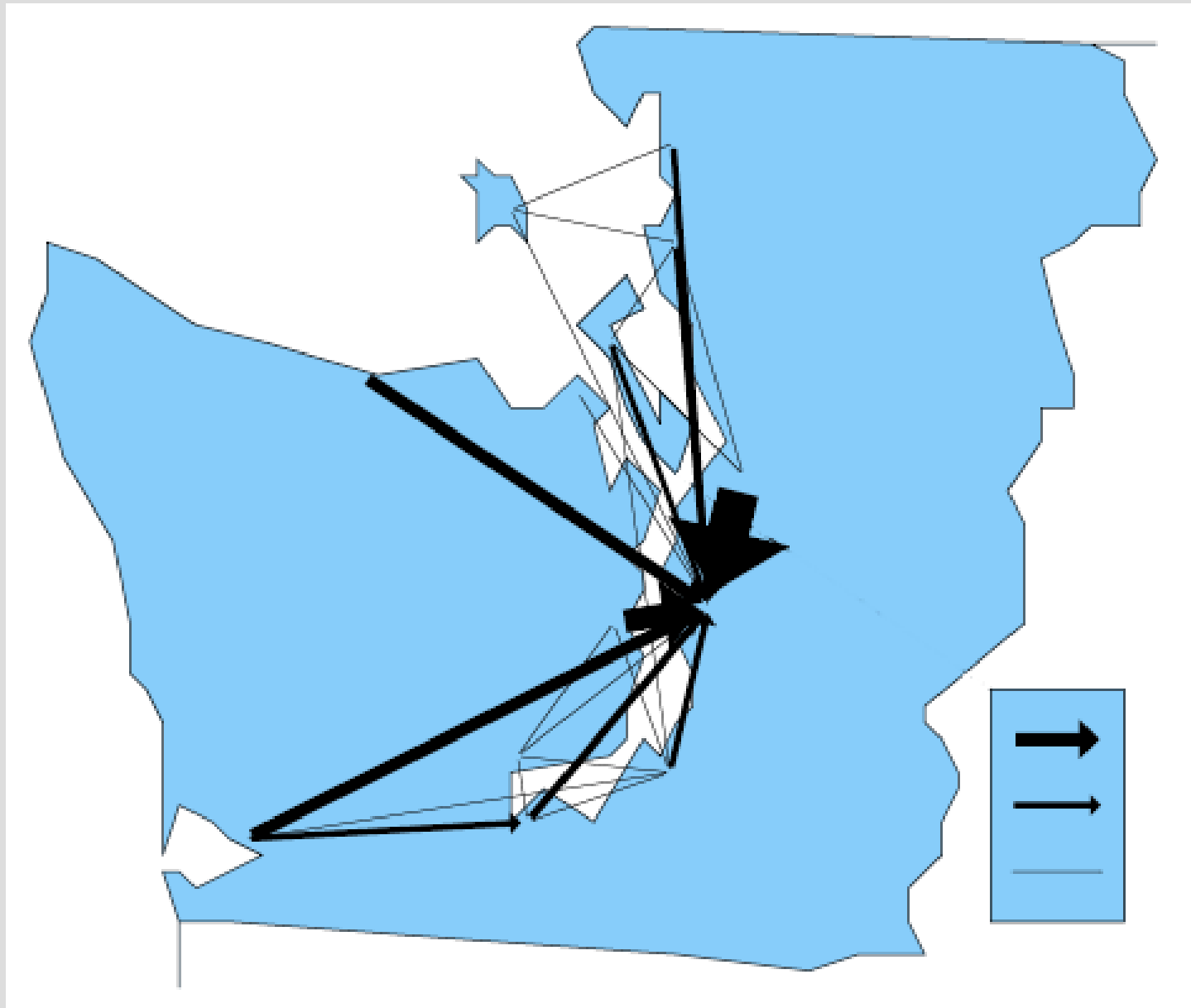


Legend Box

A legend box (an “island”) with gross moves. Numbers added later.



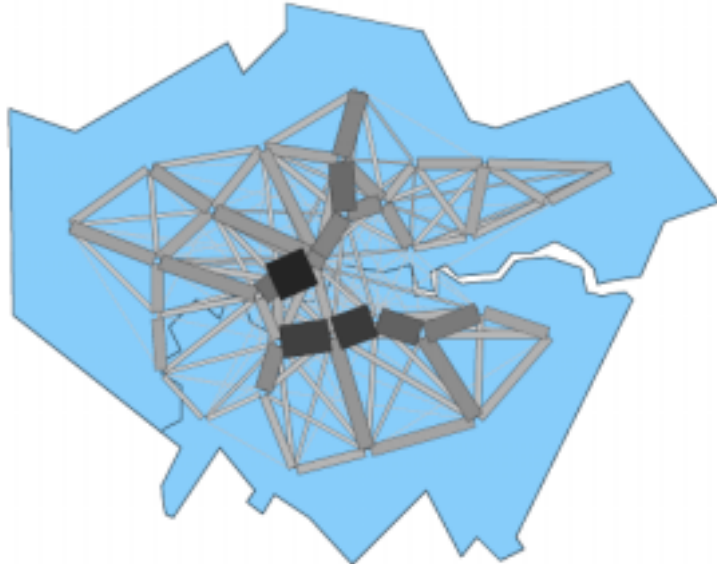
Legend box for net moves



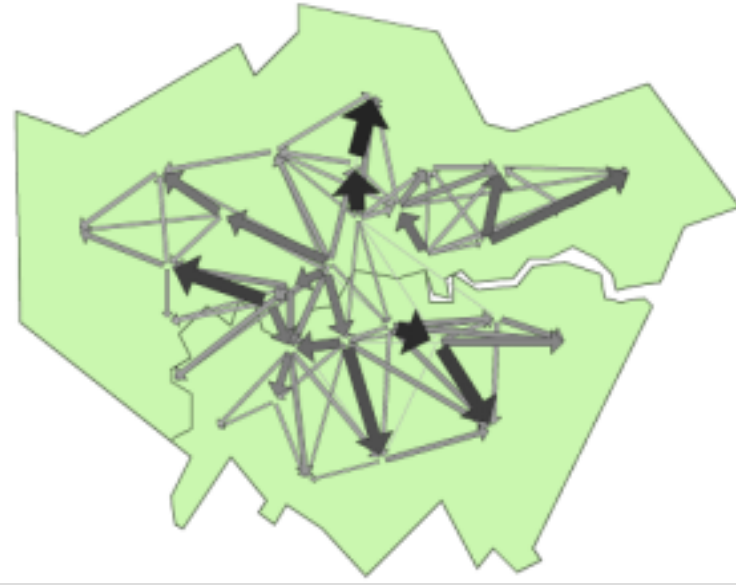
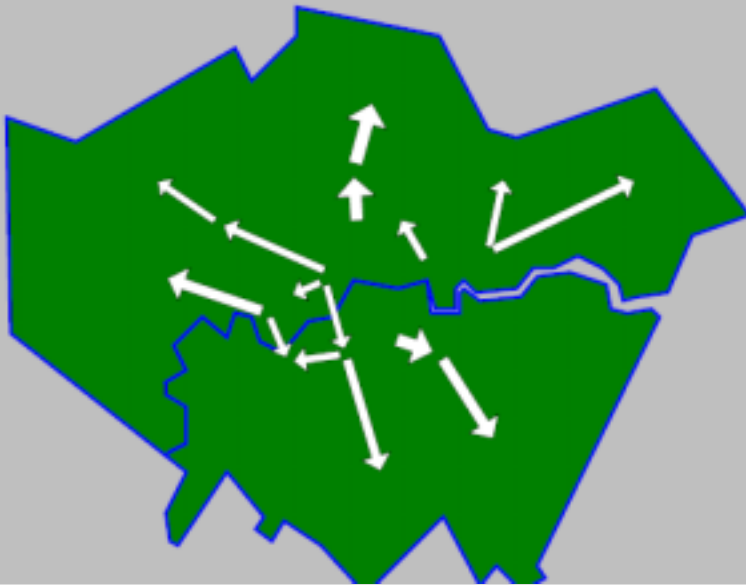
London 1965-1966 Inter-borough migration

from 33 boroughs.

Exploration of map styles, especially colors,



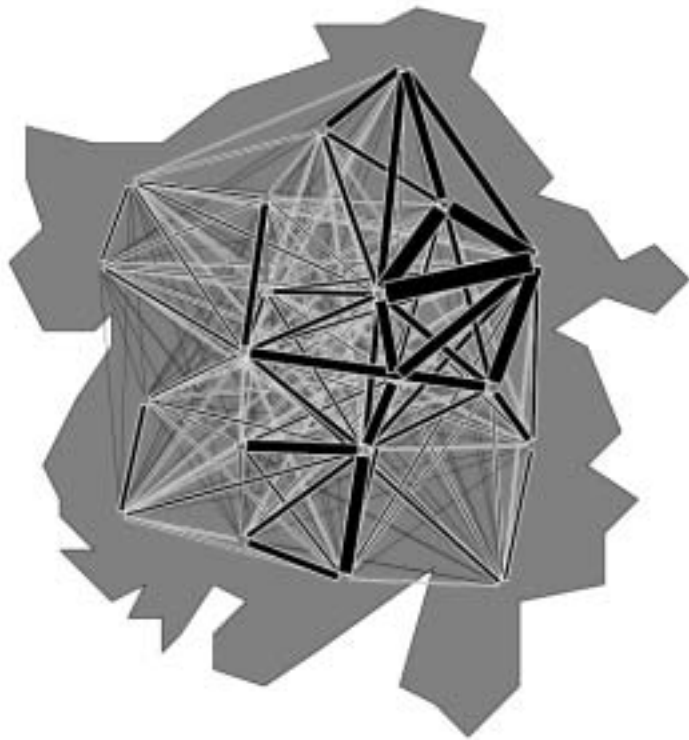
1965-1966 Outmigration



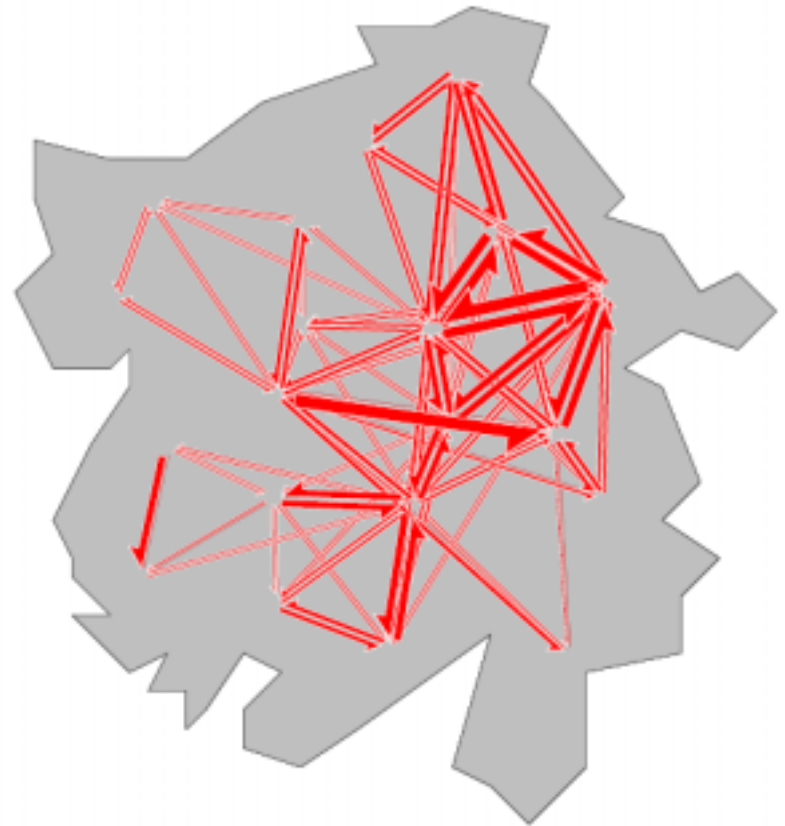
Commuting Pattern in Roanoke, VA, 1965

By Census Tract

1965 Roanoke, VA, Tract to Tract Commute Pattern



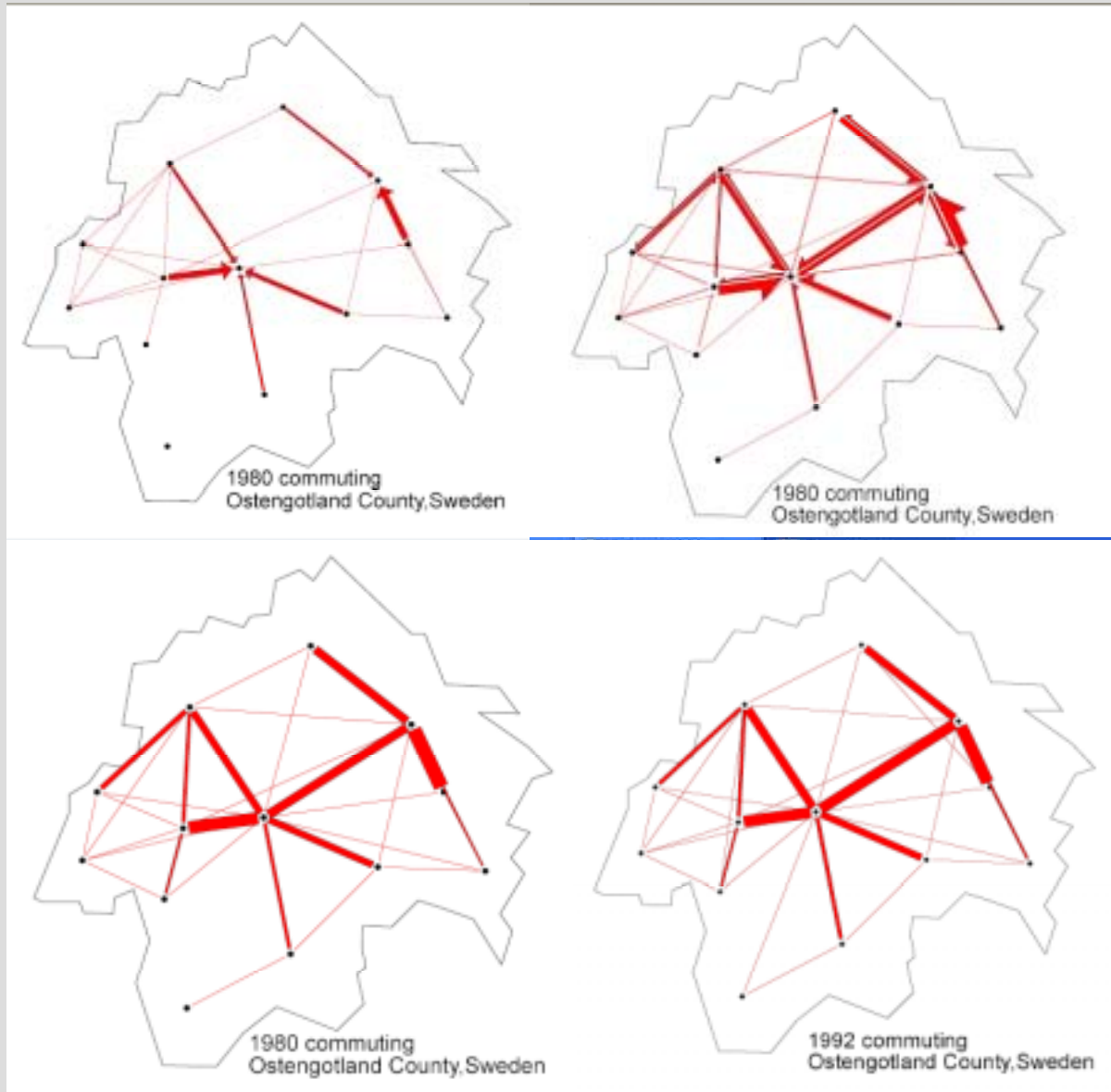
Commuting Map Roanoke, VA



Commuting in Östergötland, Sweden,

1980 (net, two-way, and total) & 1992 (total)

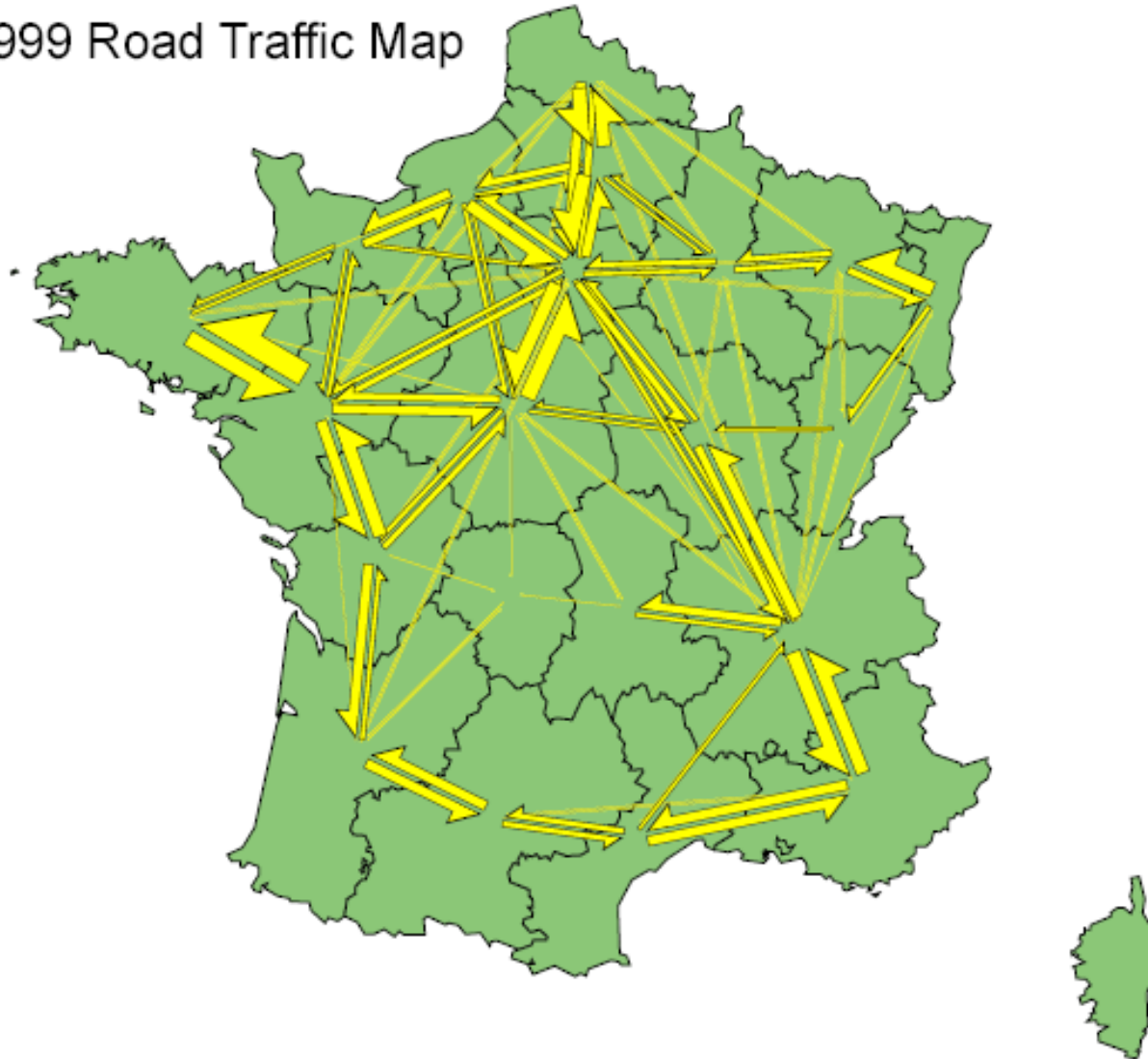
From P. Åberg (1998)



Movement between French Regions

Data courtesy of Mr. C. Calzada of Paris

1999 Road Traffic Map



Major World Trade 1978 Estimate



The next slide shows a non-geographic map

The diagram is based on a 23 by 23 table of referrals from one scientific field to another from a very large multi-year file of citations. For details see K. Boyack, 2004, *Proc.*, NAS, 101, suppl.1, 5192-5199.

The fields are positioned spatially using an ordination based on the from-to table.

The 'data points' are enlarged to show the labels.

Two-way flows above 25 referrals are shown.

Inter-industry, input-output, or other non-geographic tables, can also be rendered in this fashion.

The fields are:

Ag-Agricultural sciences

An-Anthropology

ABS-Applied Biological Sciences

AM-Applied Mathematics

APS-Applied Physical Sciences

BiC-Biochemistry

BiP- Biphysics

CB-Cell Biology

Ch-Chemistry

DB-Developmental Biology

Ec-Ecology

Ev-Evolution

Ge-Genetics

Im-Immunology

MS-Medical Sciences

Mi-Microbiology

Ne-Neurobiology

Phr-Pharmacology

Phy-Physiology

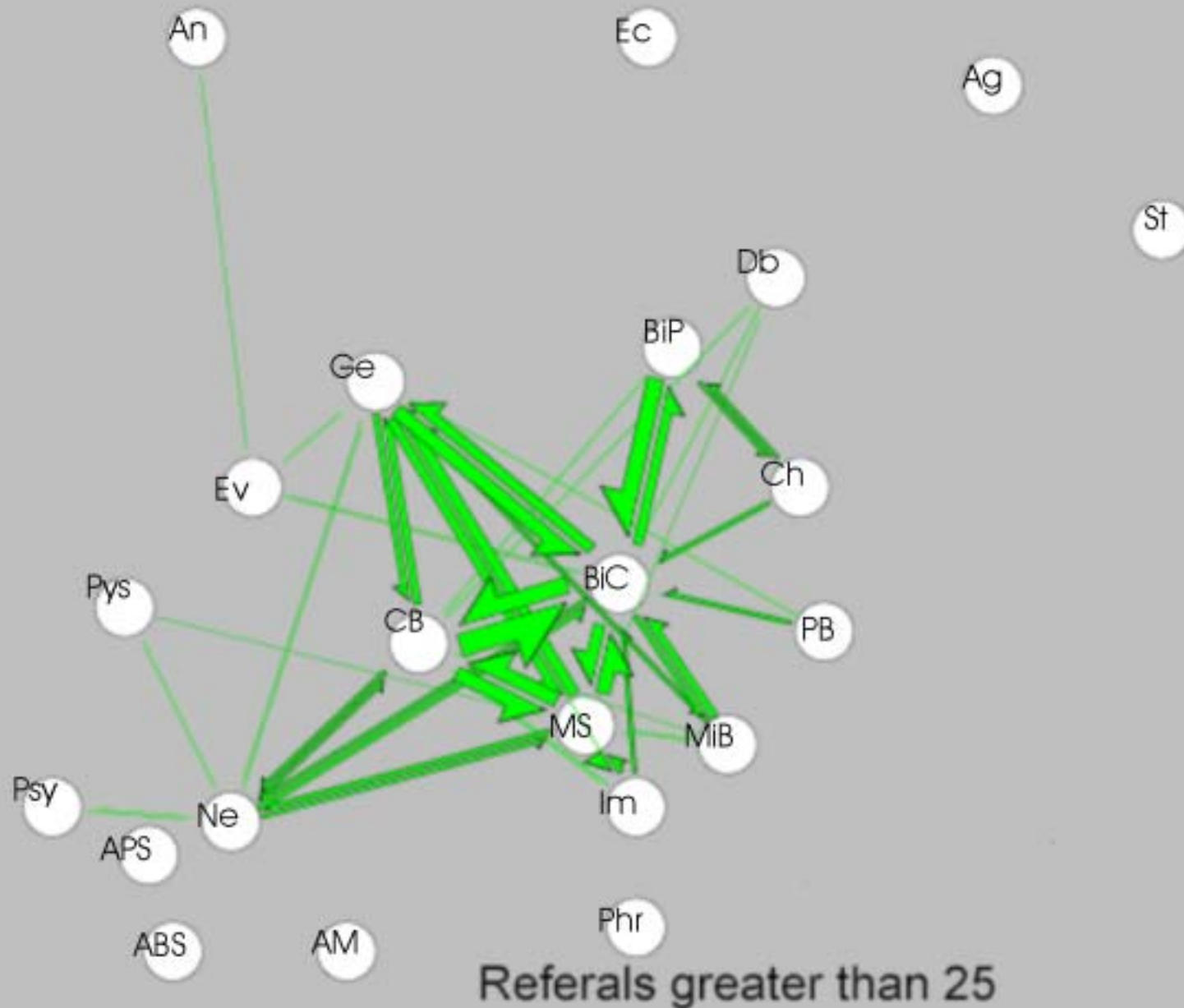
PB-Plant Biology

Po-Population Biology

Psy-Psychology

St-Statistics

Journal to journal referrals between scientific fields



End of Tutorial

Thank You For Your Attention

NOW experiment with your own data or try some of the files that came with the program in the Data_Sets folder,
or repeat part 1 of the tutorial.

Comments or samples of your work done with the flow mapper program are appreciated. Send them to:

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University of California
Santa Barbara, CA 93106-4060
<http://www.geog.ucsb.edu/~tobler>