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

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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.	CSISS presentations, news, personnel, and sitemap. Our Strategic Plan and Annual Reports are also found here.

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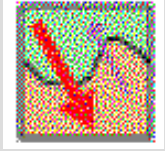
Tobler's Flow Mapper



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

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 requiremts.
2. Install Dot.Net Framework, if necessary. Go to *Start > Control Pane*l. 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 installedt, 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

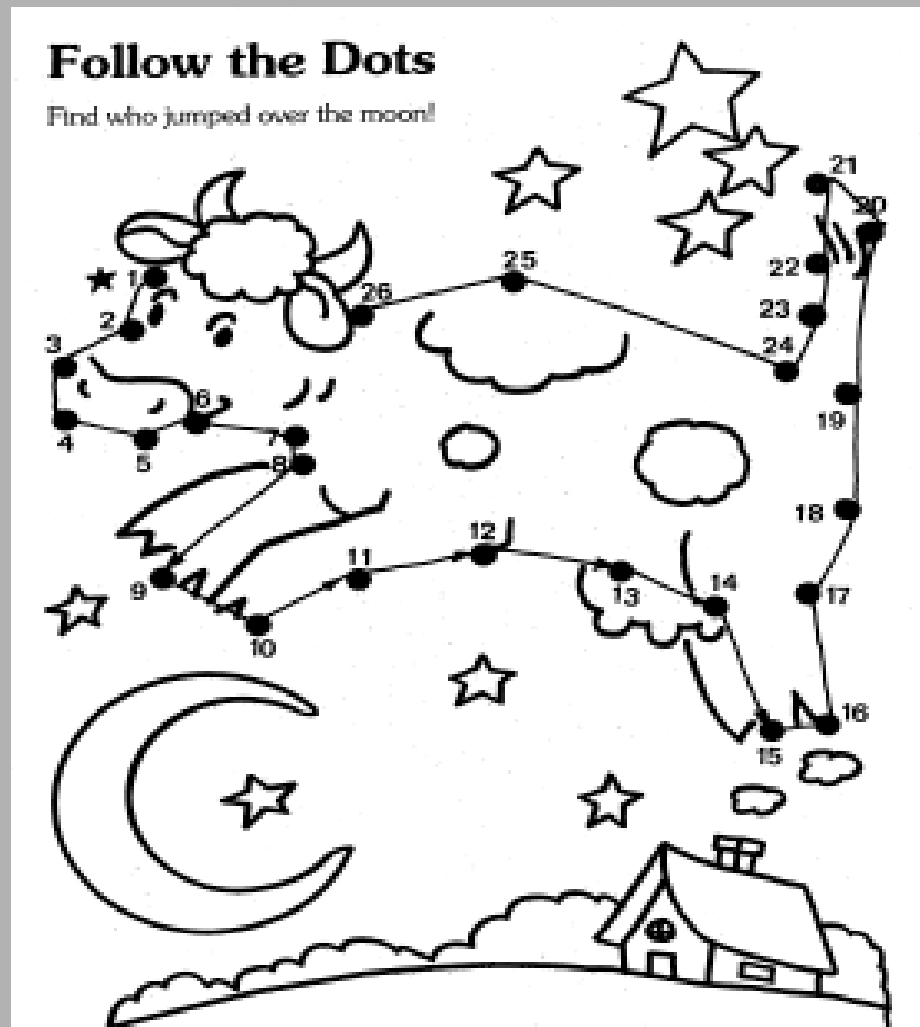
Parts I, II, III

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



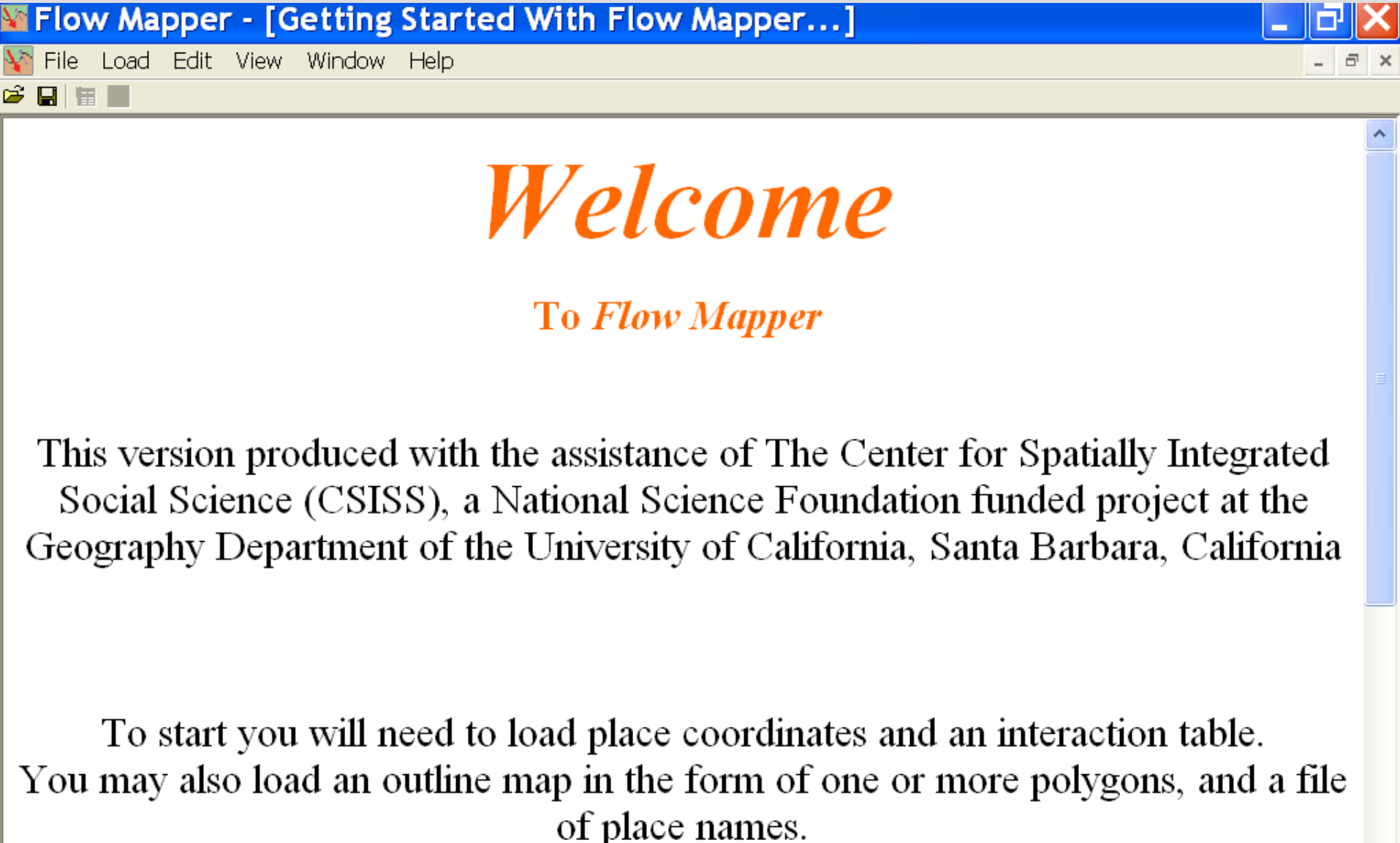
Tutorial Part I

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

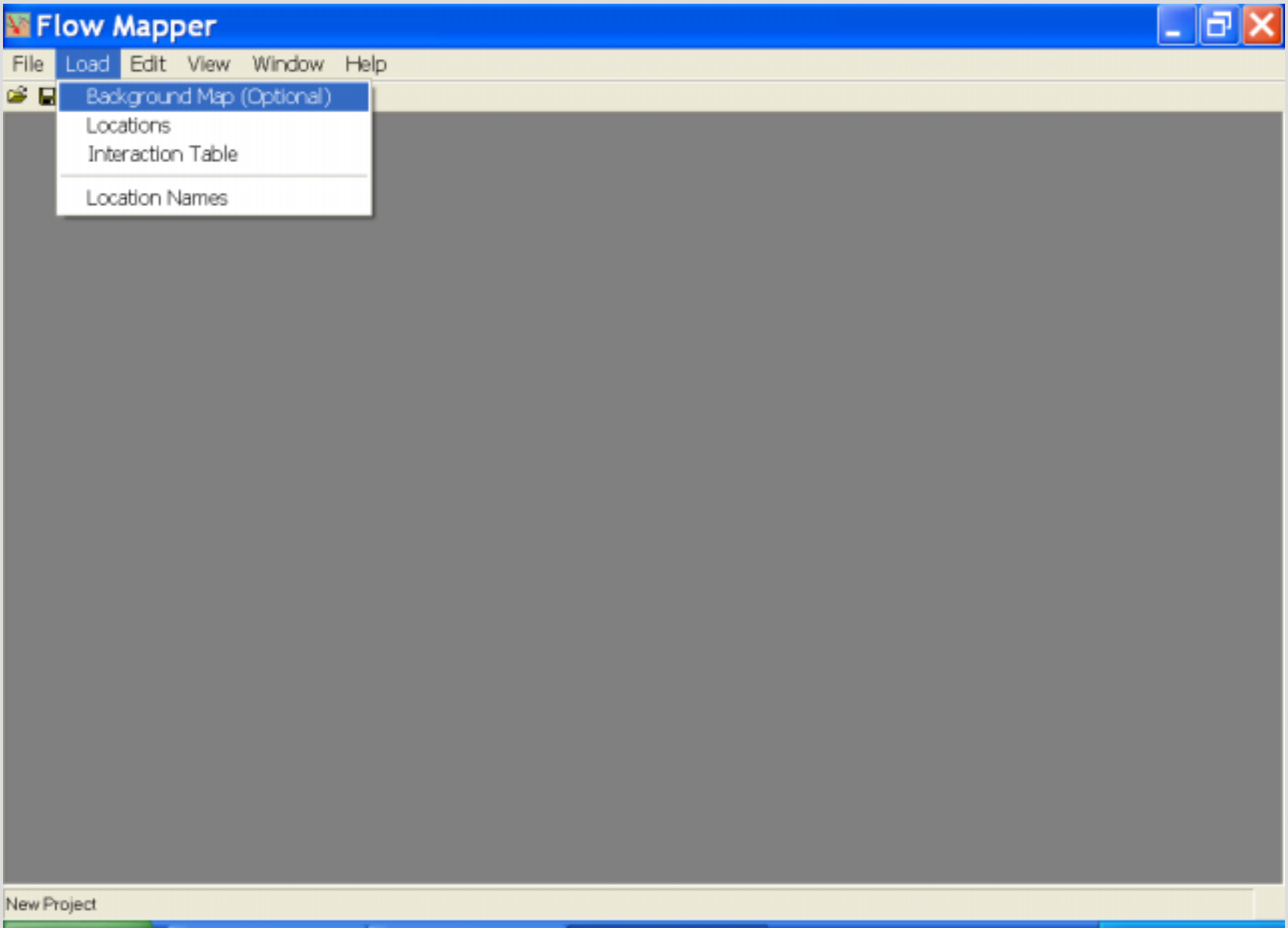
and choose the appropriate program to convert your data.

(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.

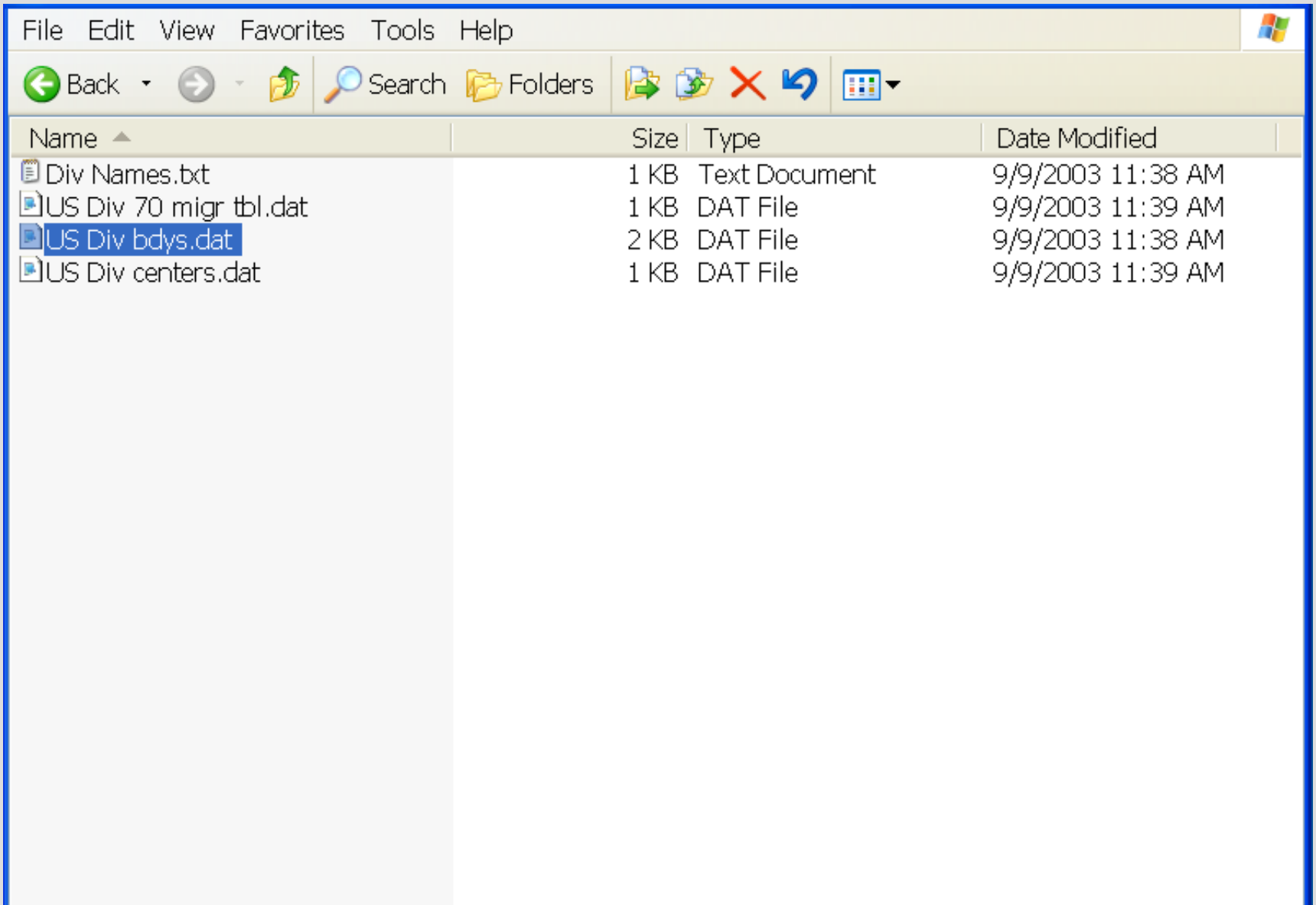
In oder to do this you will need to exit the Flow Mapper program, convert and save the data, and then restart the Flow Mapper program using the movment table that was created..

Load a background map



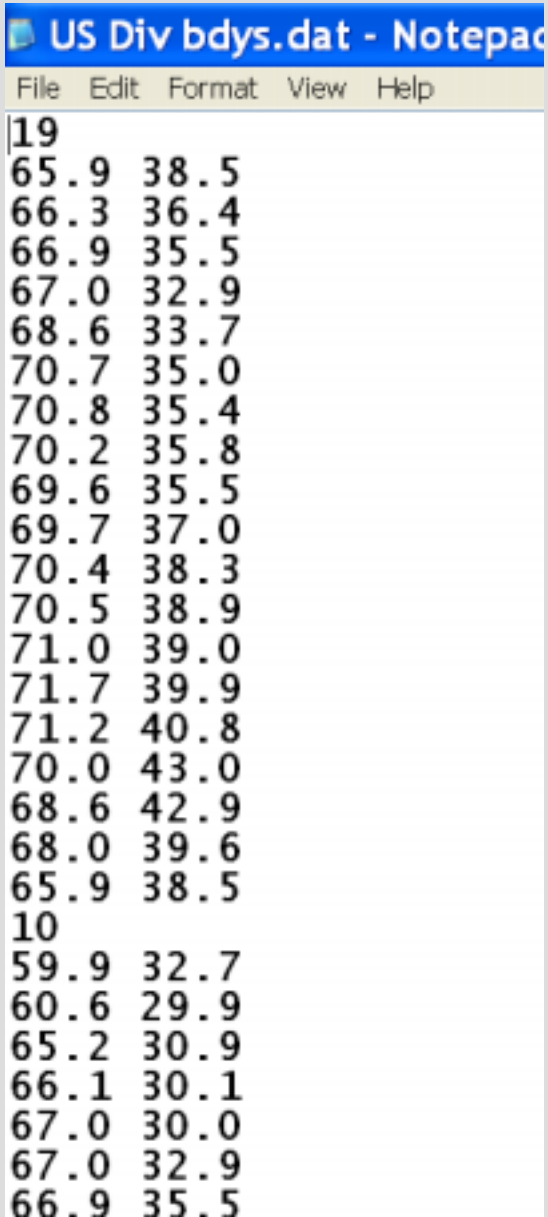
Locate the file containing the background map

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

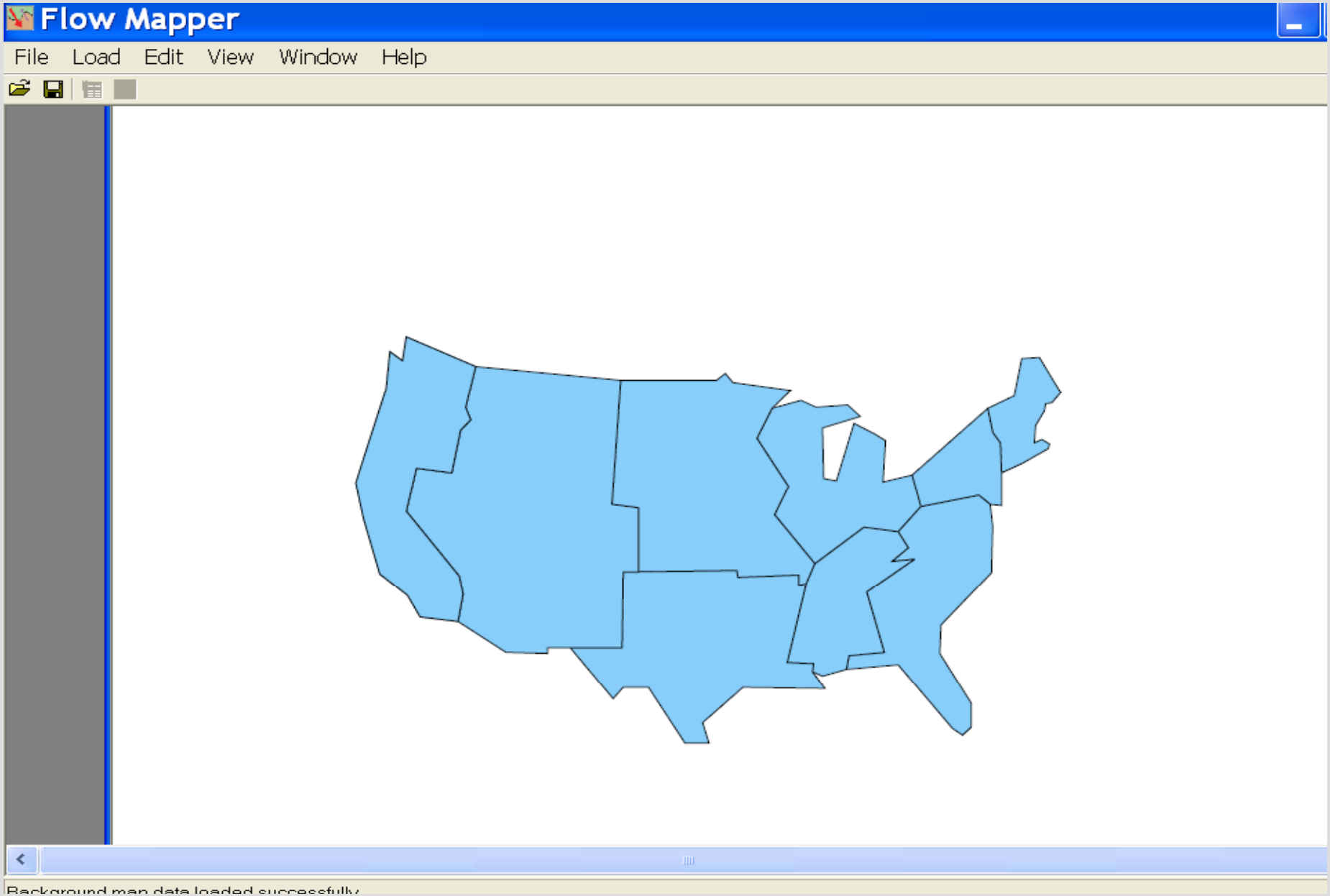


Boundary Coordinates

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

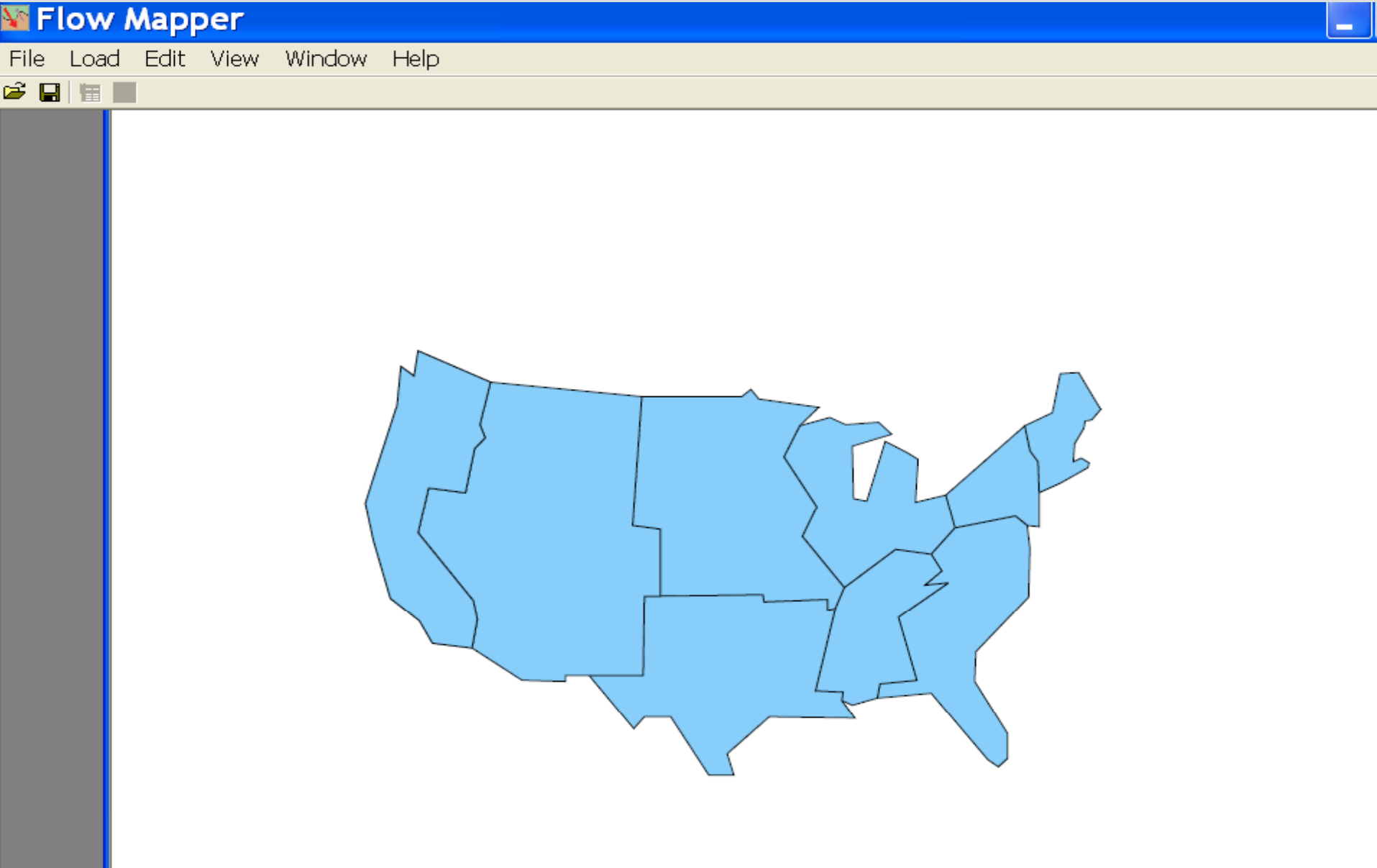


Background map selected



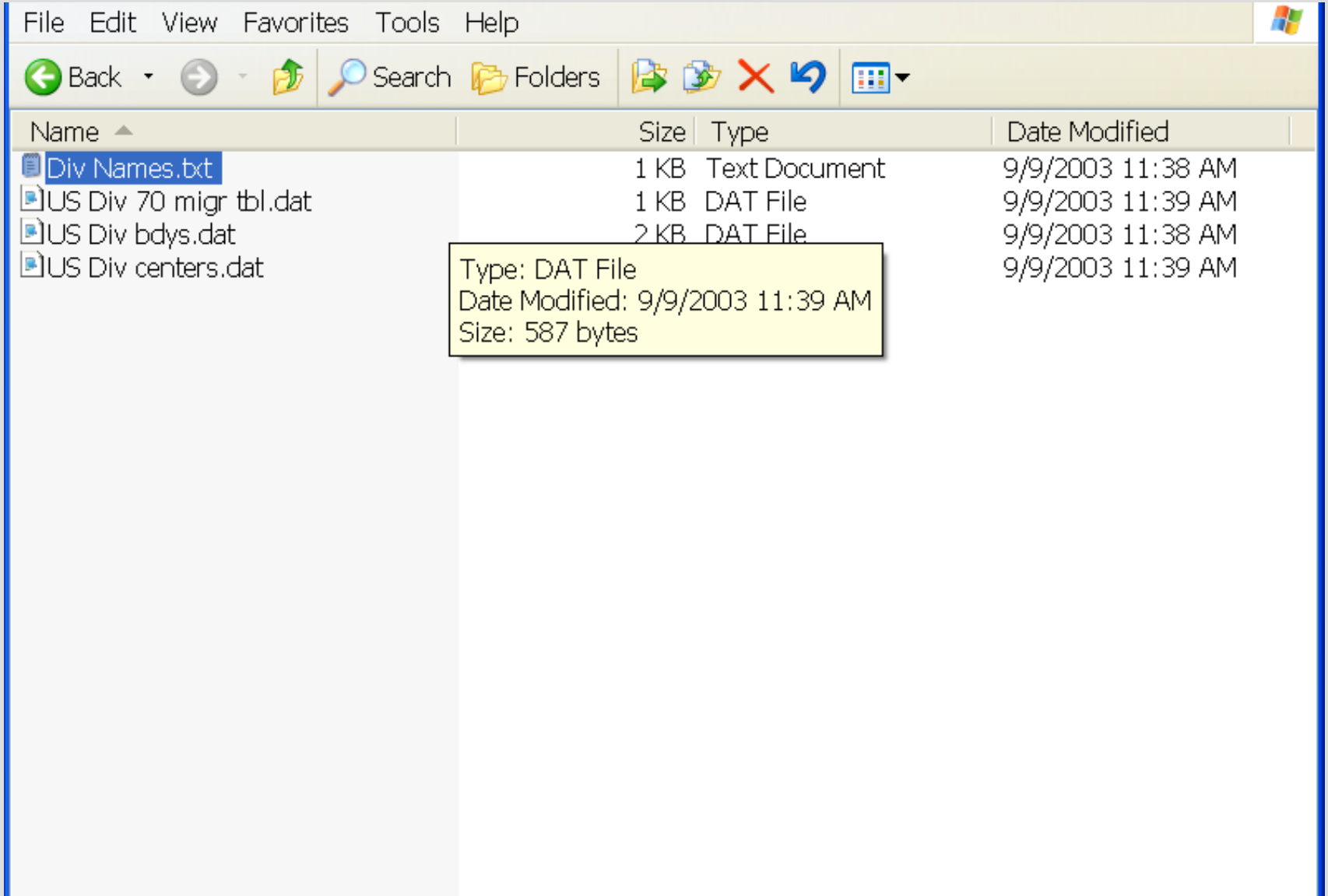
Then load location names

If you have them

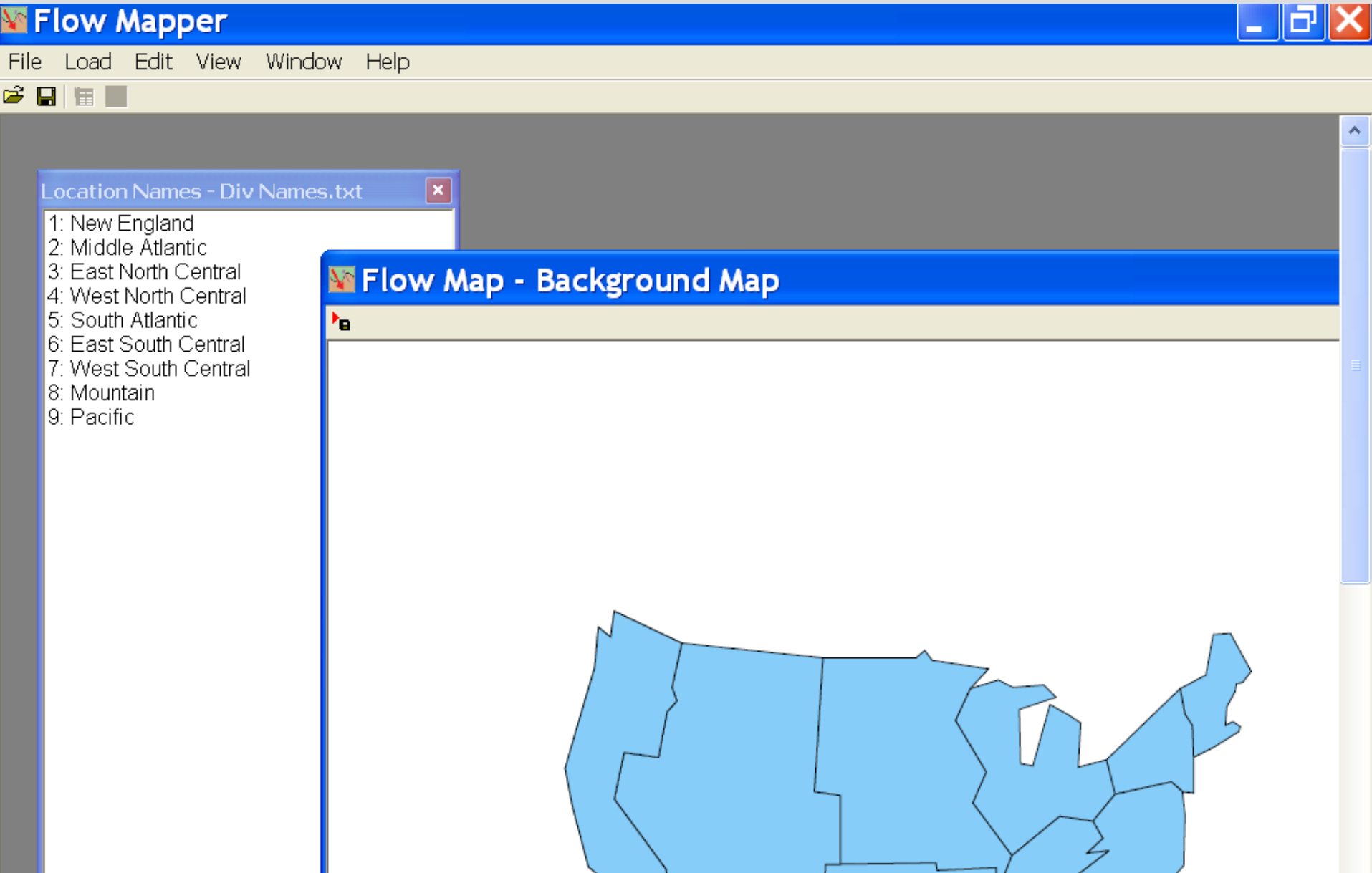


Select location names file

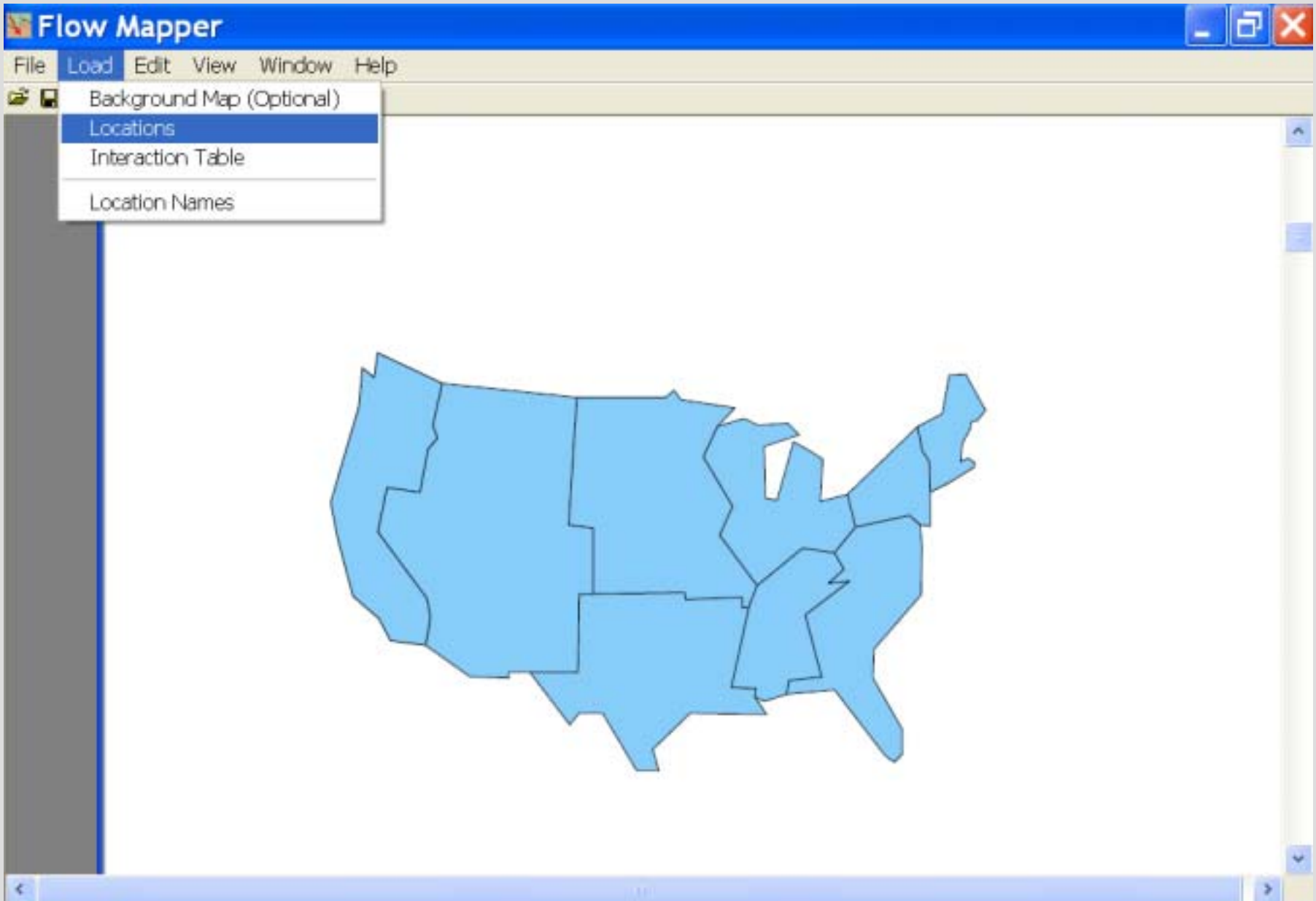
Then load it.



Location names selected and loaded.

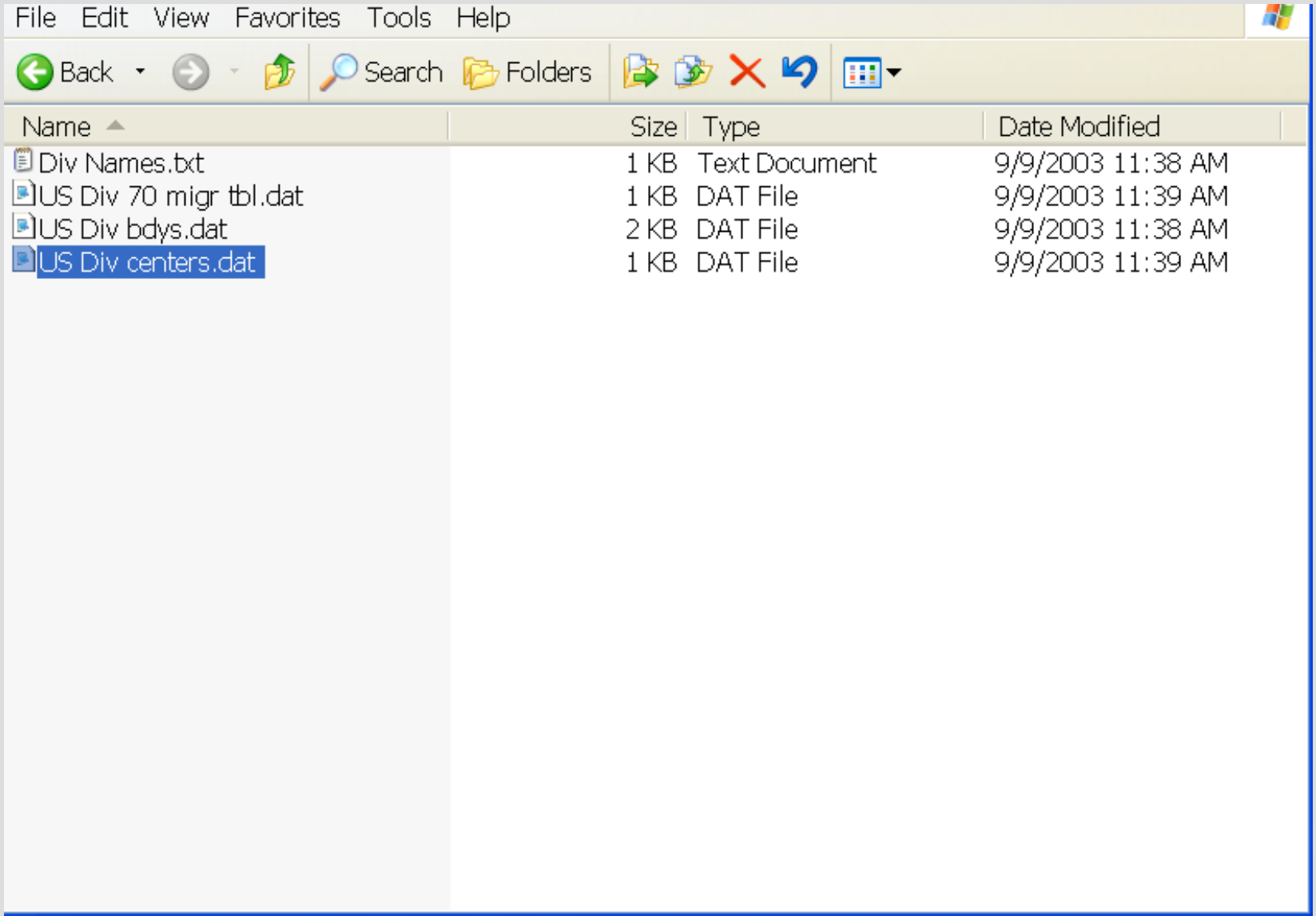


Next: Load locations



Select the centroid coordinate file

Then load it,



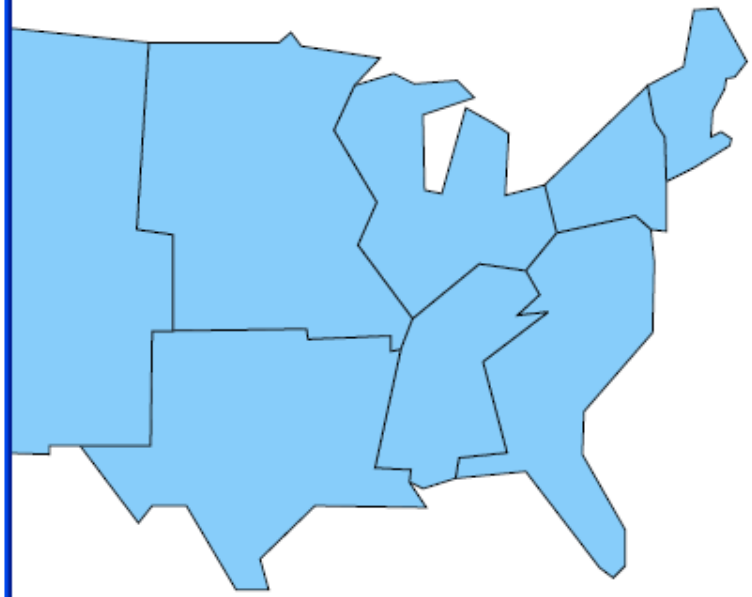
Locations (centroids) loaded

Flow Mapper

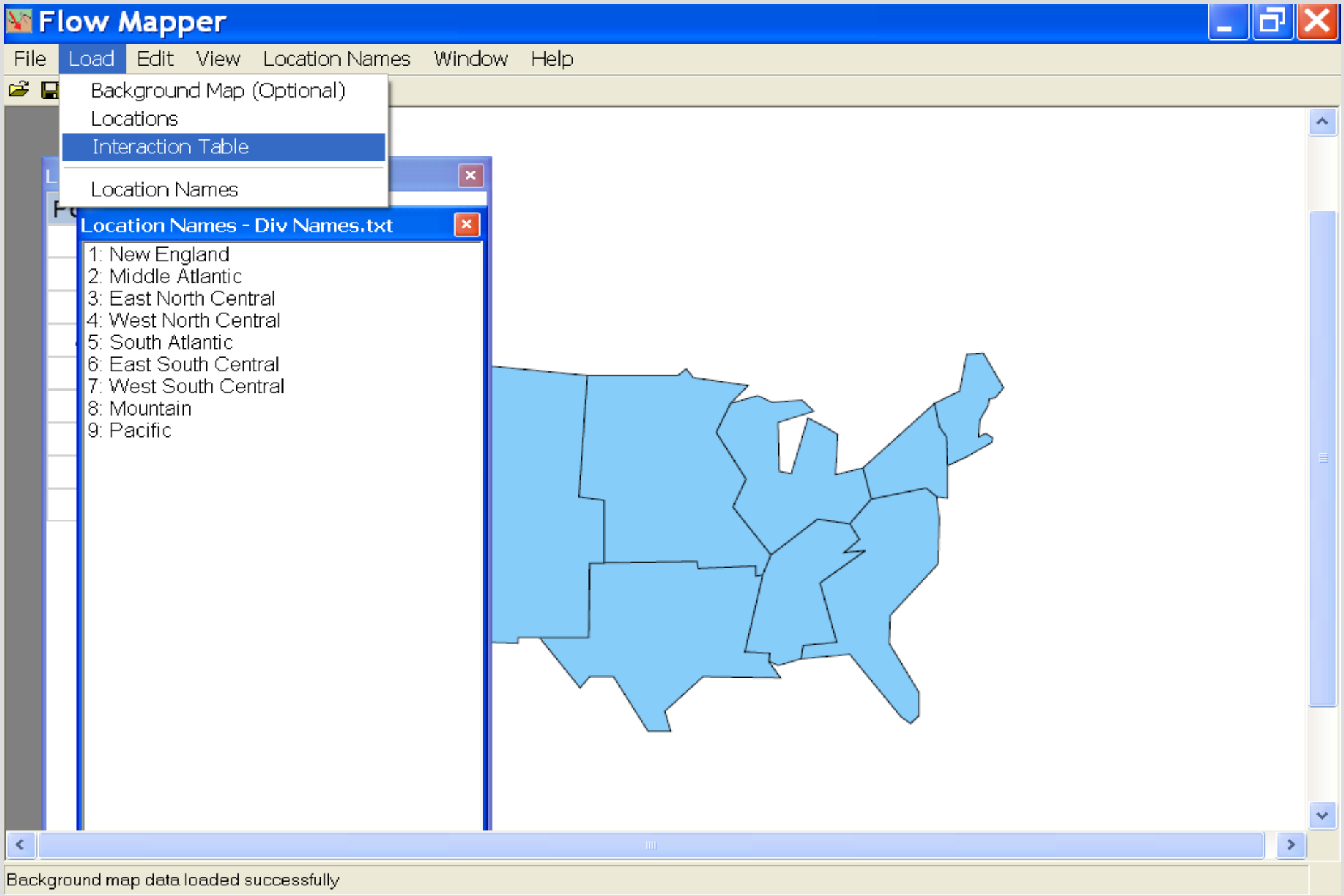
File Load Edit View Locations Window Help

Locations - US Div centers.dat

Point	X	Y
1	70	40
2	64	34
3	53	30
4	43	35
5	62	26
6	55	23
7	46	19
8	31	33
9	19	30

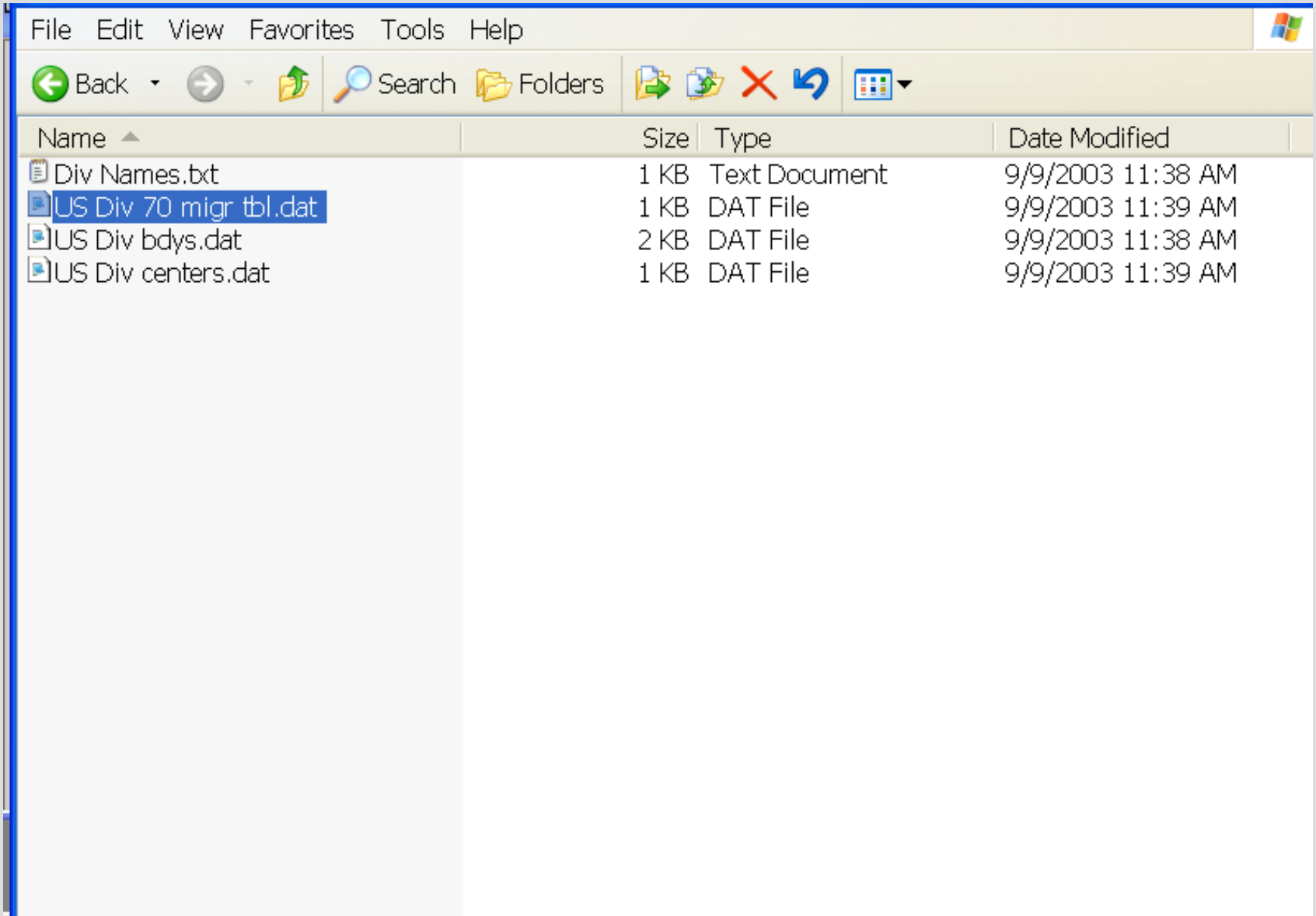


Load interaction table

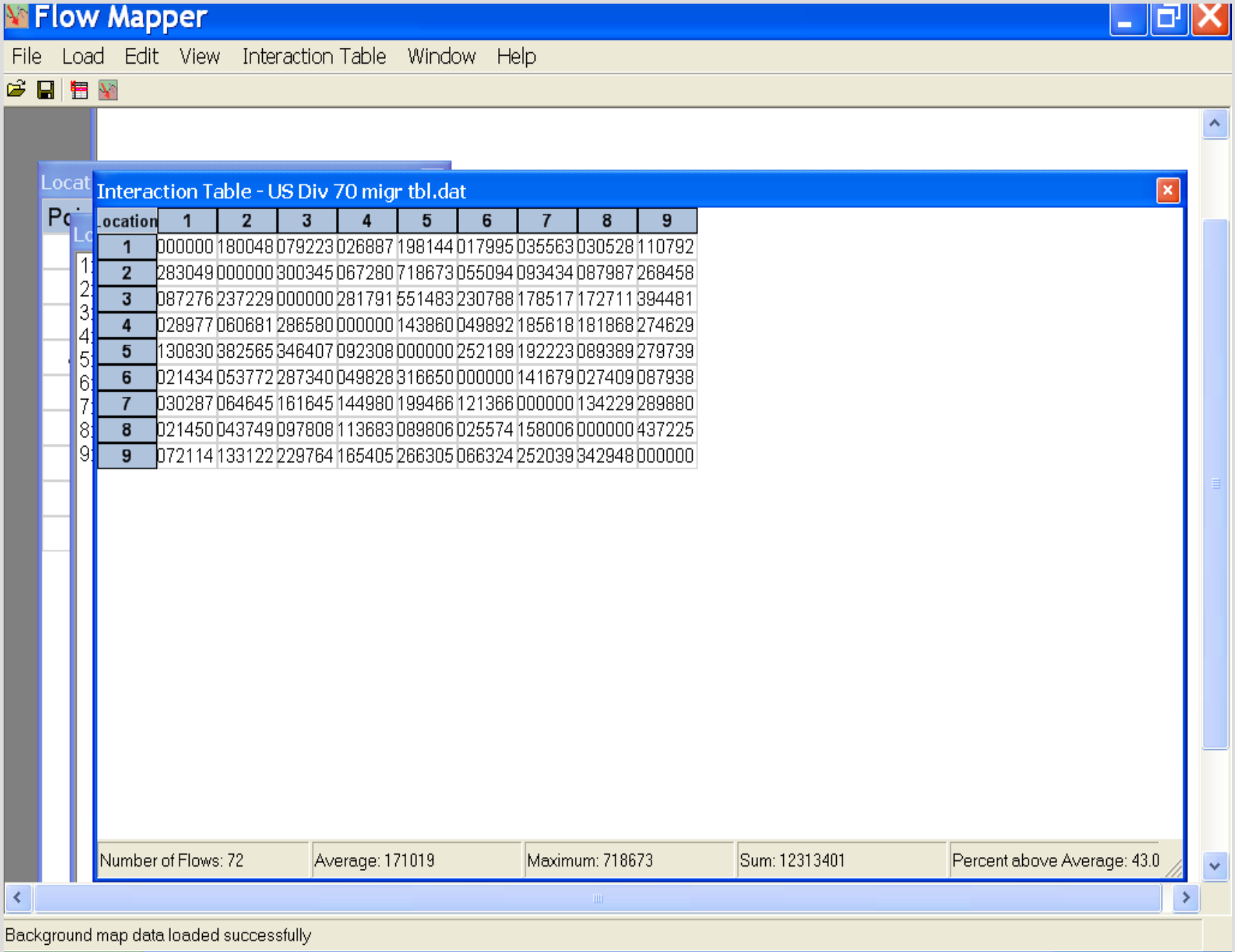


Select interaction table

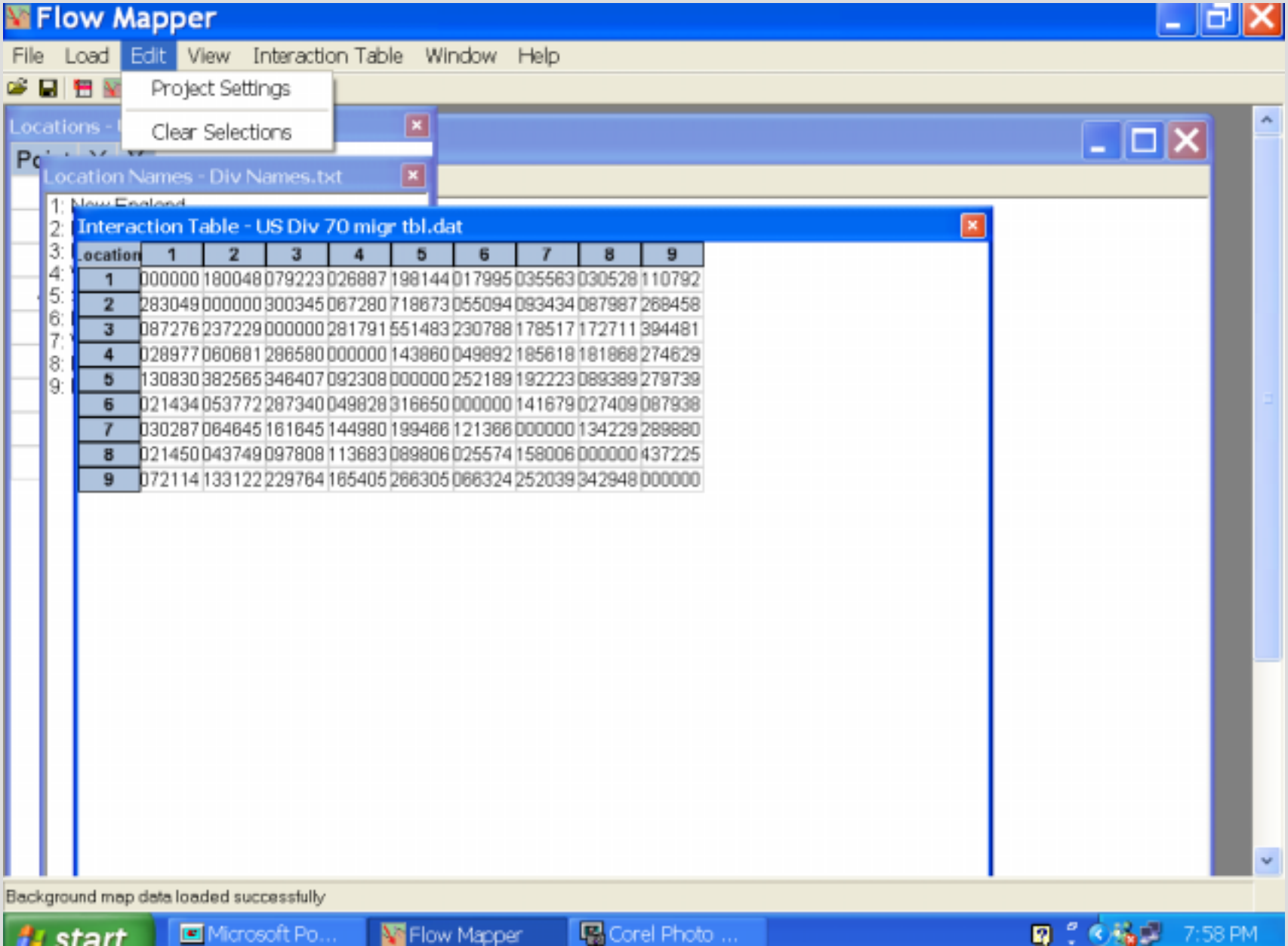
Then load it



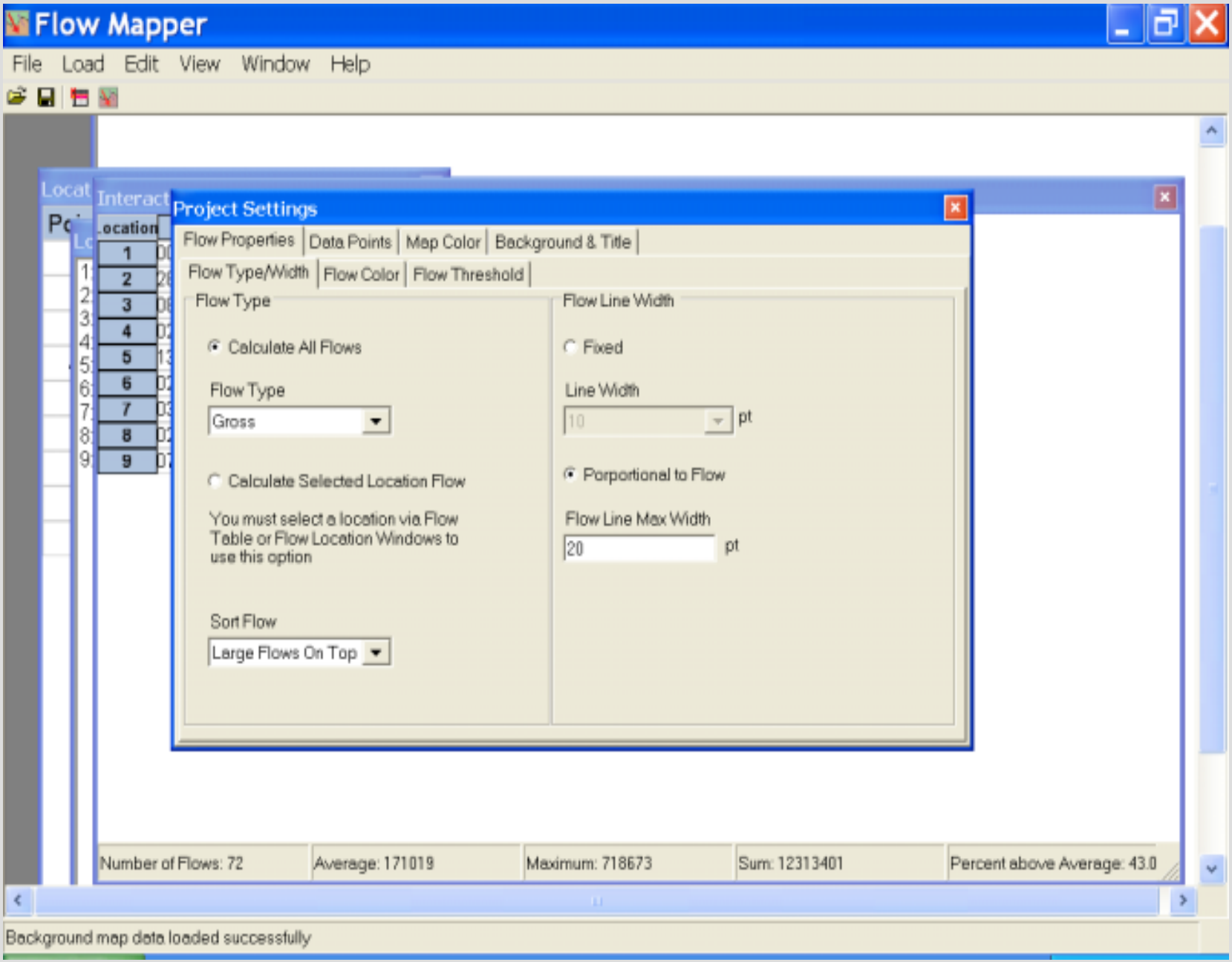
Interaction table loaded



Select EDIT from the menu



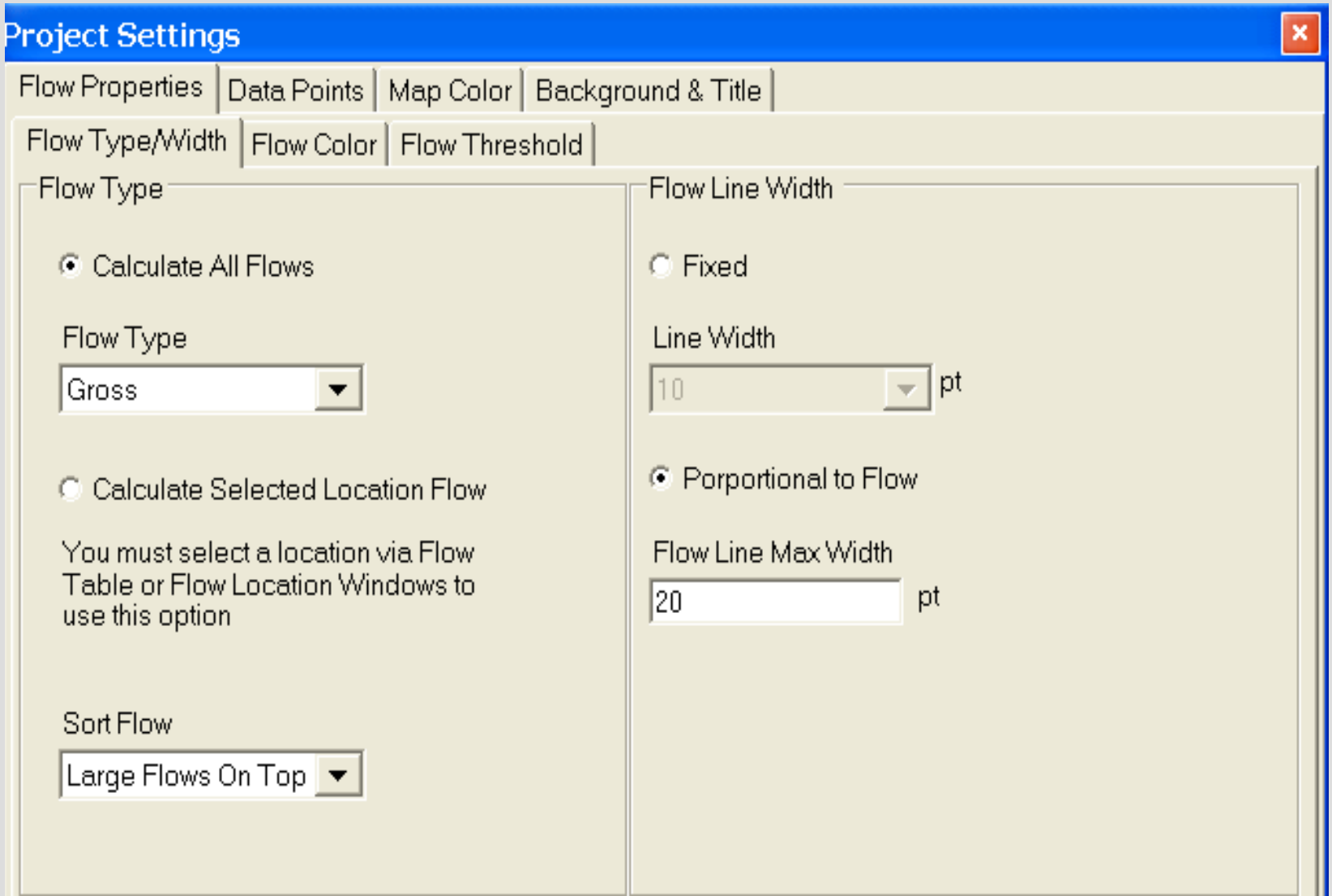
Project settings menu selected



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

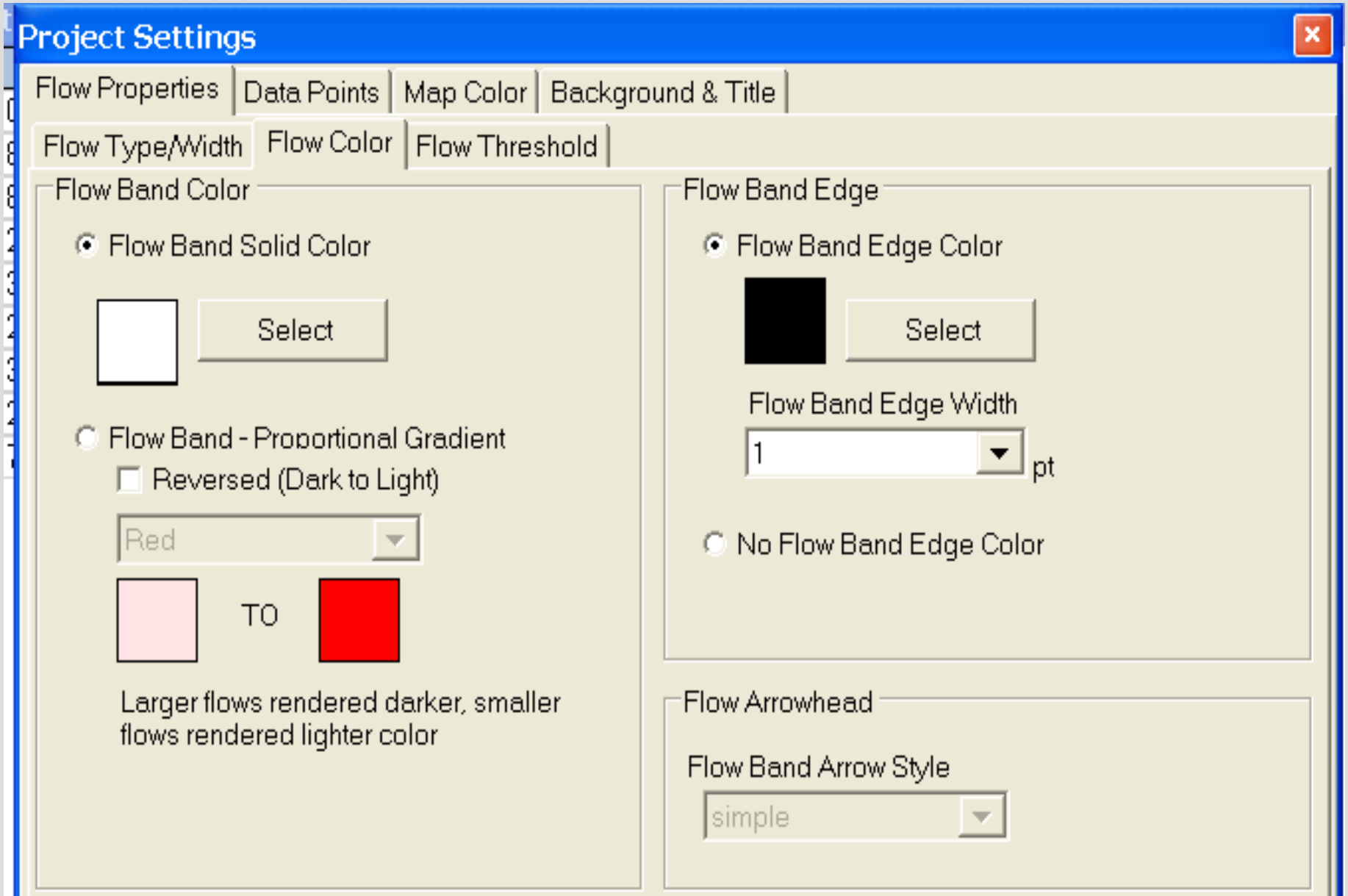
Sort: Large/small on top, large recommended

Line Width: fixed, proportional, maximum size



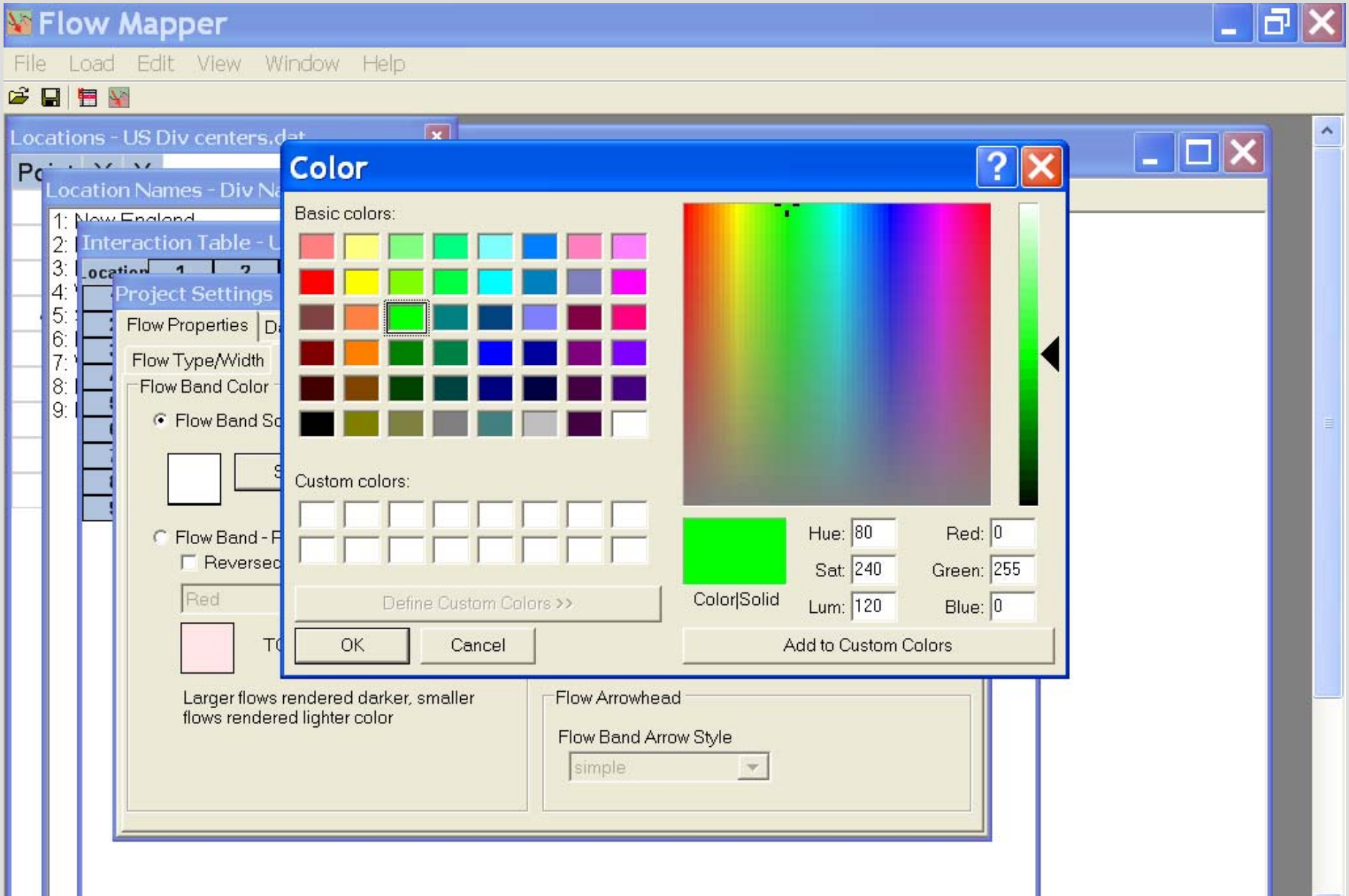
Flow band properties

Solid color, gradient, arrowhead style, edge color options



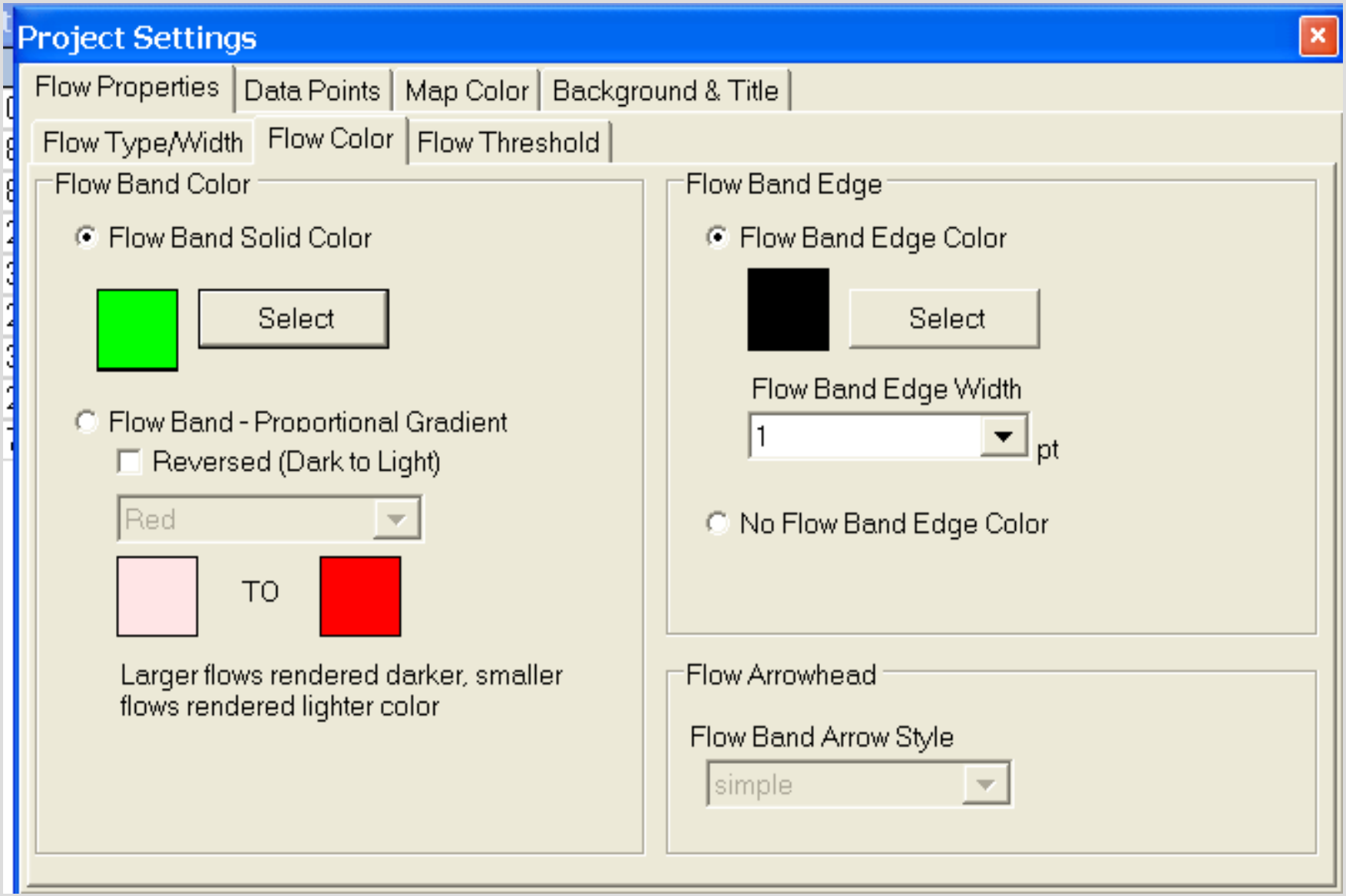
Color selection menu

Note RGB values. Click OK after choosing.



Color appears in the flow band box

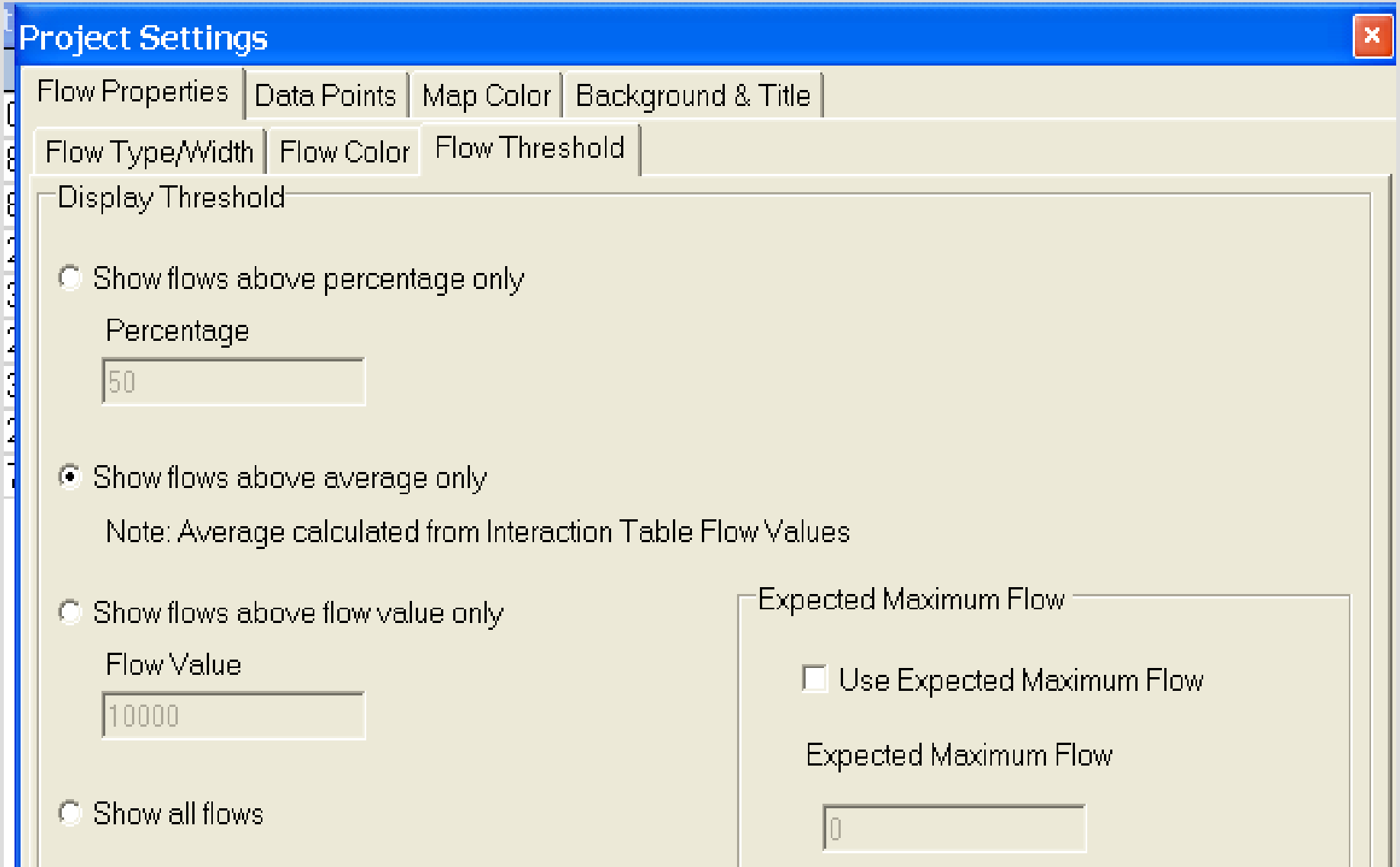
Gradient available in three colors. Edge color helpful when overlaps occur.



Threshold

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

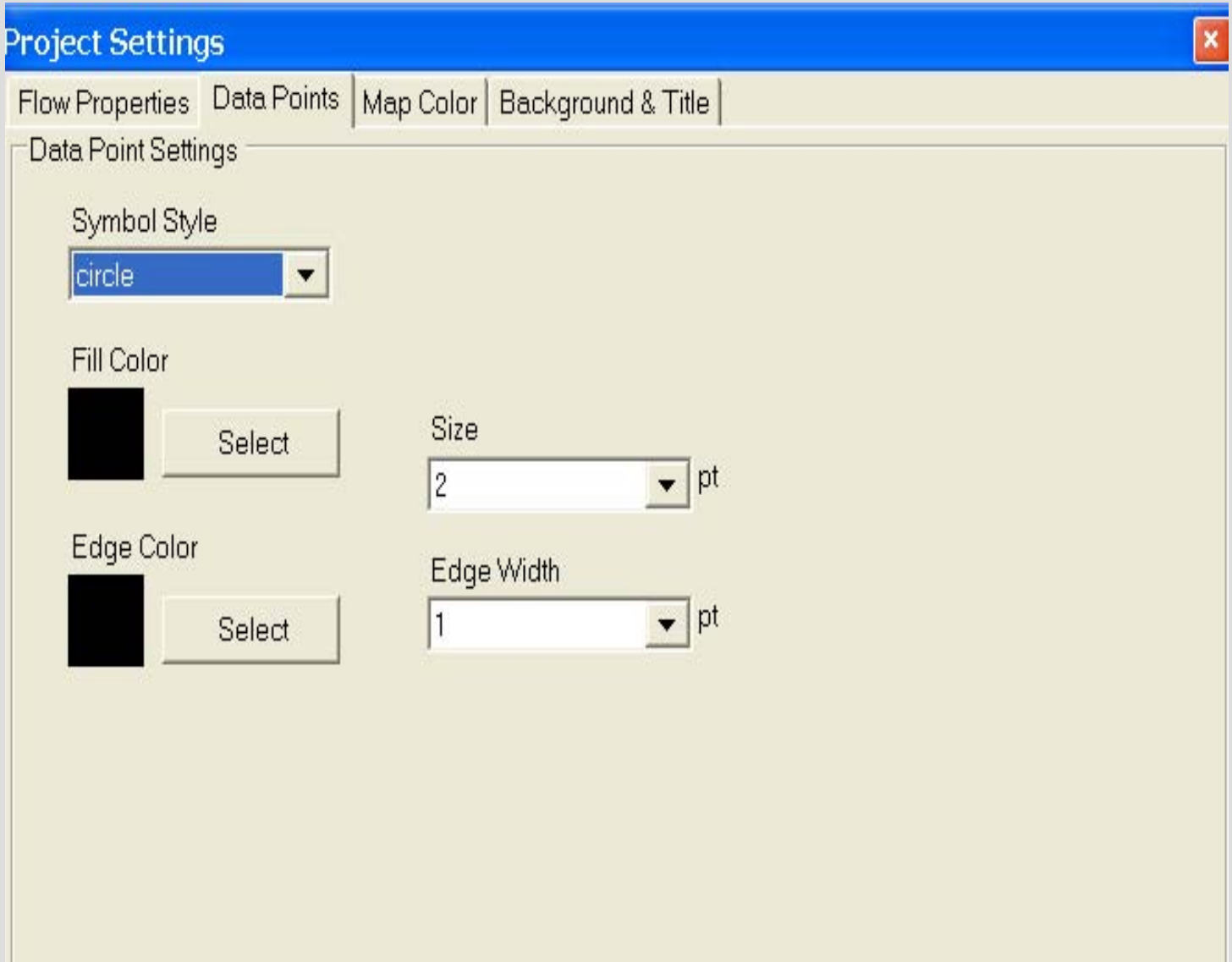
Note that the average calculated from the interaction table is of all array entries and that the gross flows may exceed this and net flows can be much smaller.



Centroid point display

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

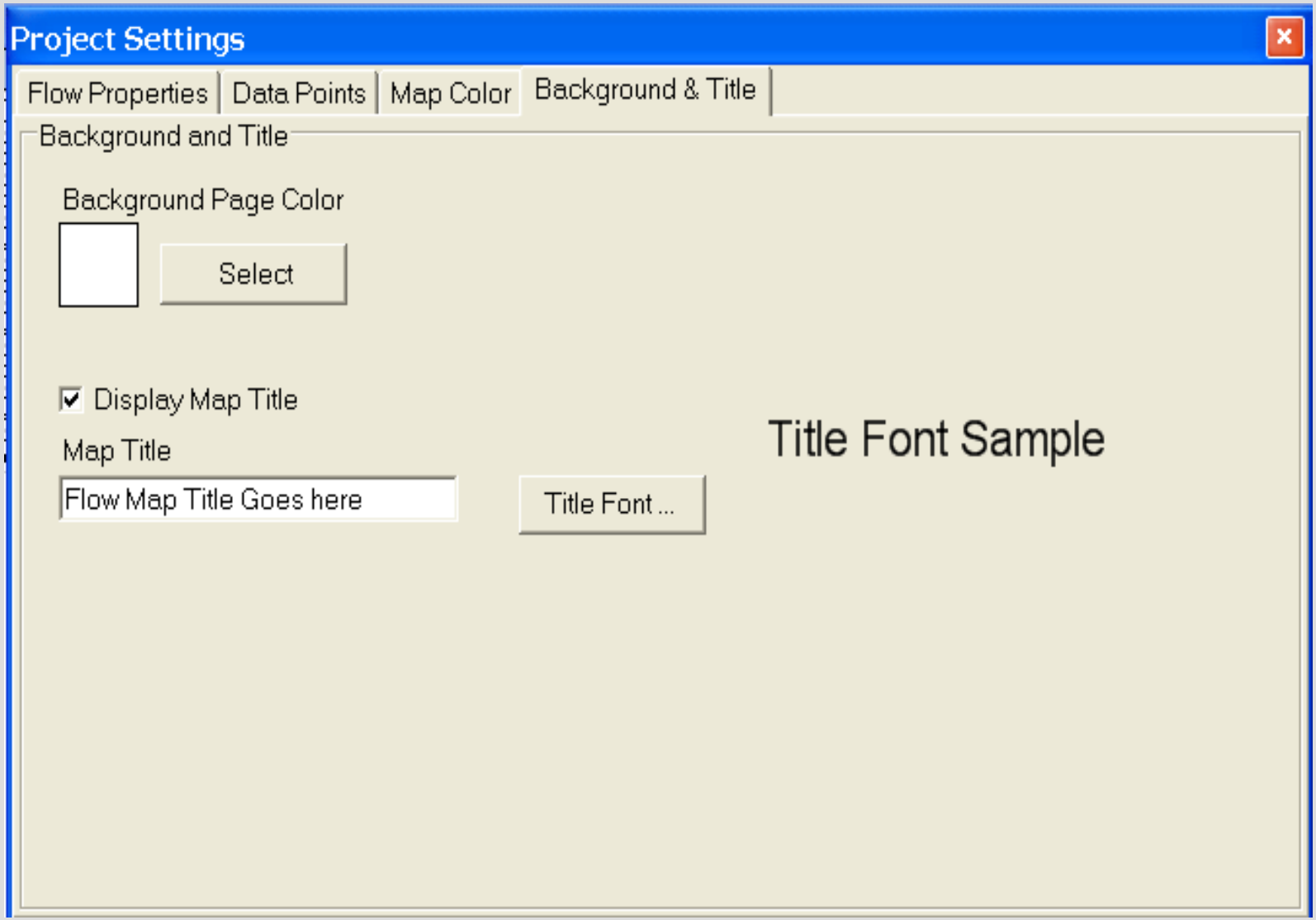
A centroid must be displayed for it to be identified when the mouse hovers on it



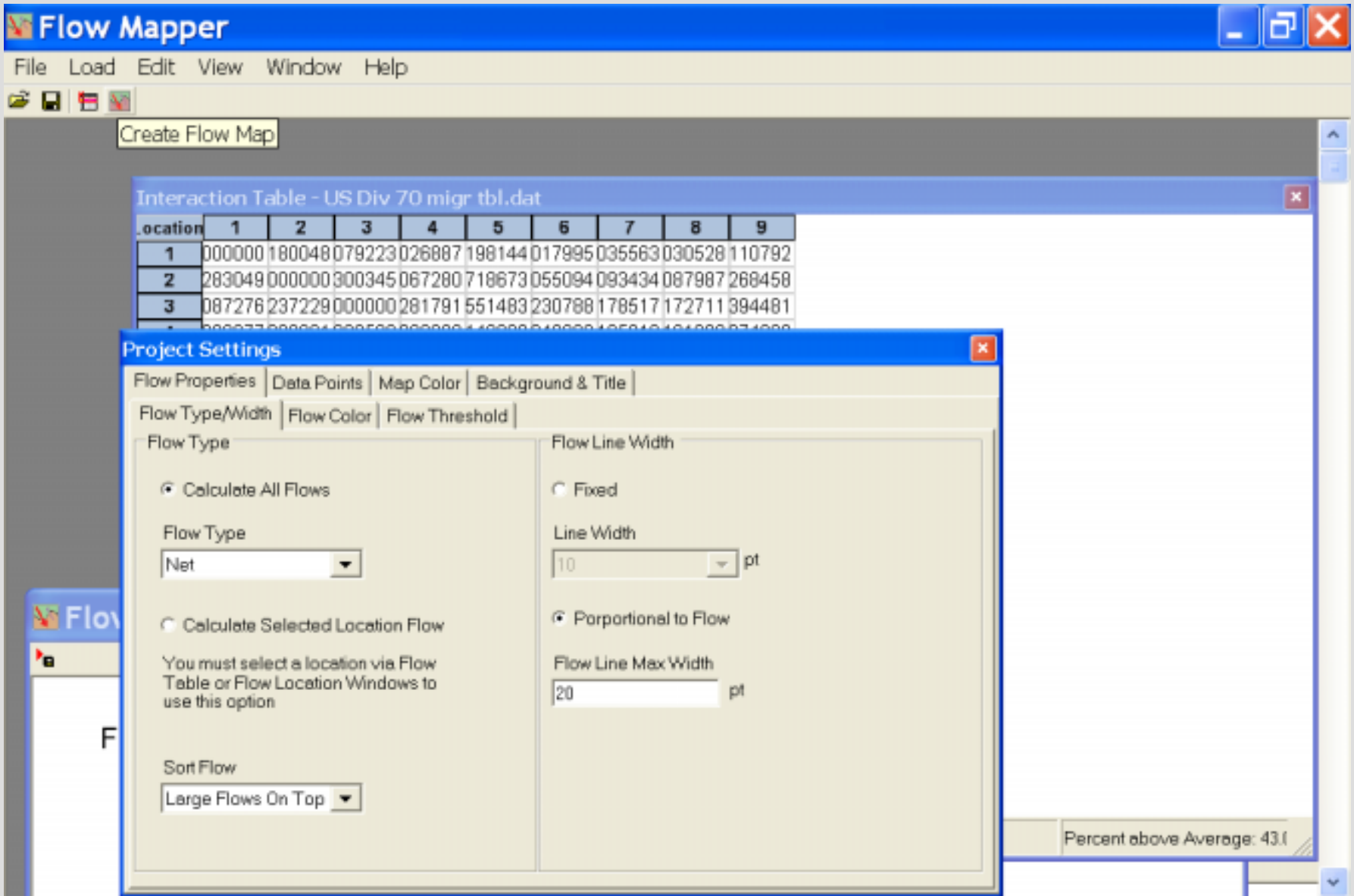
Background color and title

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

Back-slash separates title lines

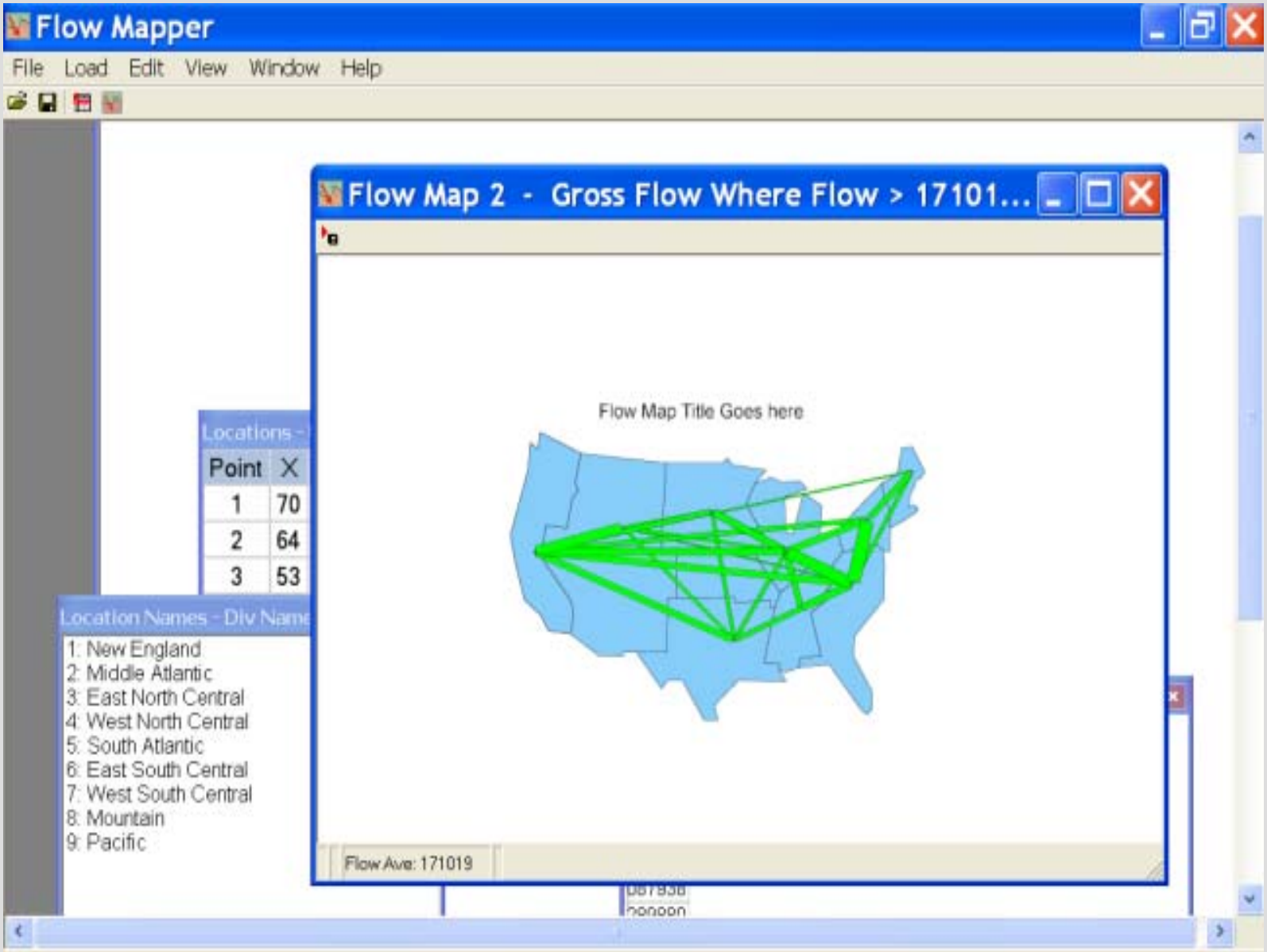


To make a map click on the rightmost icon on the second line in the upper left.



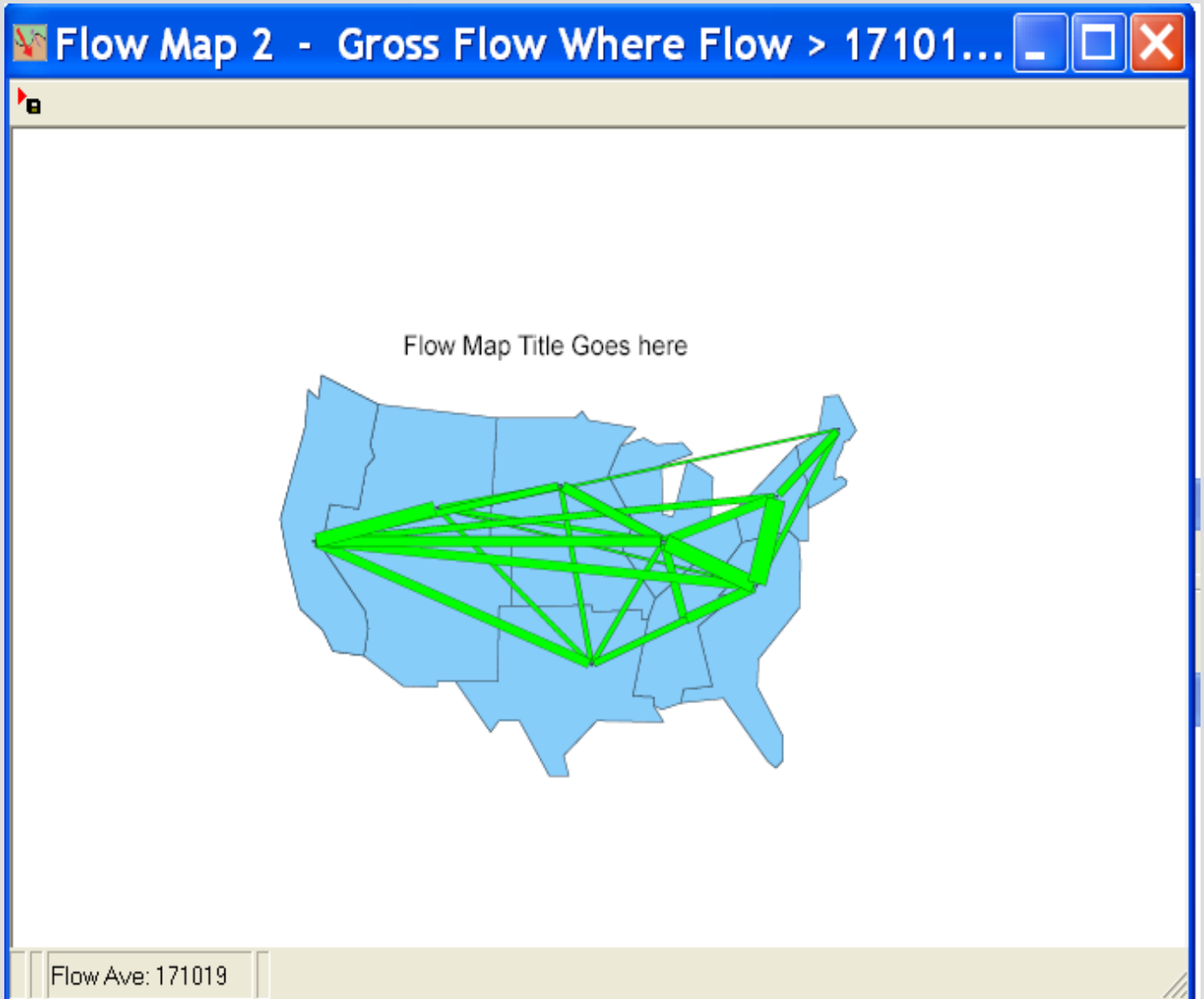
Here is a map on the screen

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



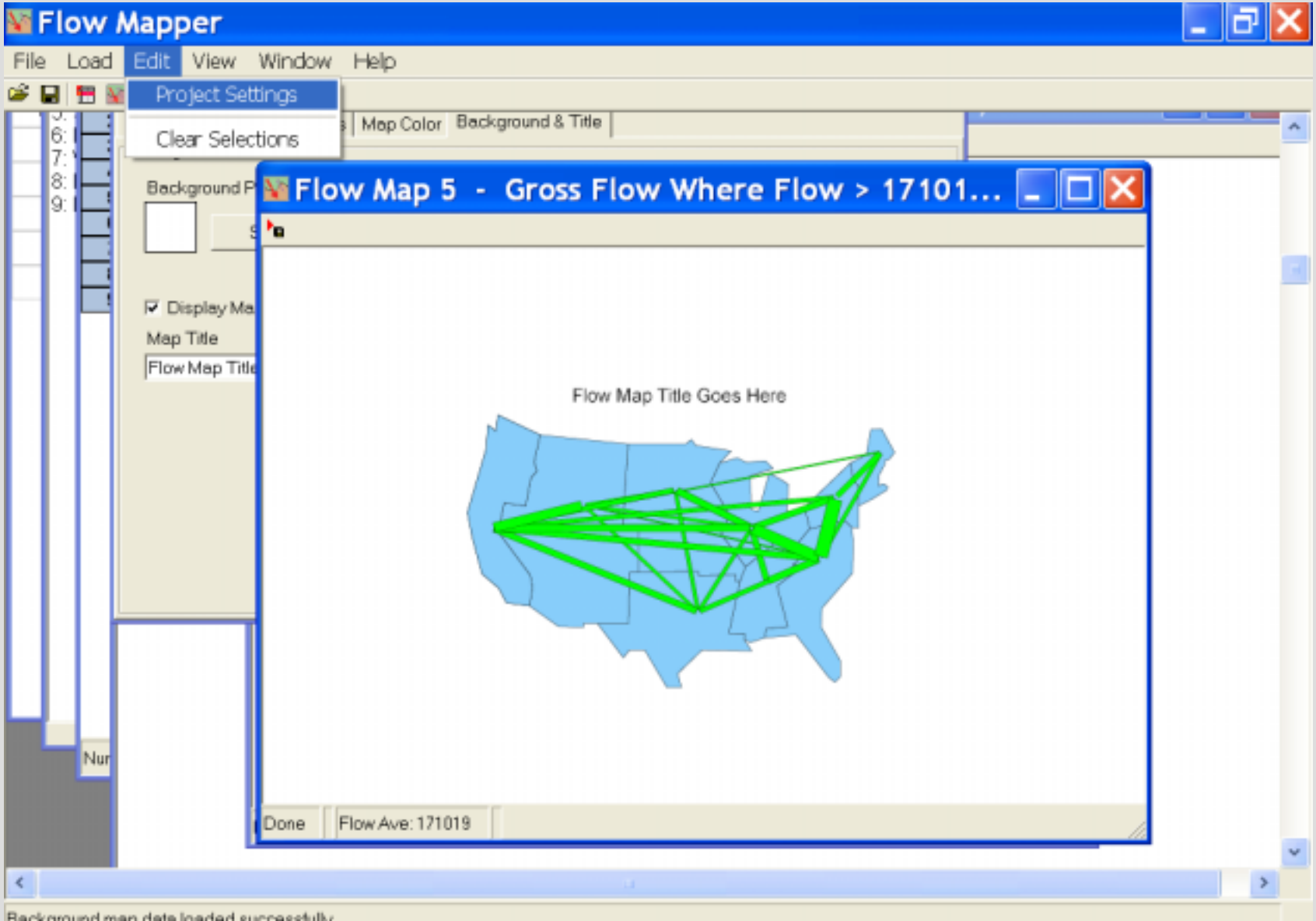
To save the map

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.



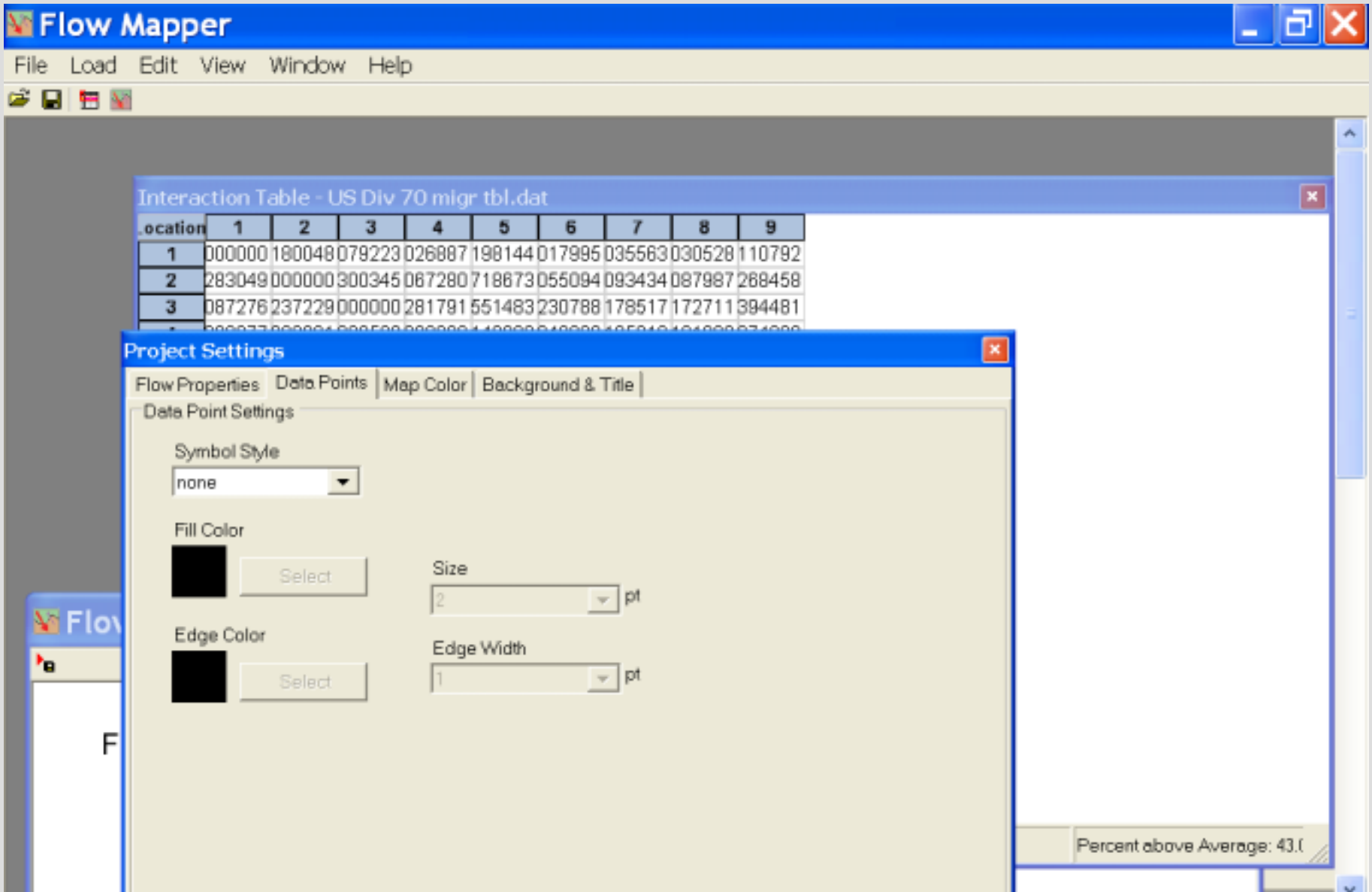
For a new map click the Edit option again.

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



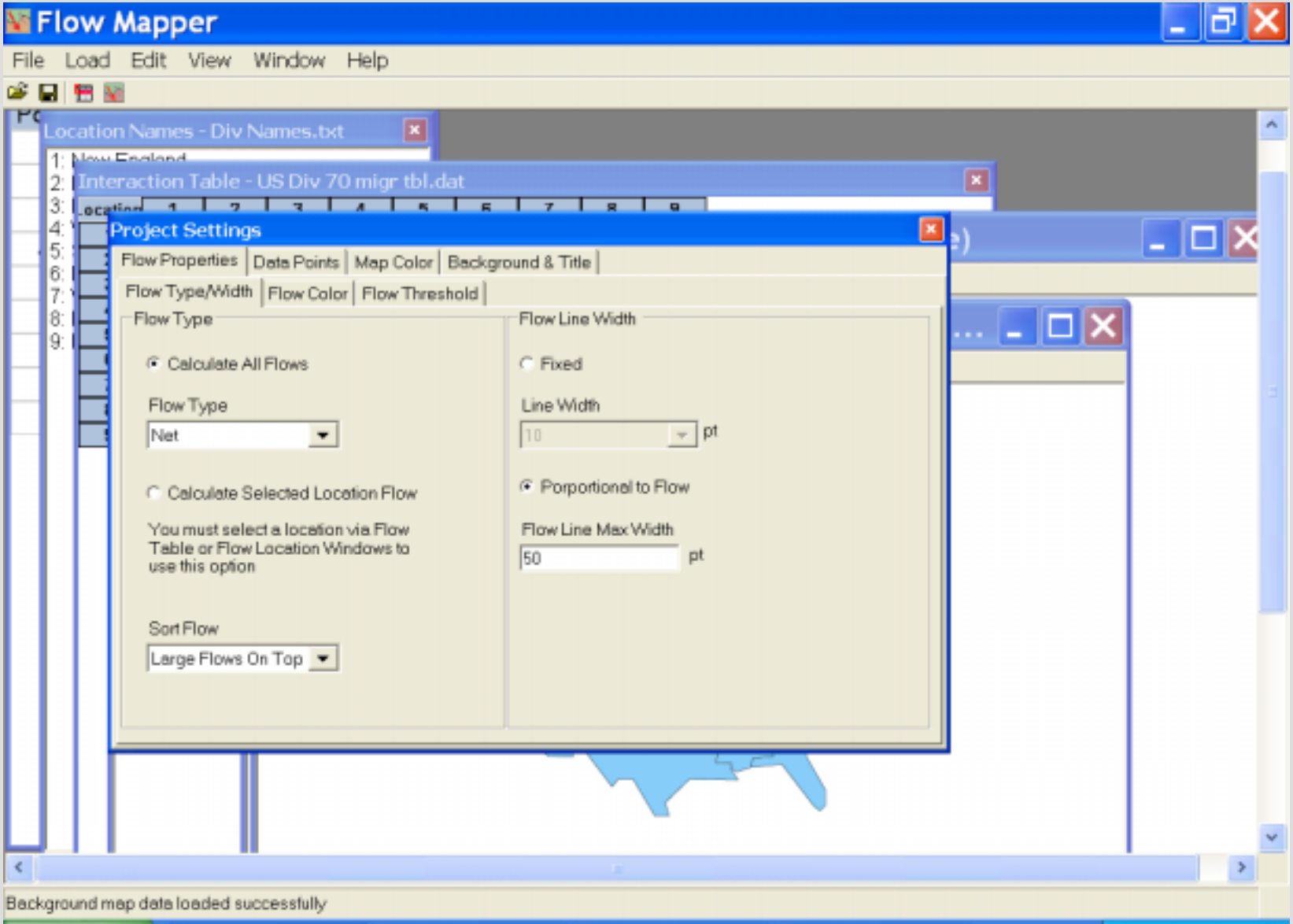
To move back to first menu click on flow properties

Upper left just below ‘Project Settings’



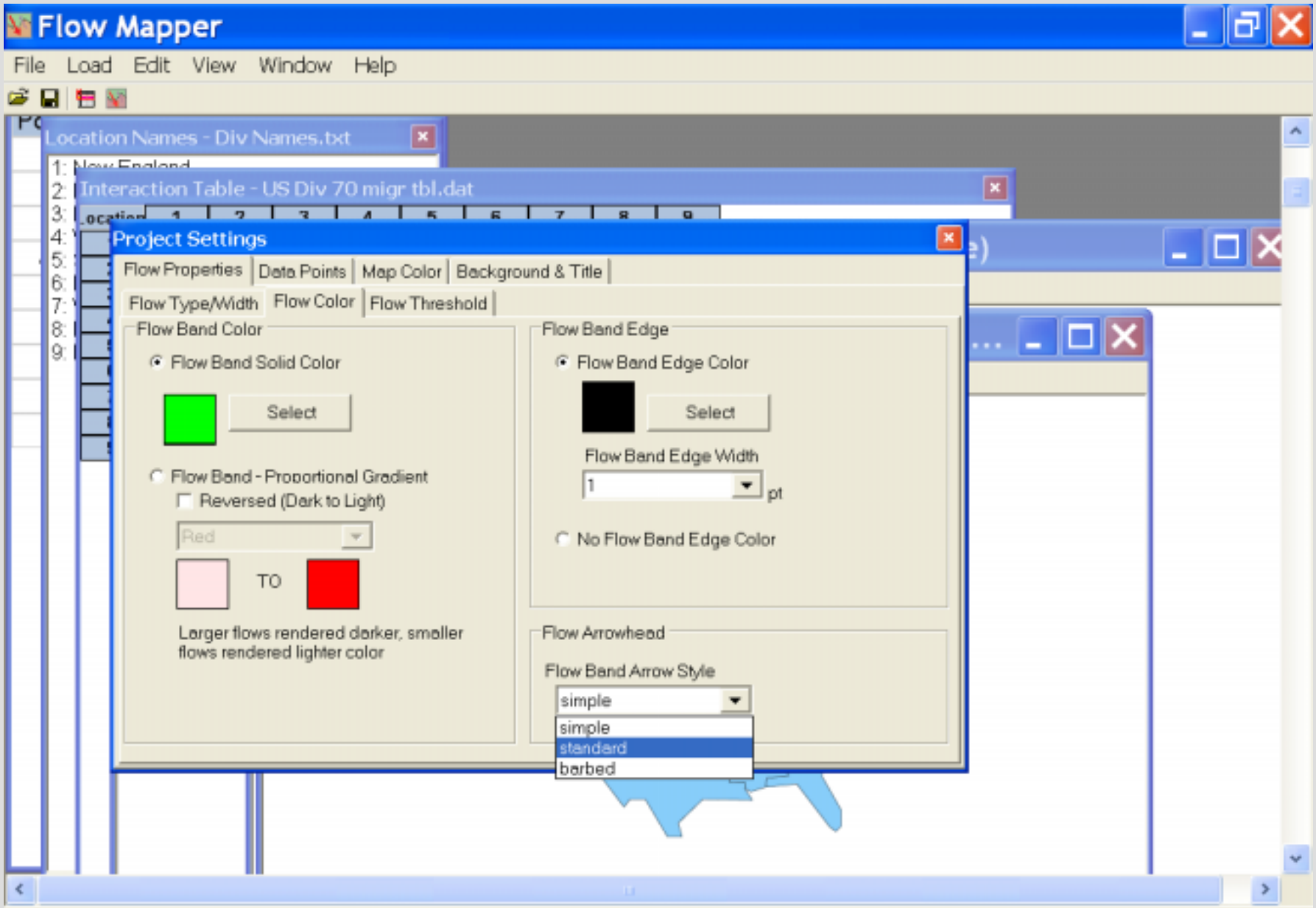
Settings changed for a net flow map

with changed symbol width

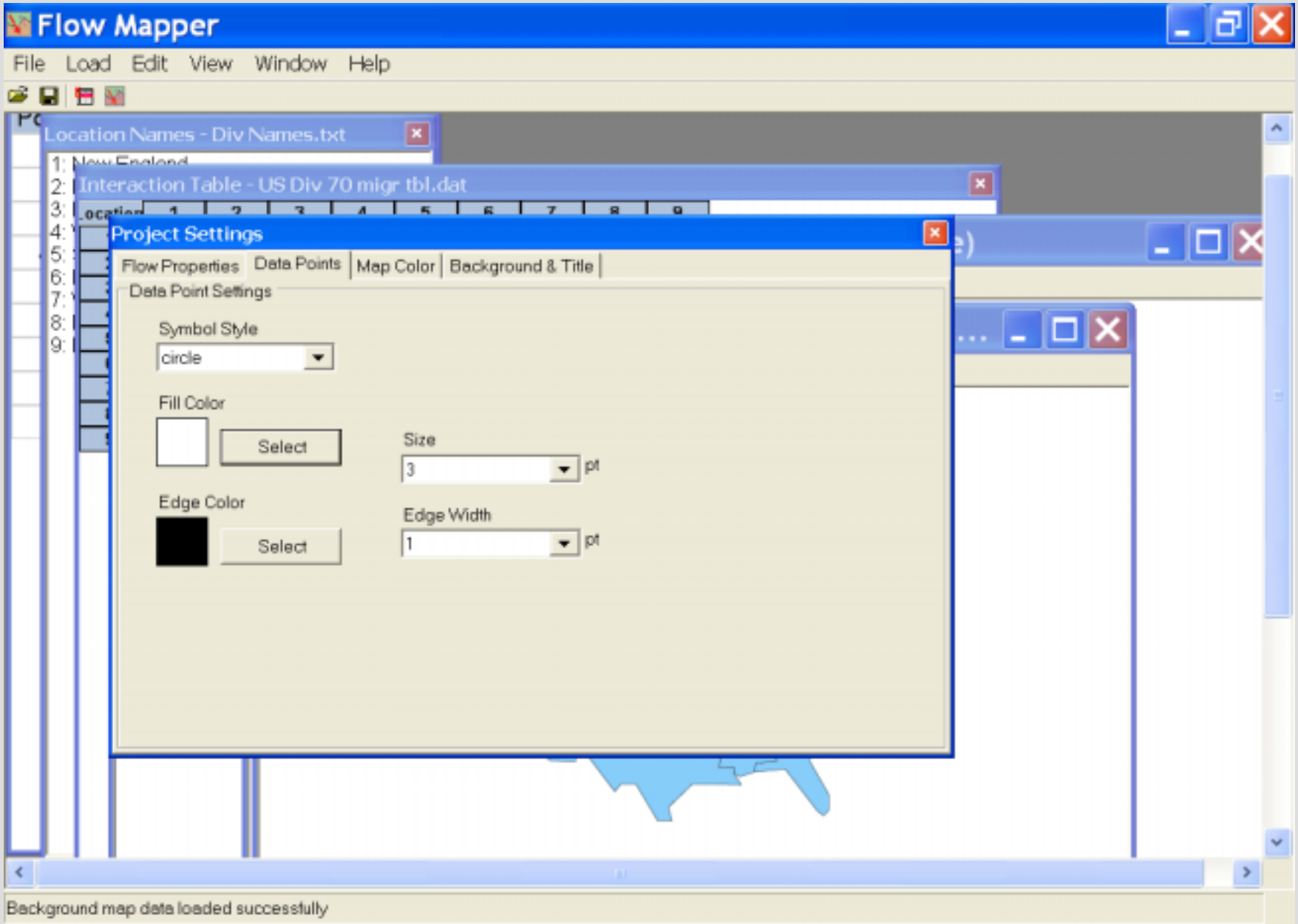


Arrow style changed

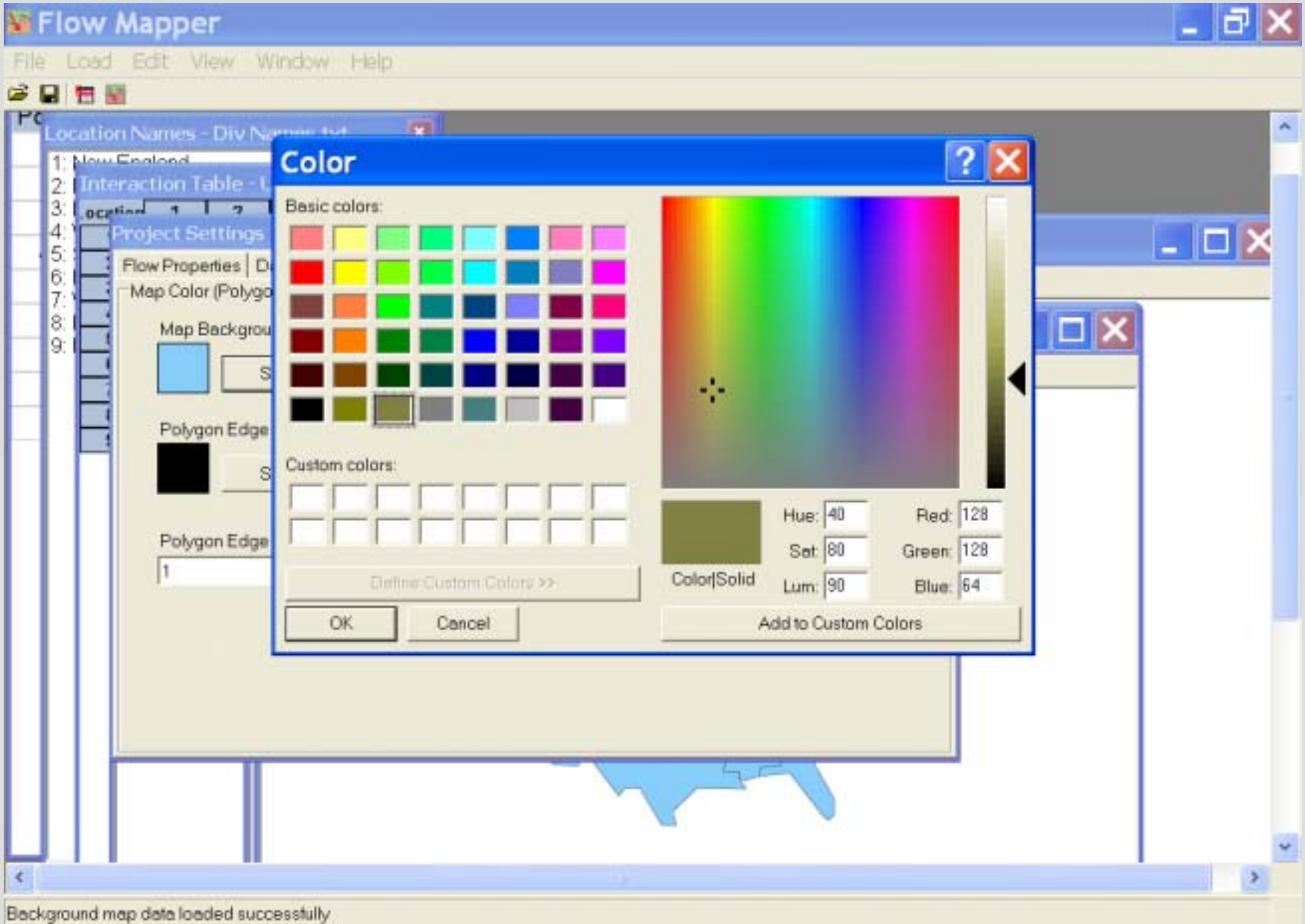
simple, standard, barbed



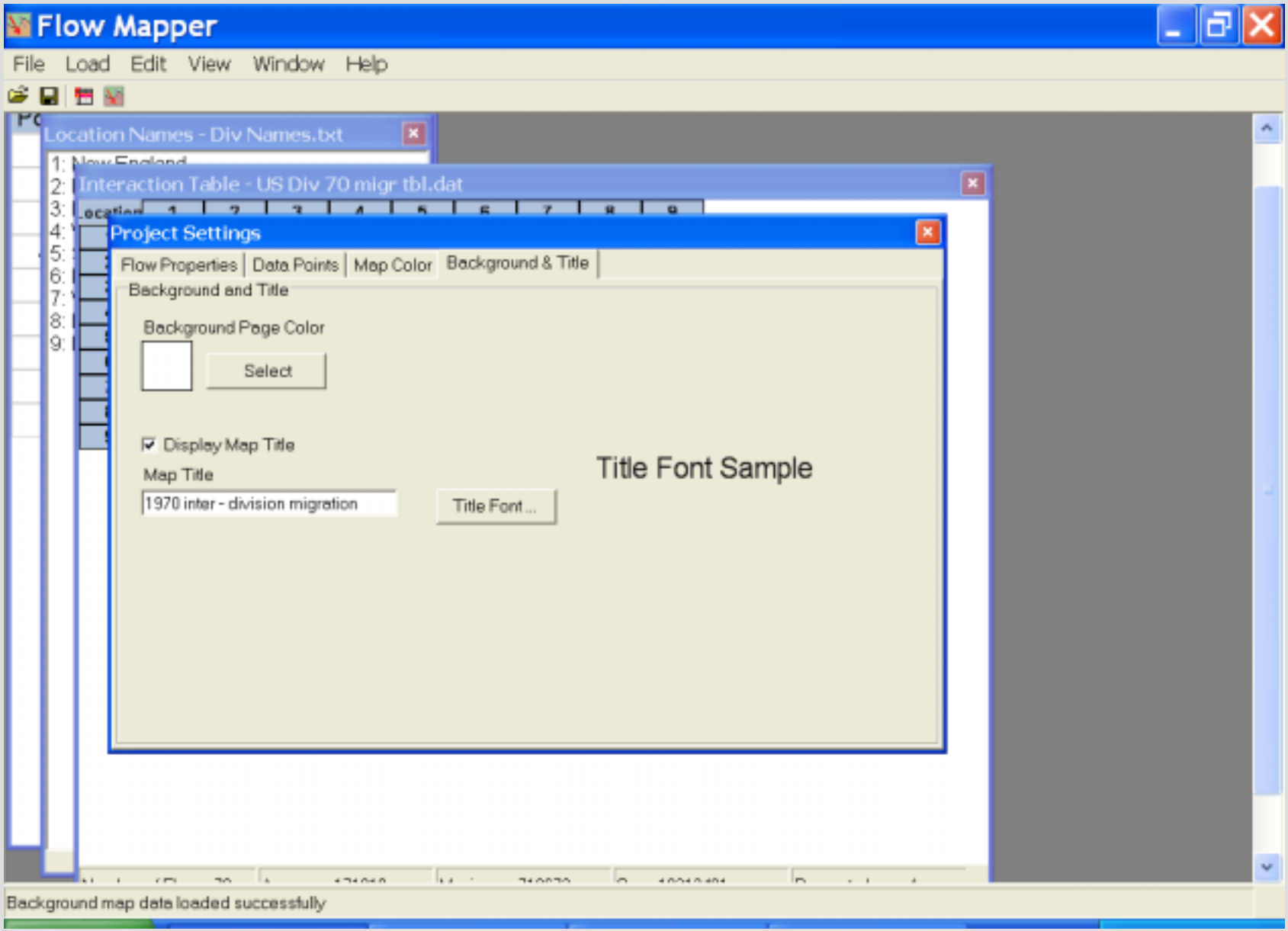
Displaying locations with a white circle.



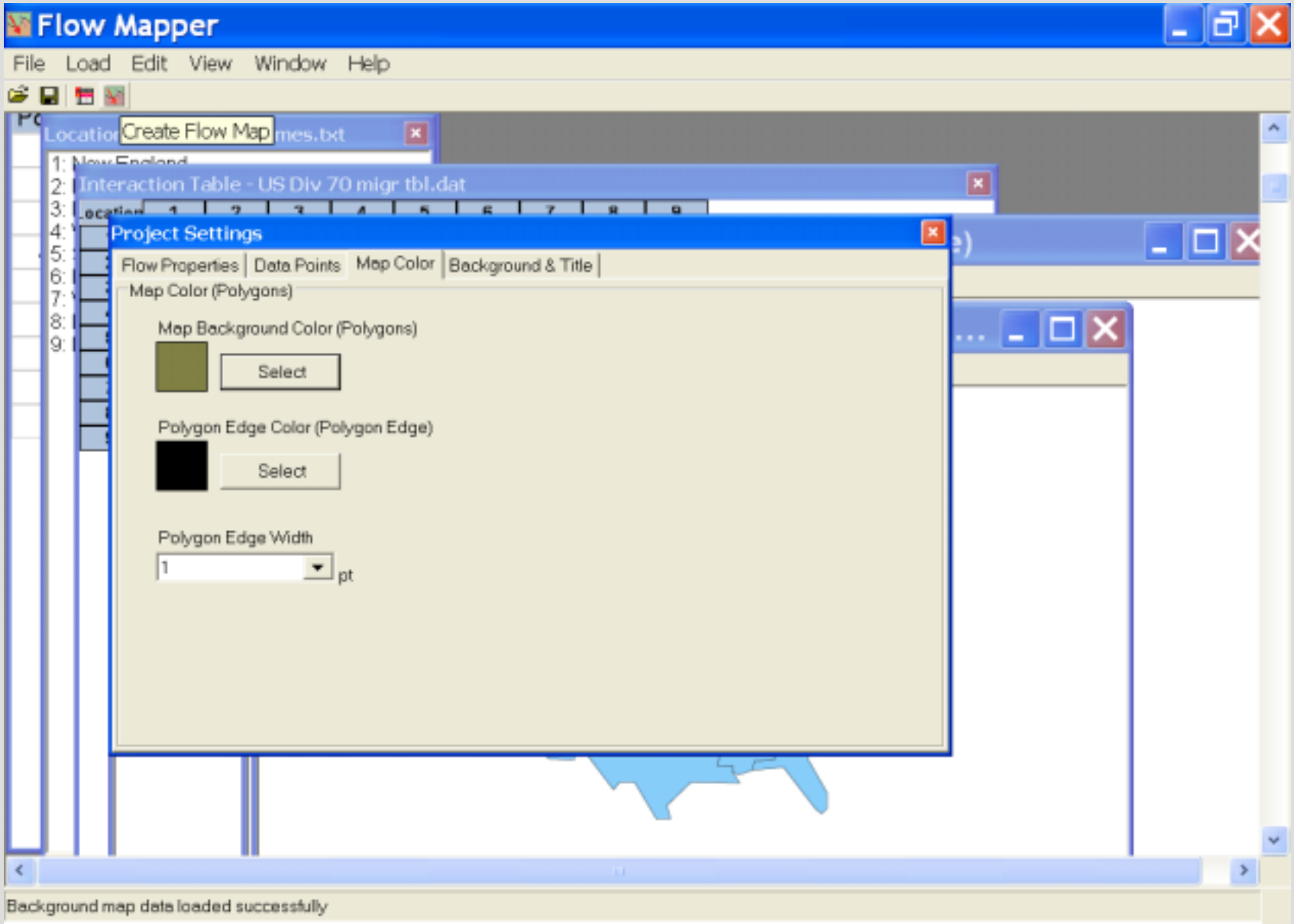
Changing map color



Changing title

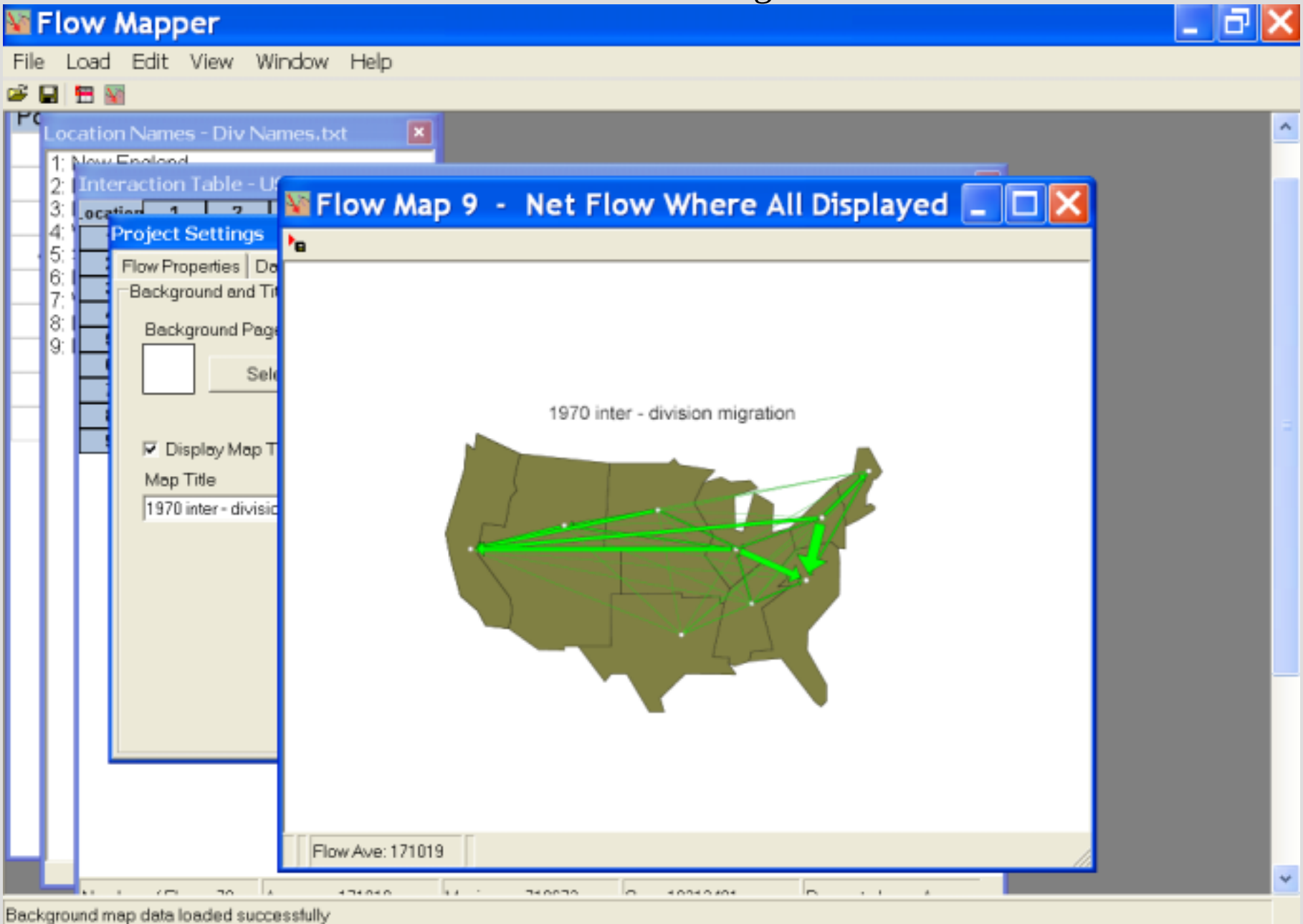


Creating new map.

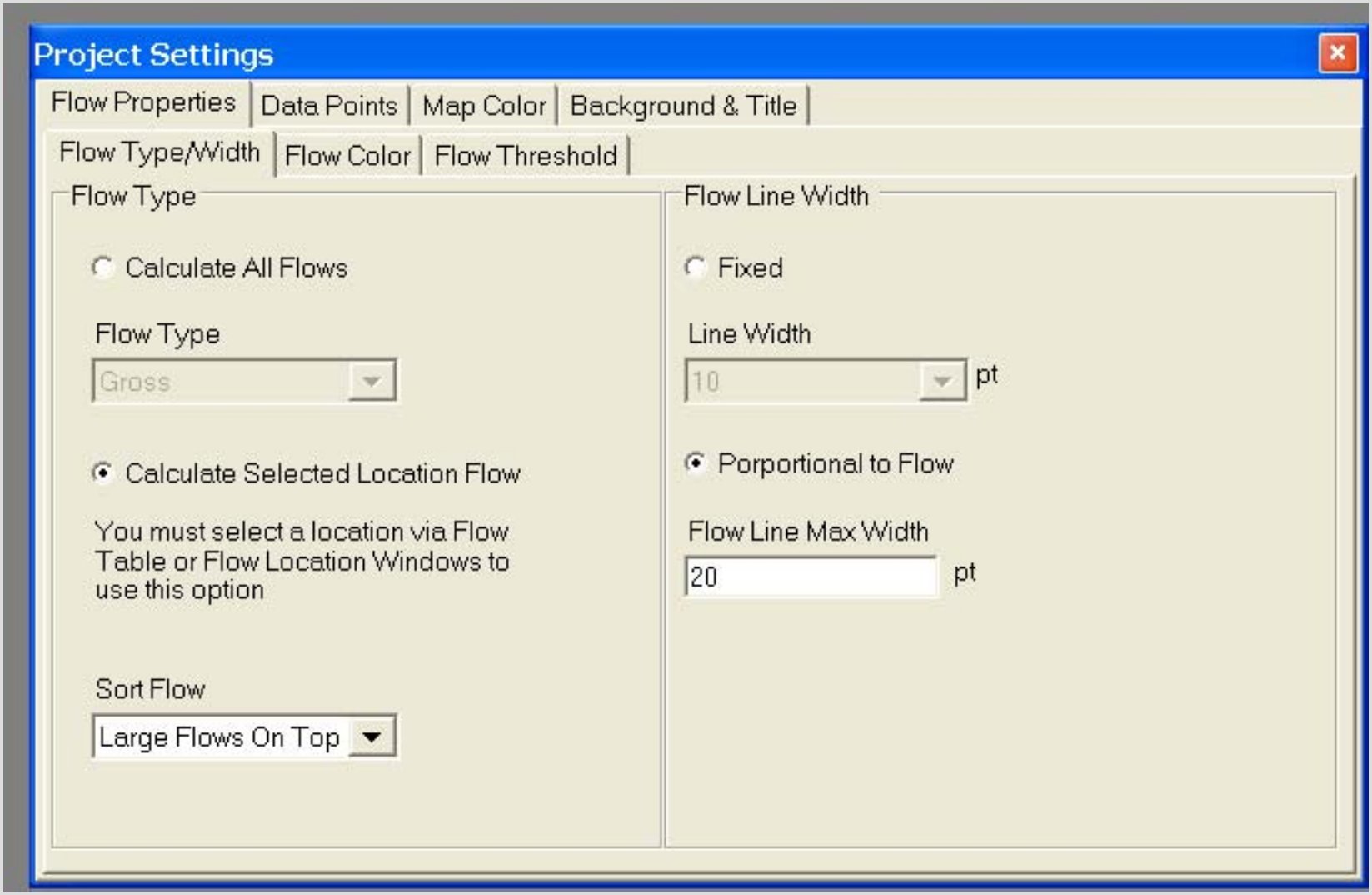


New map displayed

Save it if it looks good

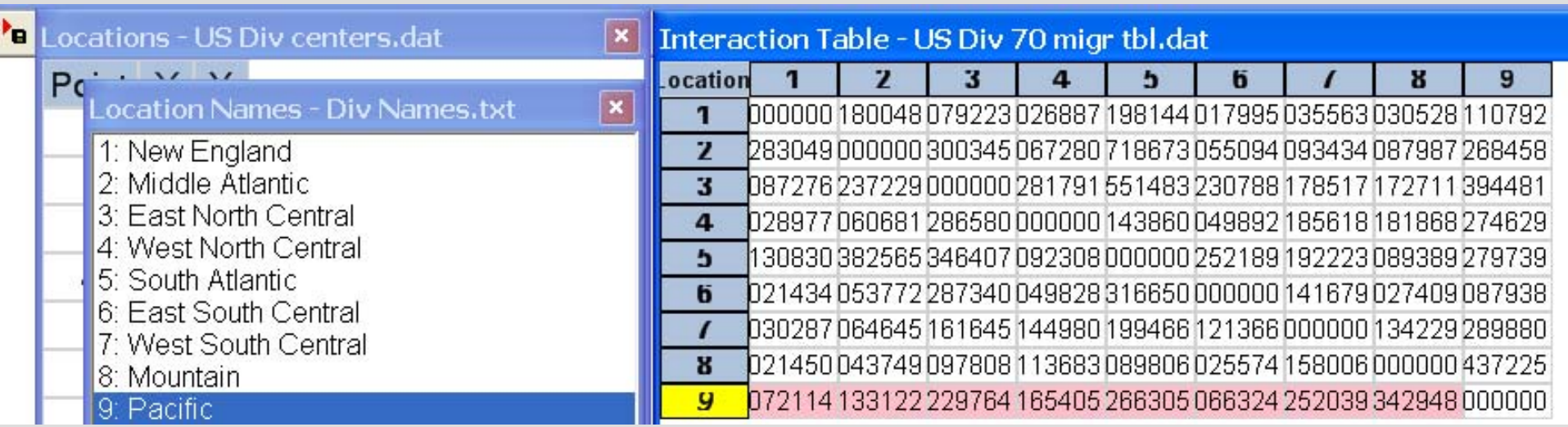


To get moves from (or to) only one place use the ‘Calculate Selected Location Flow’ on the ‘Flow Type’ menu

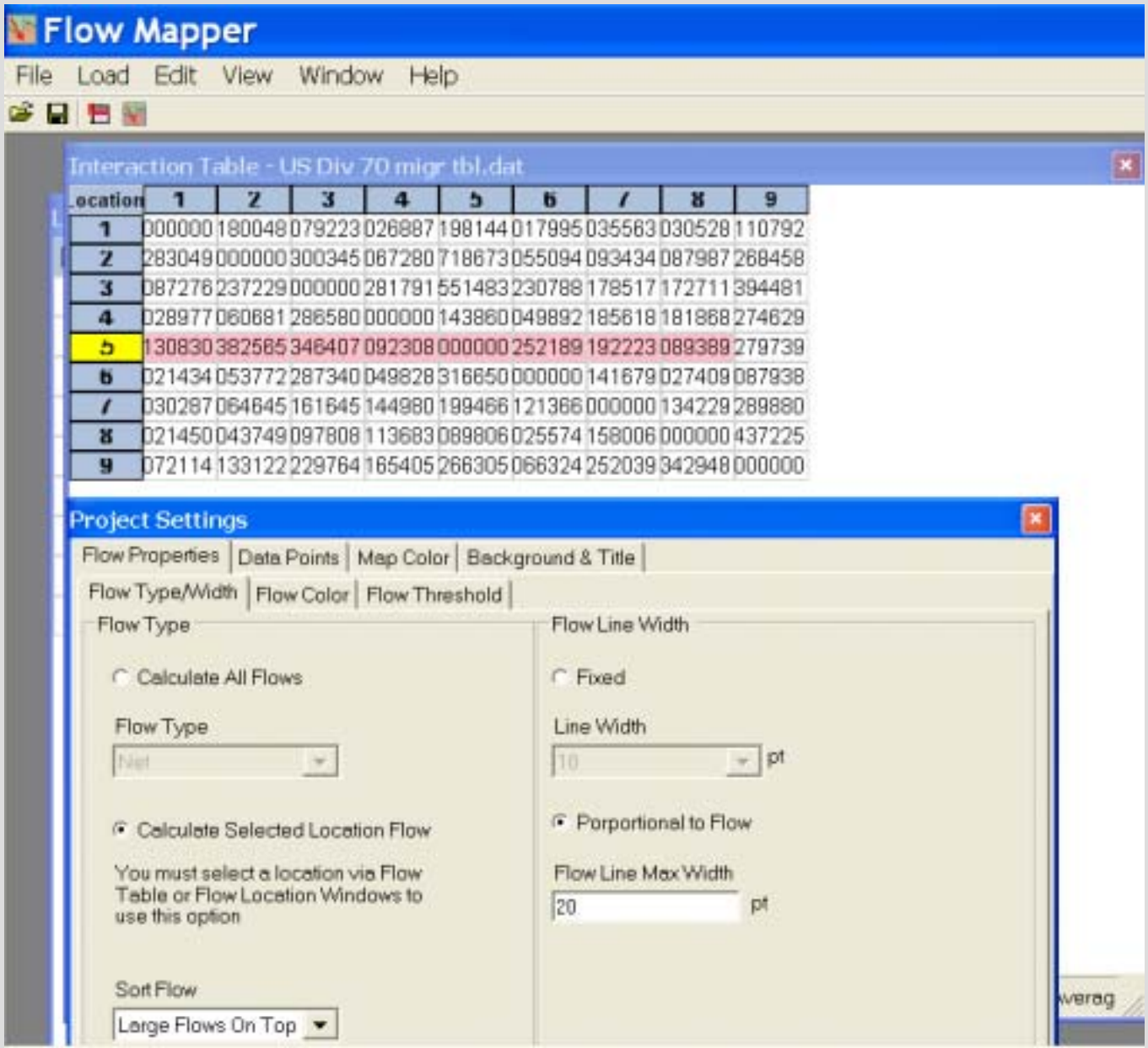


Next highlight a row (for ‘from’ a place) or a column (for ‘to’ a place) on the interaction table.

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.

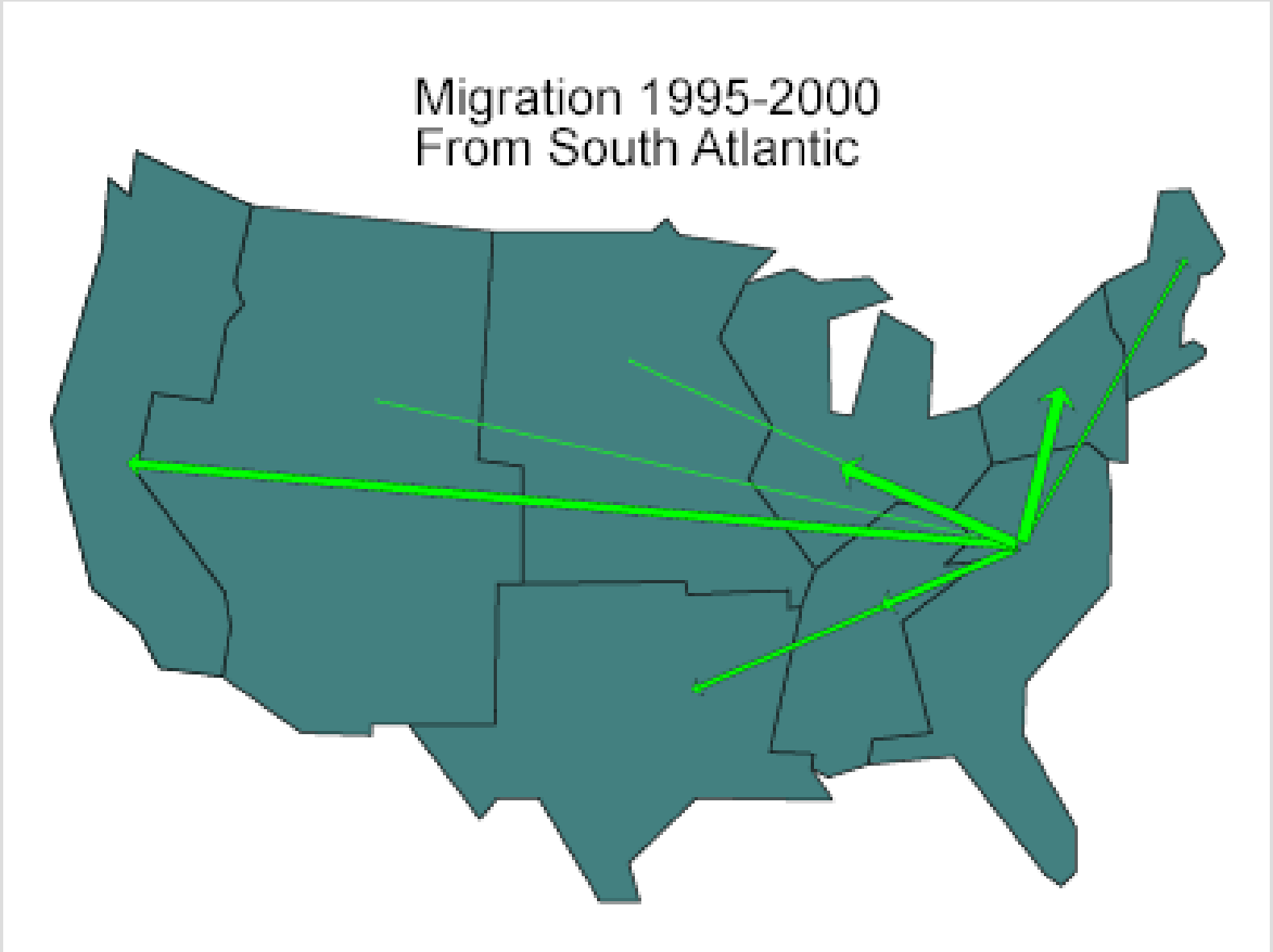


Or view the interaction table and click on a row



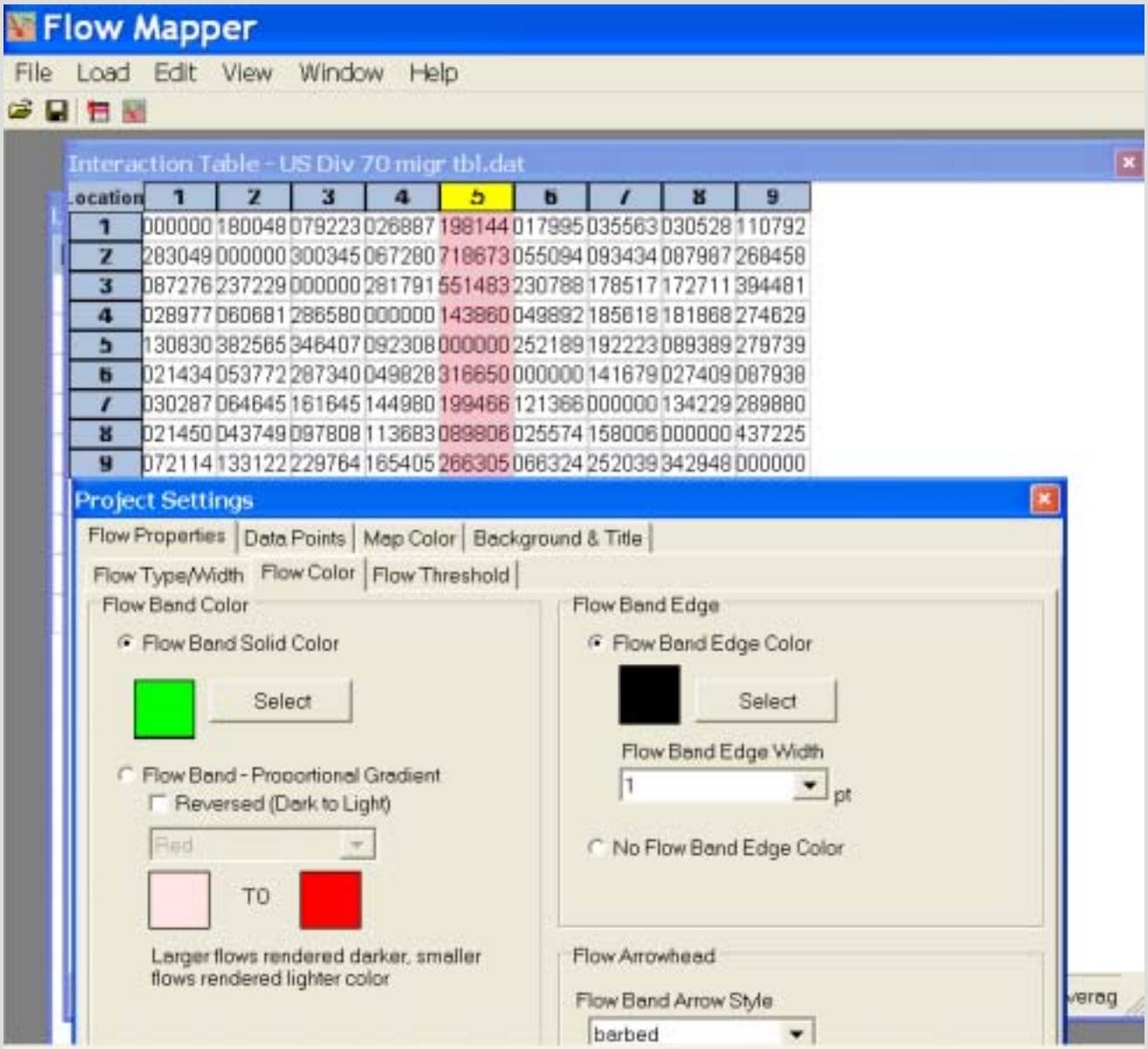
Location	1	2	3	4	5	6	7	8	9
1	000000	180048	079223	026887	198144	017995	035563	030528	110792
2	283049	000000	300345	067280	718673	055094	093434	087987	268458
3	087276	237229	000000	281791	551483	230788	178517	172711	394481
4	028977	060681	286580	000000	143860	049892	185618	181868	274629
5	130830	382585	346407	092308	000000	252189	192223	089389	279739
6	021434	053772	287340	049828	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

The moves from the South Atlantic Division

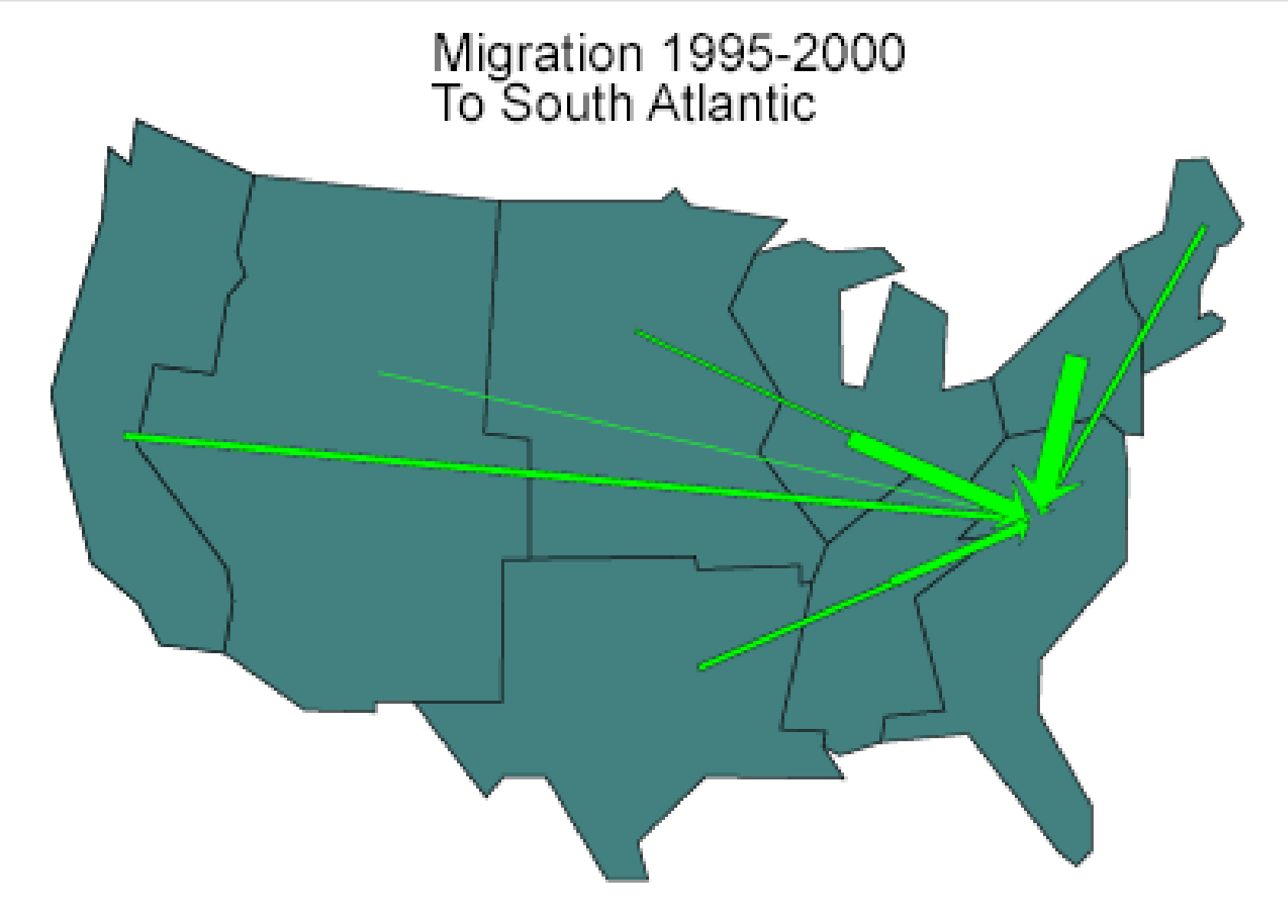


Or moves to the South Atlantic Division

Notice choice of arrowhead type



The moves to the South Atlantic Division



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

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

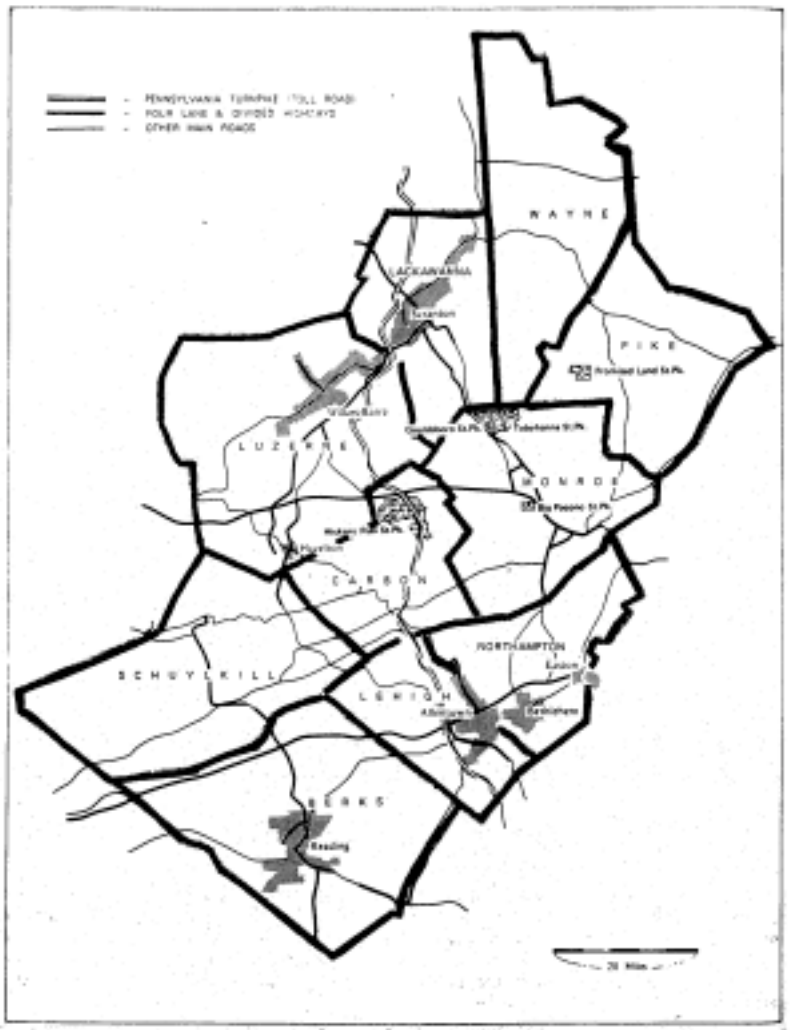
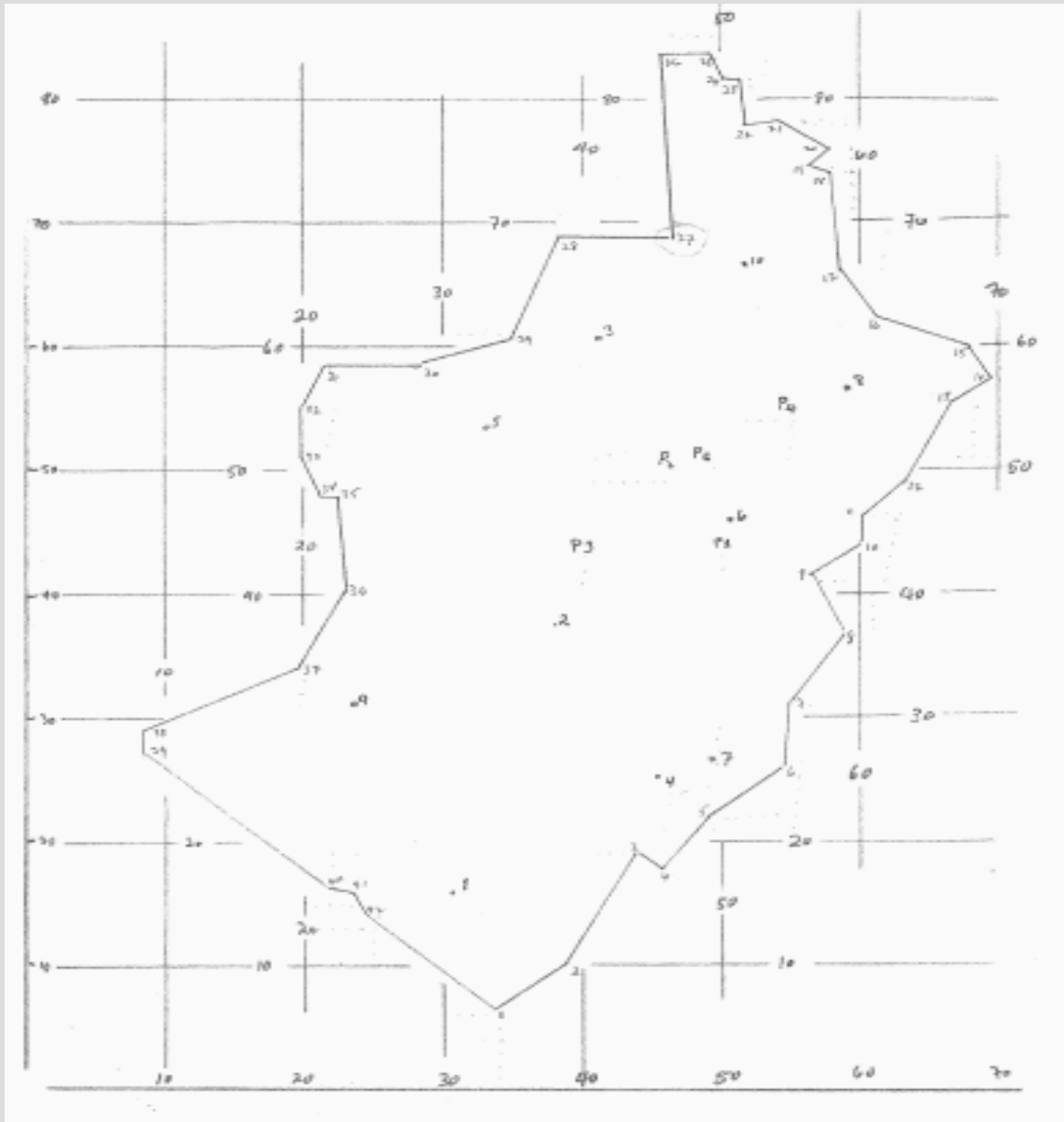


FIGURE 1: Map of the Study Area.

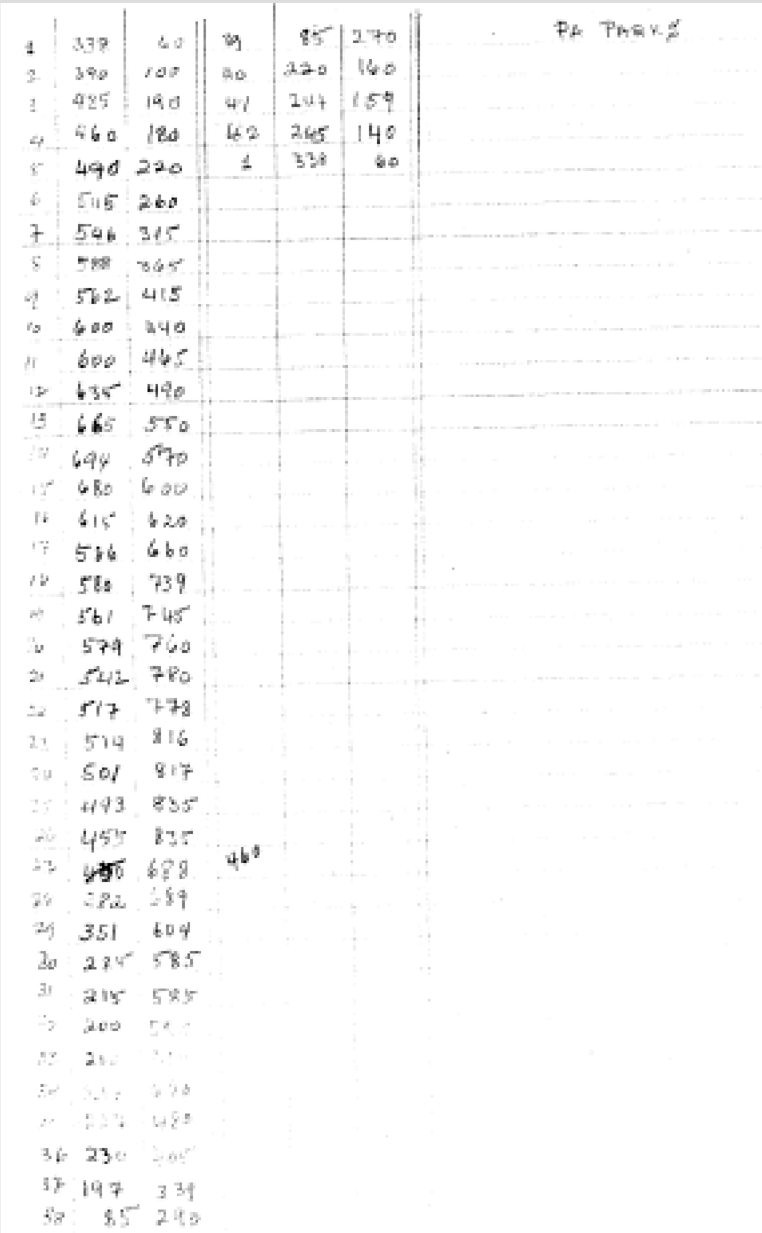
Getting coordinates

Area outline and centroids, using graph paper.The results go into an ASCII file.

Or use a digitizer but only if you have lots of experience with it.



My recording of coordinates



1	338	60	39	85	270
2	390	100	40	220	160
3	425	190	41	244	159
4	460	180	42	265	140
5	490	220	1	338	60
6	515	260			
7	546	315			
8	588	365			
9	562	415			
10	600	440			
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	501	817			
25	493	835			
26	455	835			
27	480	628	460		
28	282	289			
29	351	604			
30	234	585			
31	215	585			
32	200	[illegible]			
33	[illegible]	[illegible]			
34	[illegible]	[illegible]			
35	[illegible]	[illegible]			
36	230	[illegible]			
37	197	339			
38	85	290			

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
Leheigh
Lucerne
Monroe
Northhampton
Pike
Schuykill
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	Big Pocono	Gouldsboro	Hickory Run	Promised Land	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_j	1737	12486	11628	2658	4952	33461

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

This representa a rather different situation. Given is a ten by five table of interaction relating the residents of ten counties and their attendence 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, wth 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-Bethleham. 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 ('Boundry.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.

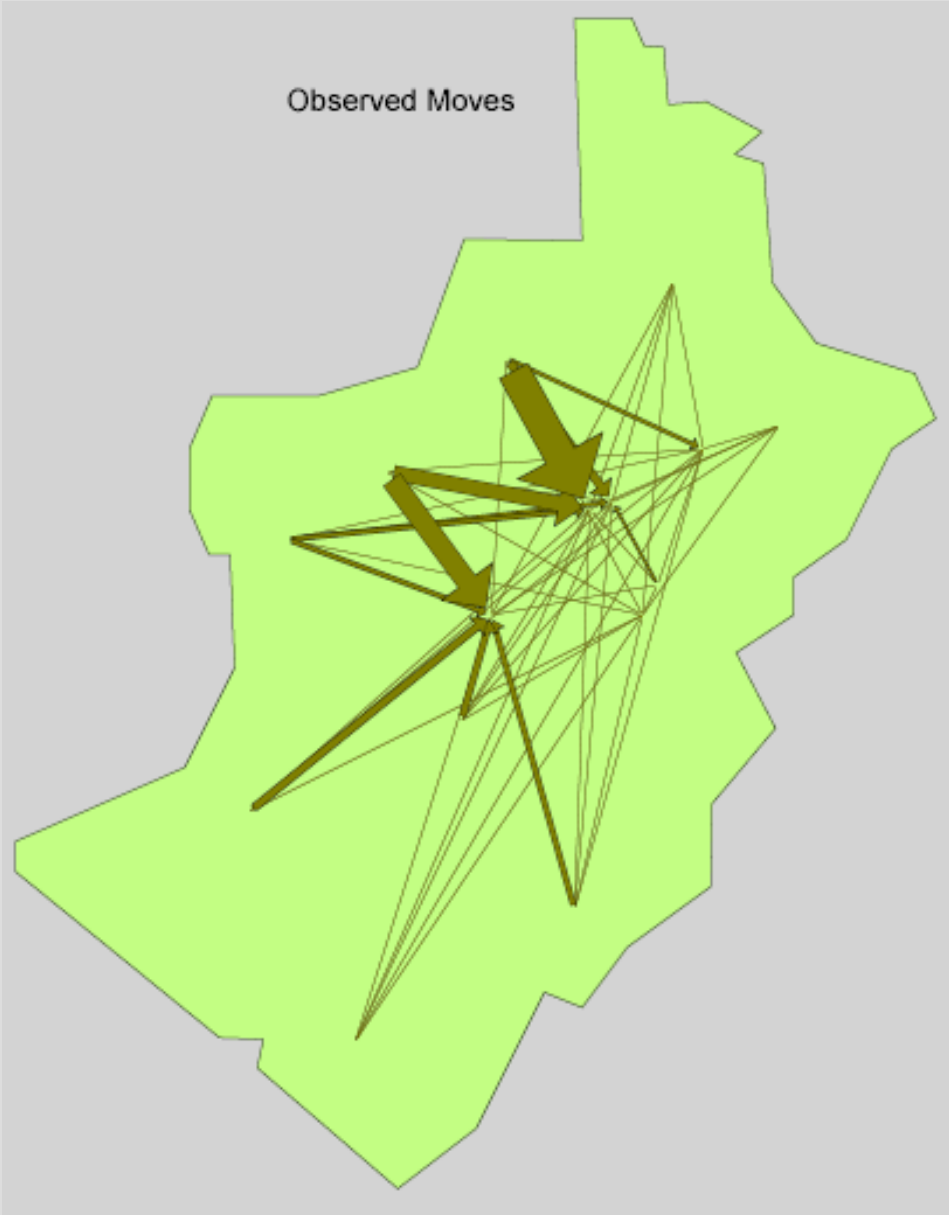
The full table could show moves between counties & between parks.

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
Northhampton	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	Big Pocono	Gouldsboro	Hickory Run	Promised Land	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
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Schuylkill	63	101	1886	48	40	2138
Wayne	8	20	12	124	18	183
InSum I_j	1737	12486	11628	2658	4952	33461

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

Estimated table using the QTP model

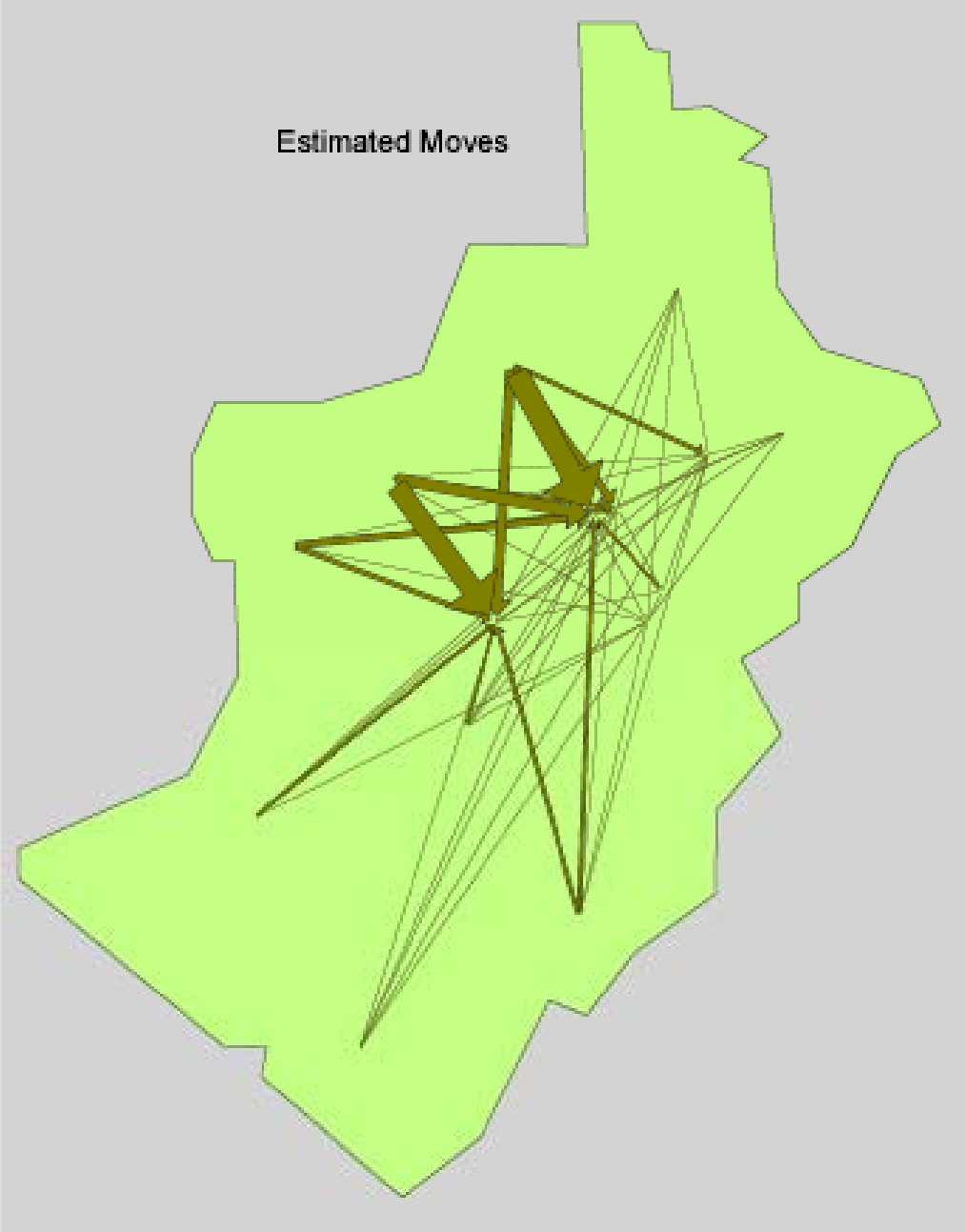
See QTP.doc under reprints on my web site for a description of the model.

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	

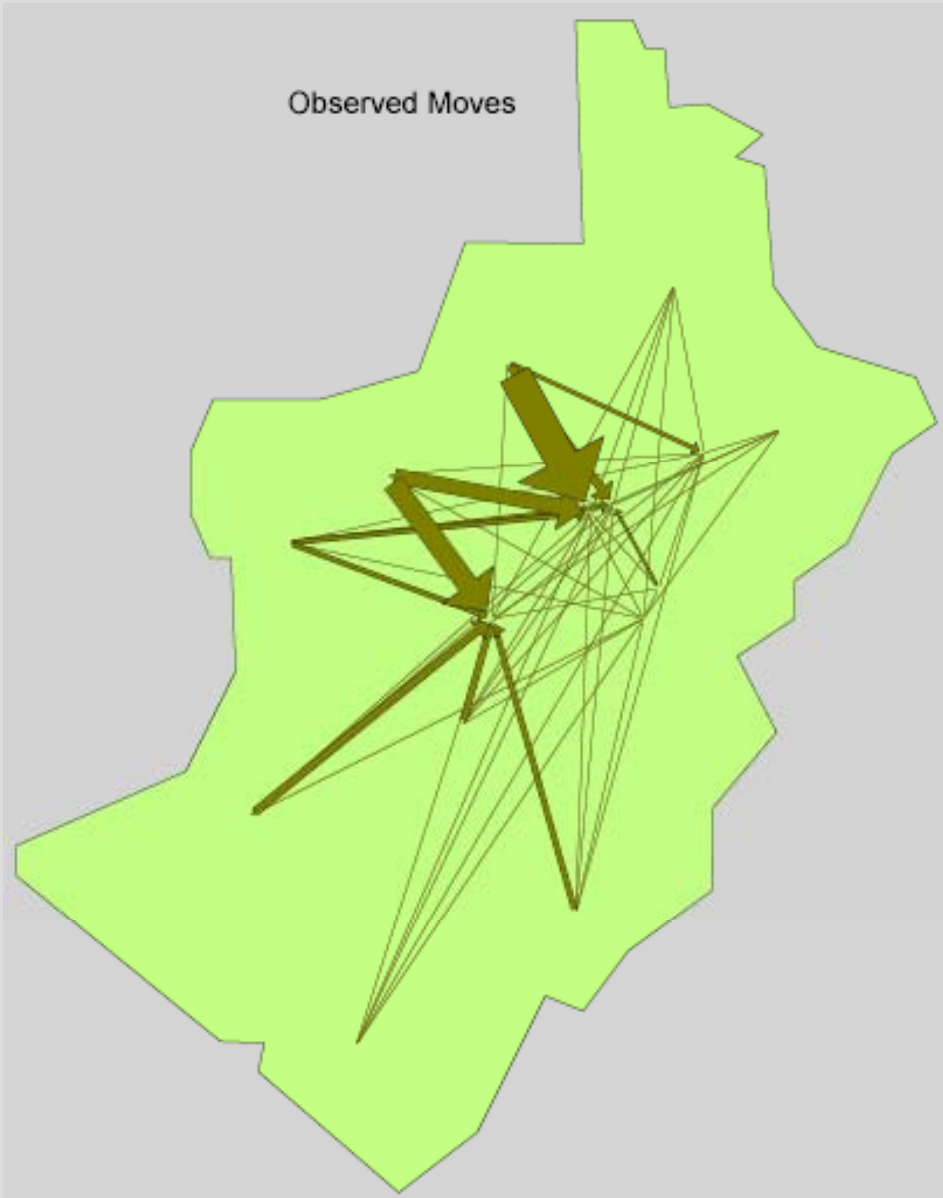
Correlation between observed and estimated: $r^2 = 0.85$, n=50

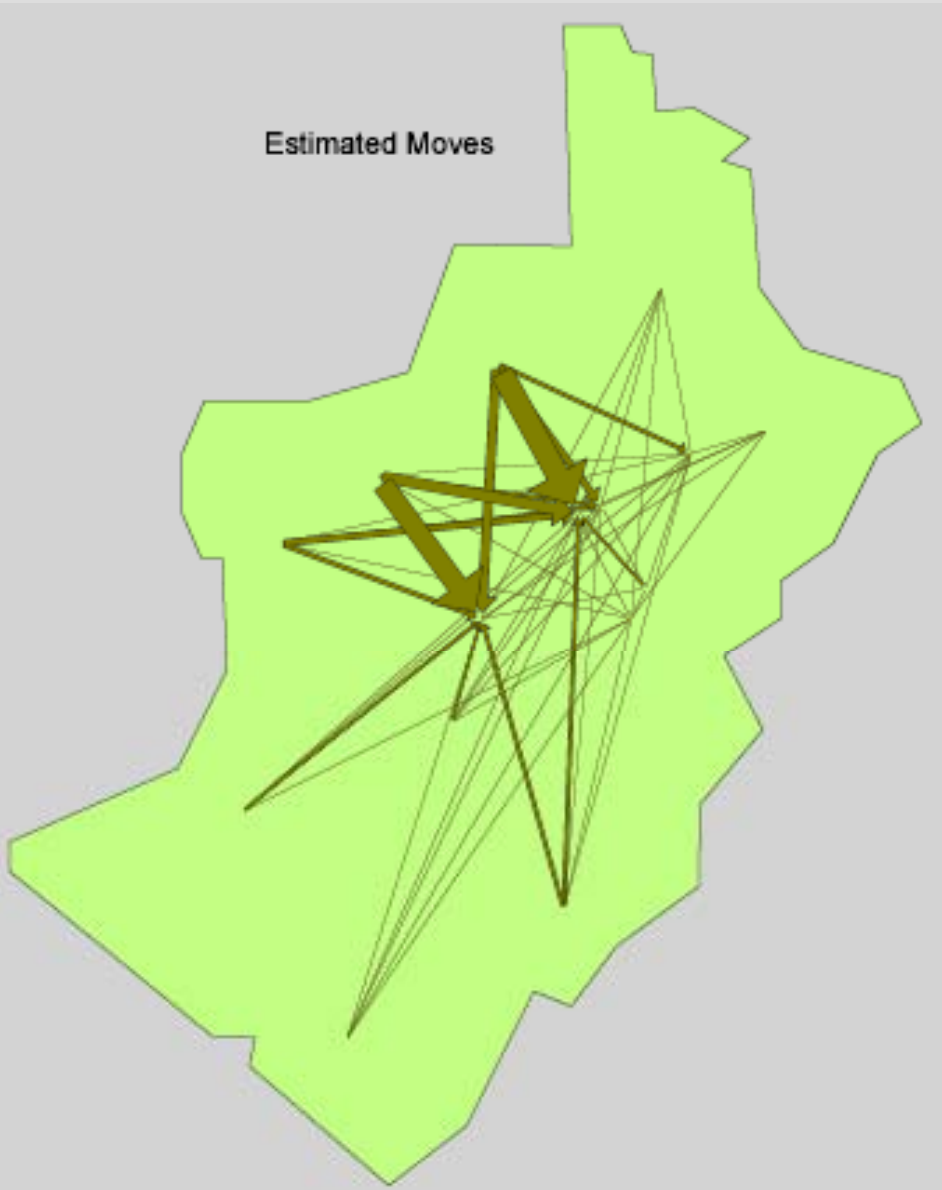
Estimated Moves



Observed Moves versus QTP Estimated Moves

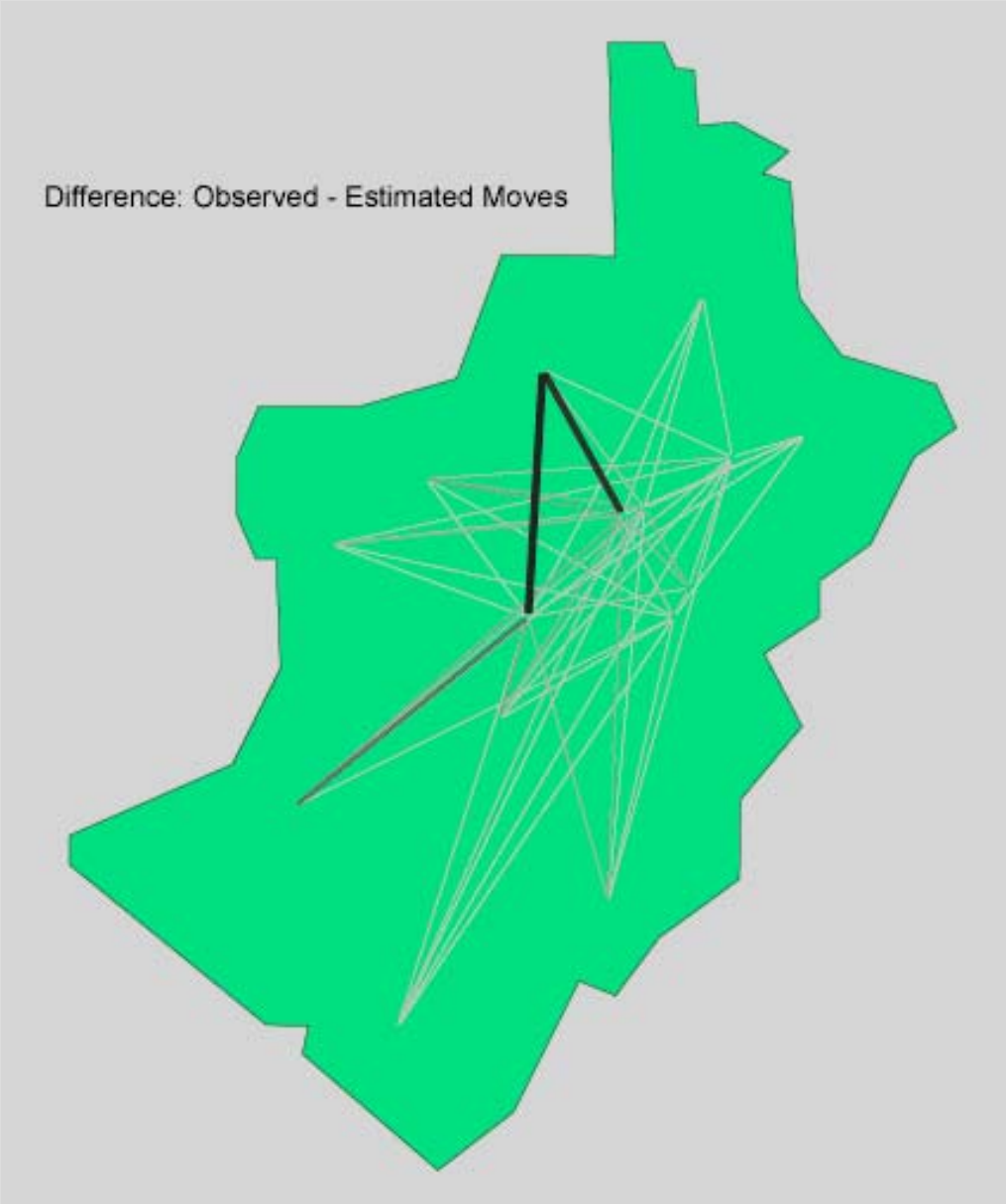
Park attendance





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

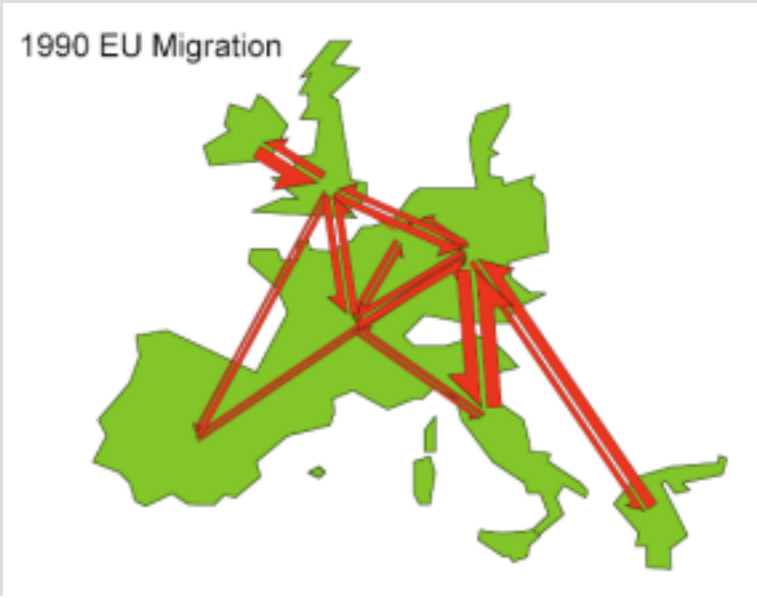
Now experiment with your own data or try some of the files that came with the program in the Data Sets folder,
or continue with part 3 of the tutorial

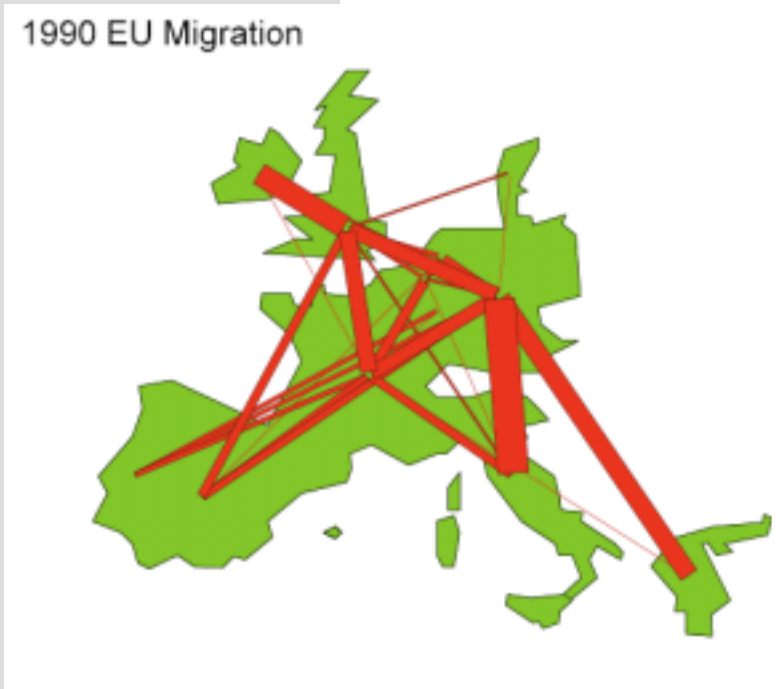
Tutorial Part III

Examples produced using the Flow Mapper program.

by Waldo Tobler

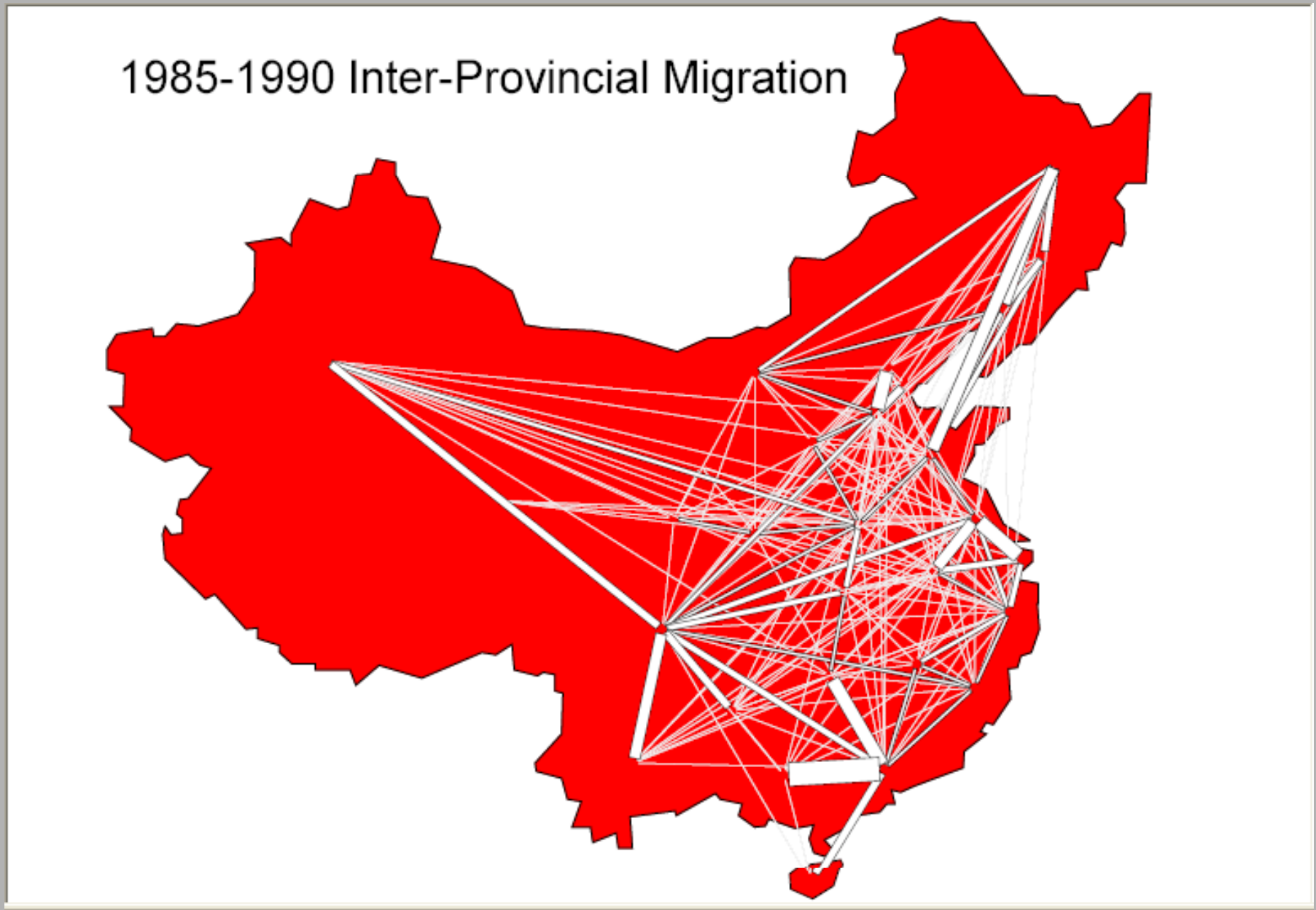
Two-way, Total (Gross), and Net Migration





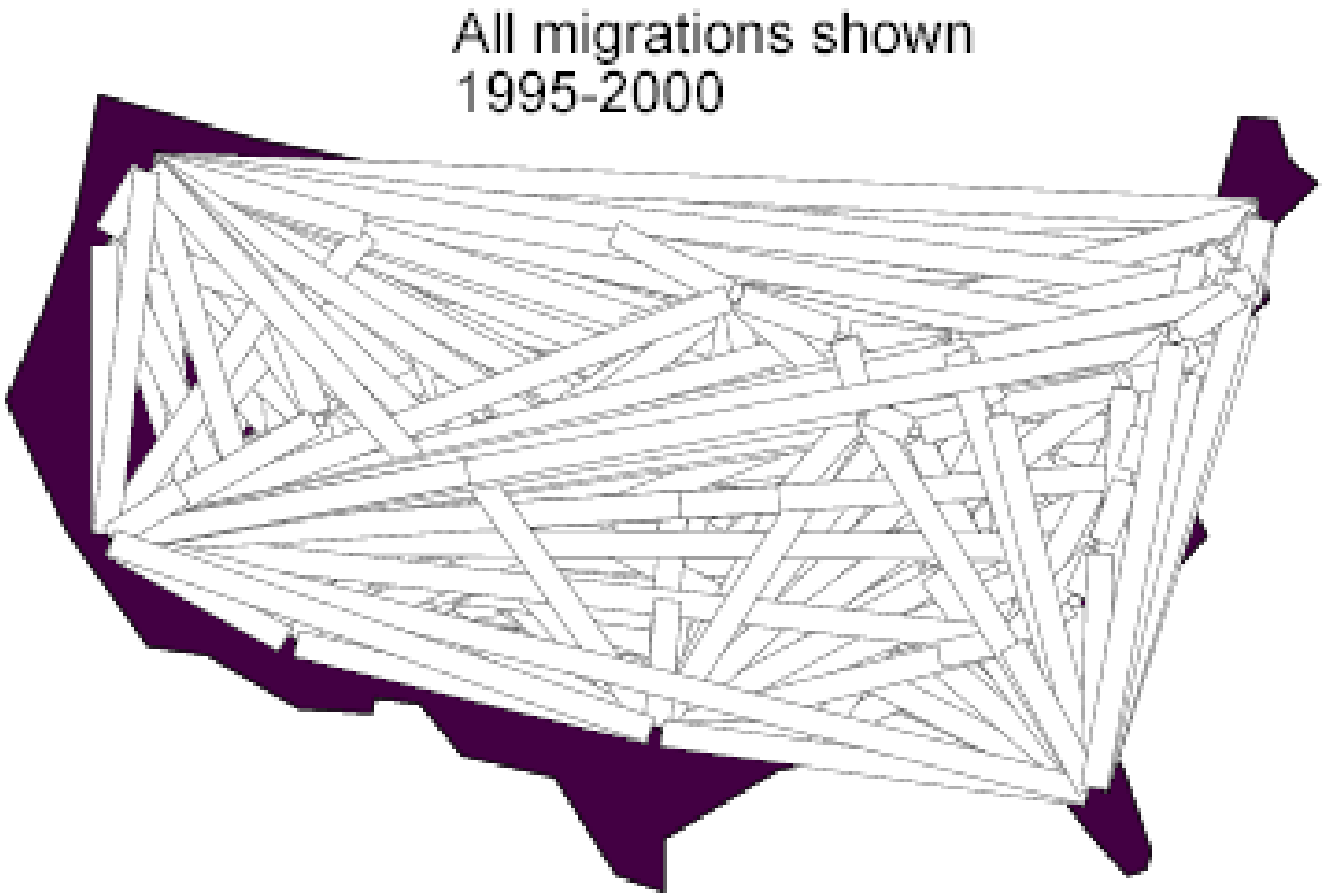
Showing the majority of inter-provincial moves in China

Using the flow mapper program



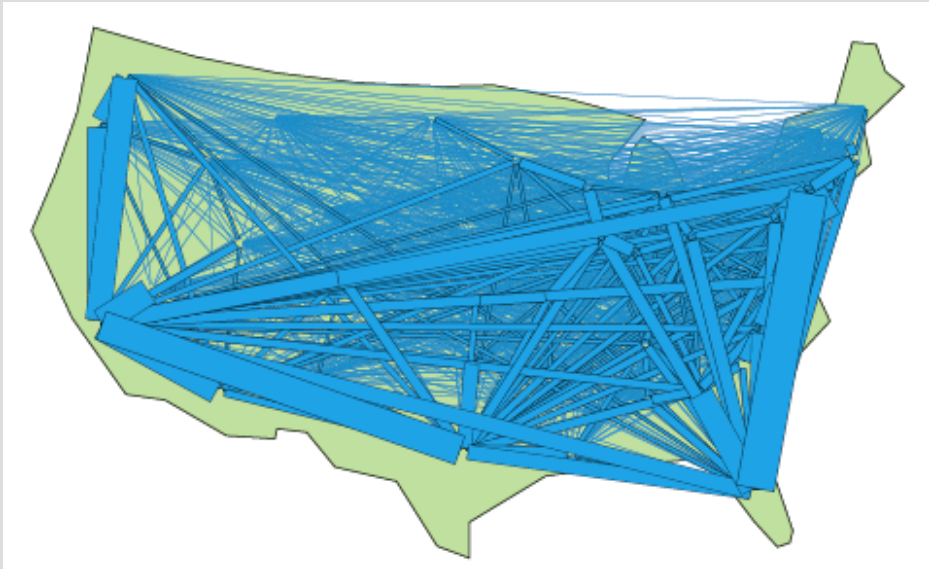
Showing 2256 flows

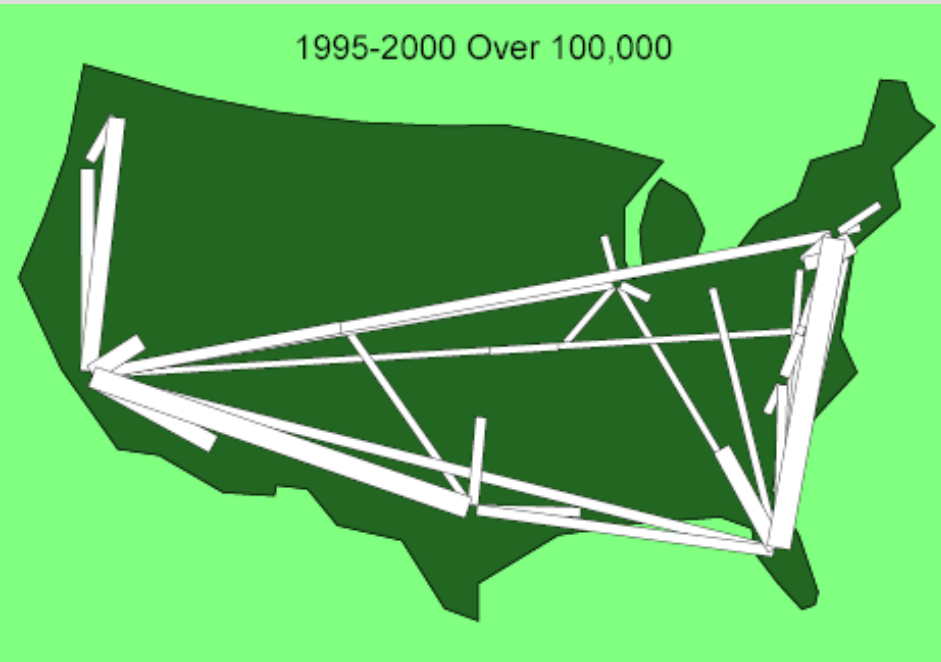
from 48 by 48 table, with constant width bands. Not very useful.

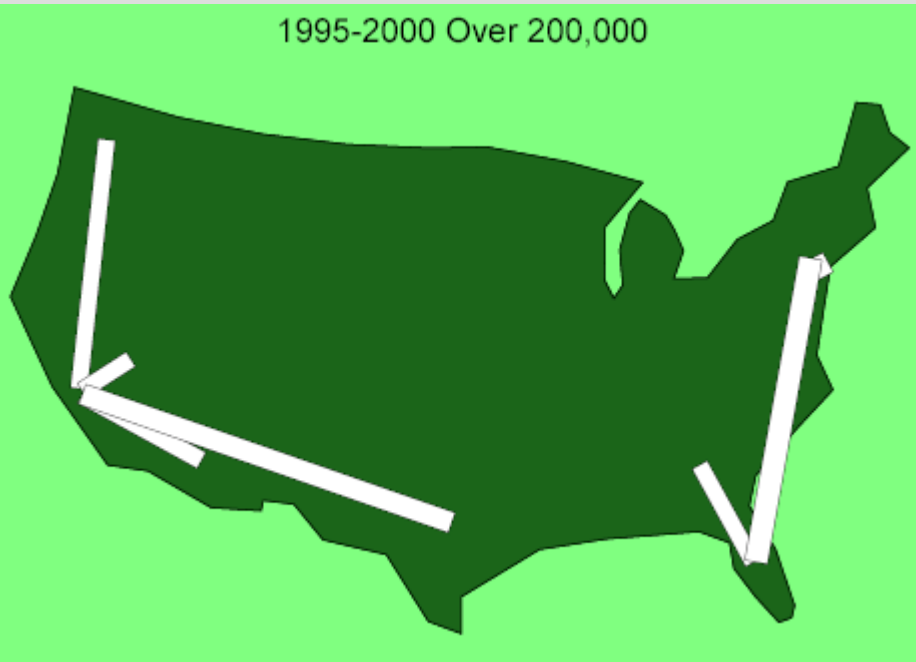


1995-2000 Total Migration

Variable width bands, and parsing by quantity.

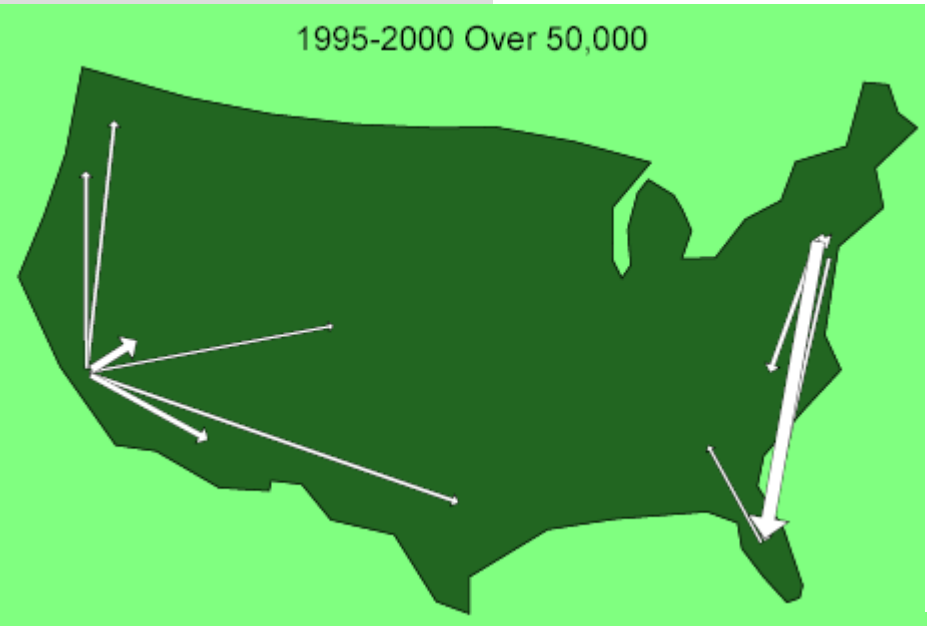


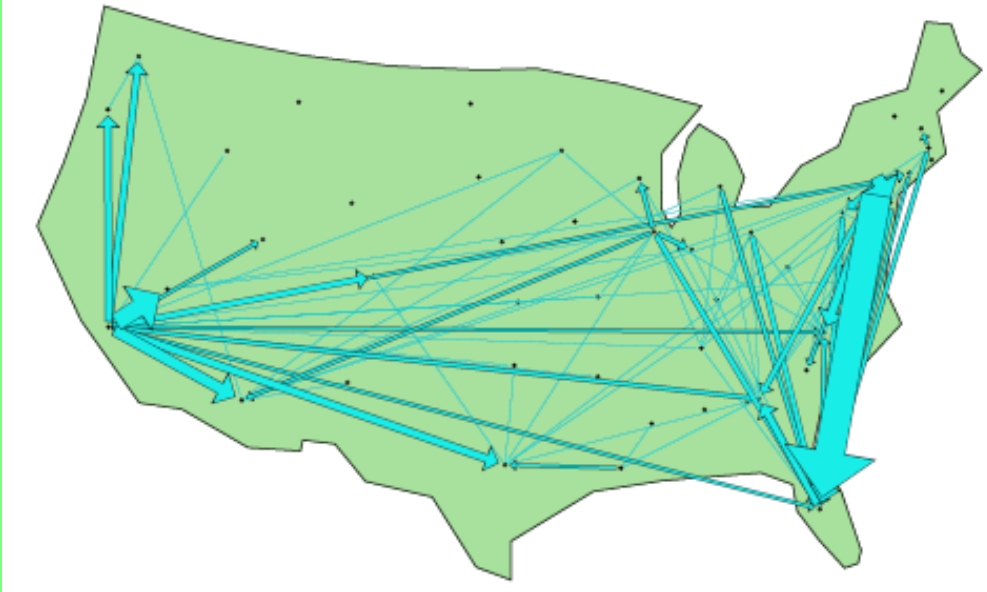




1995-2000 Net Migration

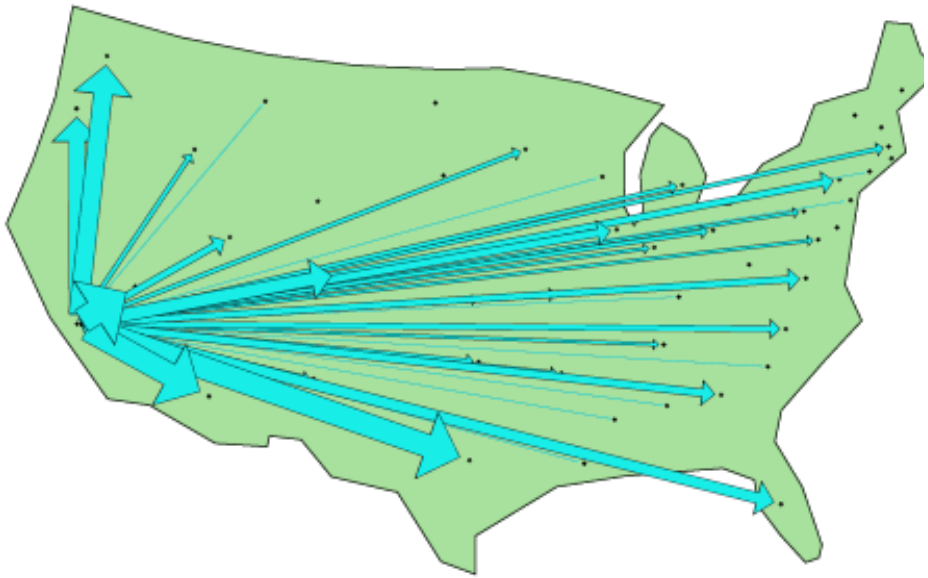
Complete and simplified.



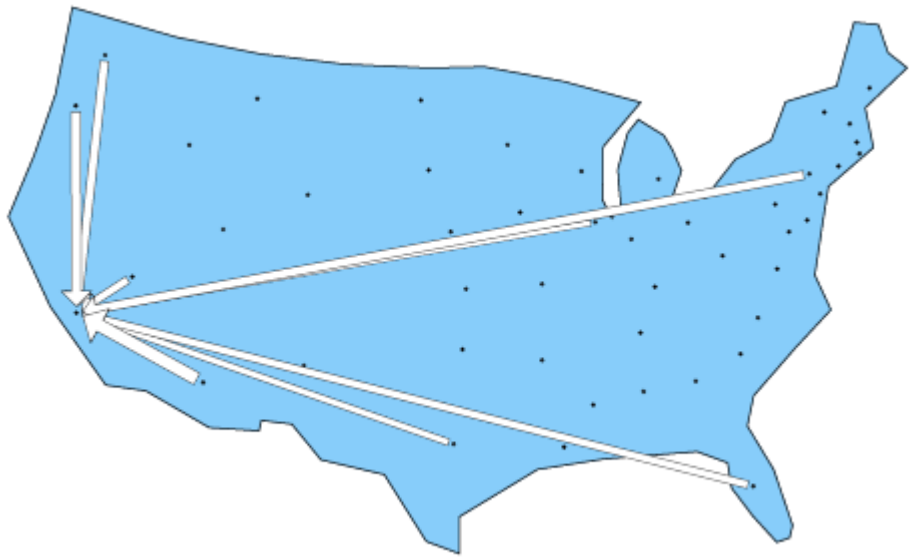


1995-2000 Migration from and to California

Flows from CA

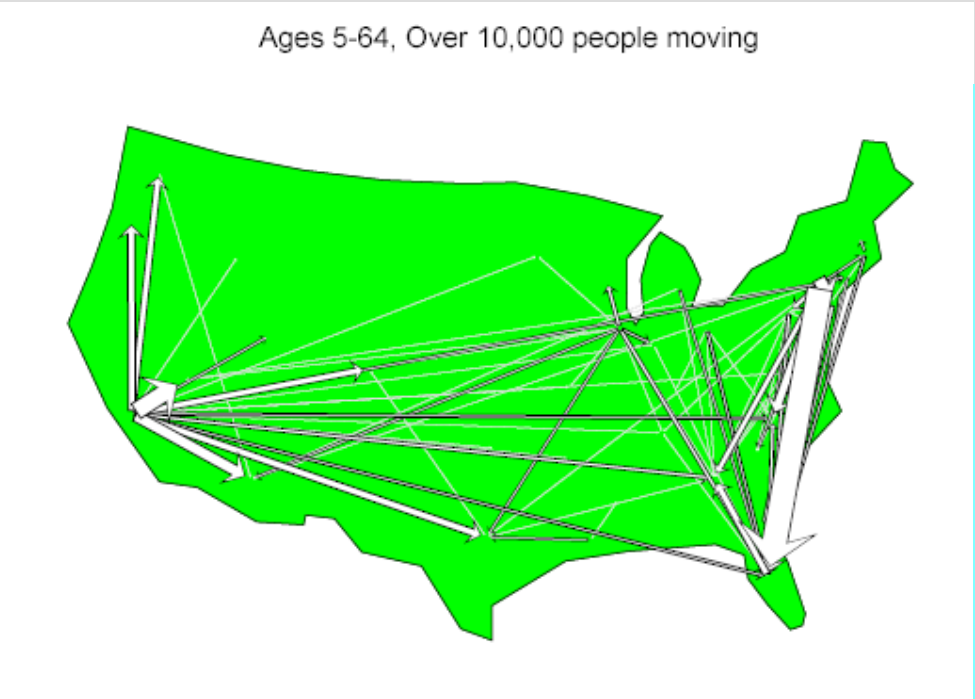


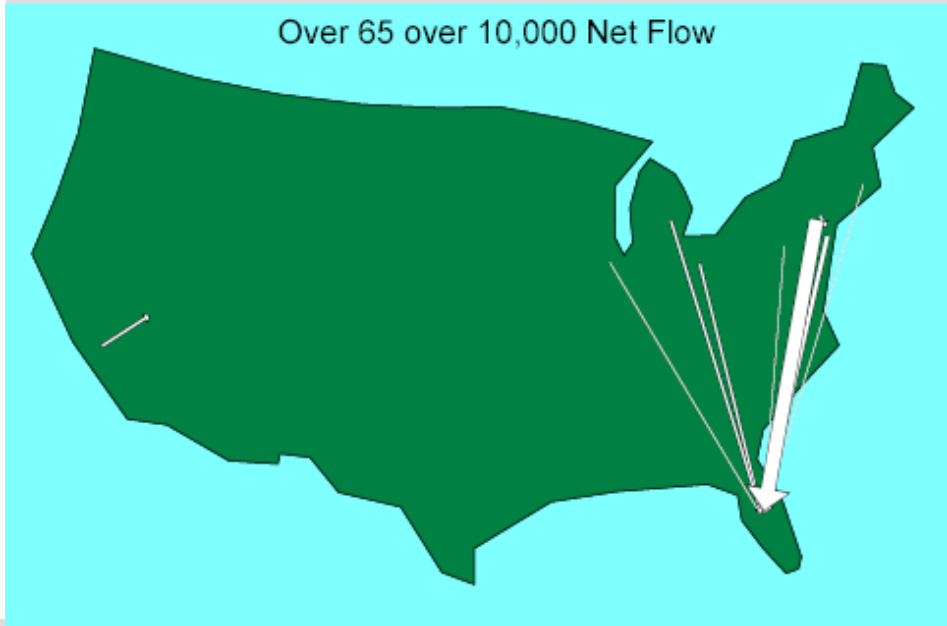
Major flows to CA



1995-2000 Net Migration

by two age groups, and movement size.





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

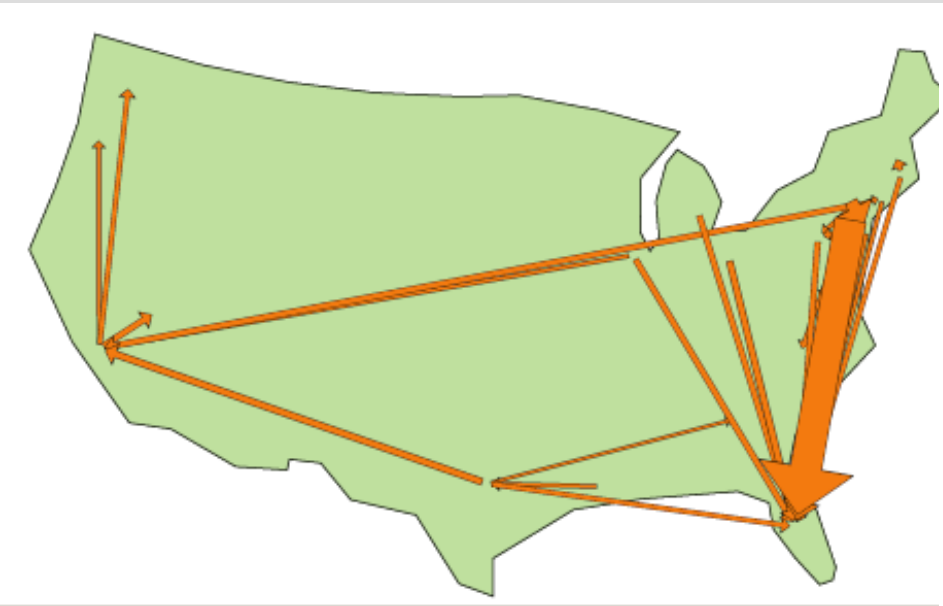
1984

1994

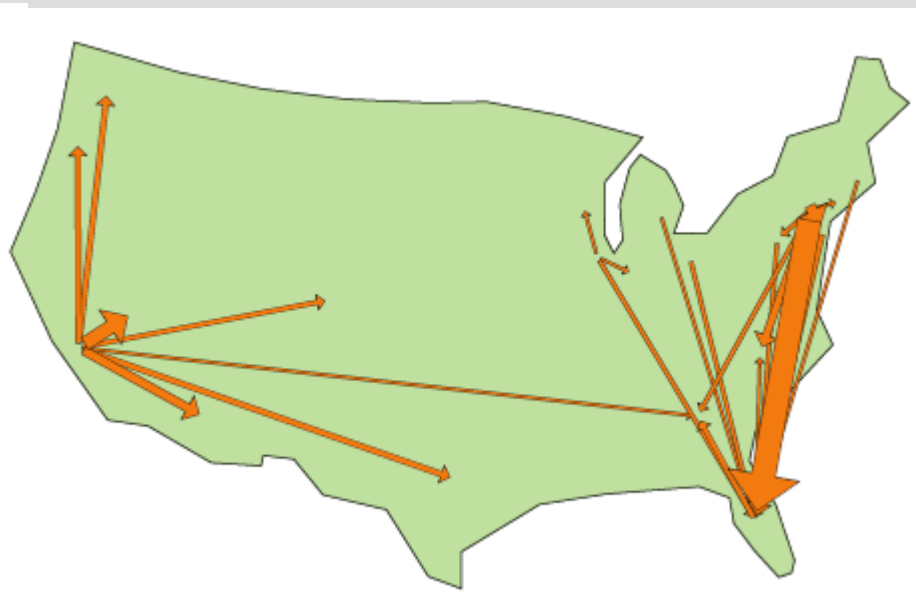
Net Migration in the United States

US Census Data

1985-1990

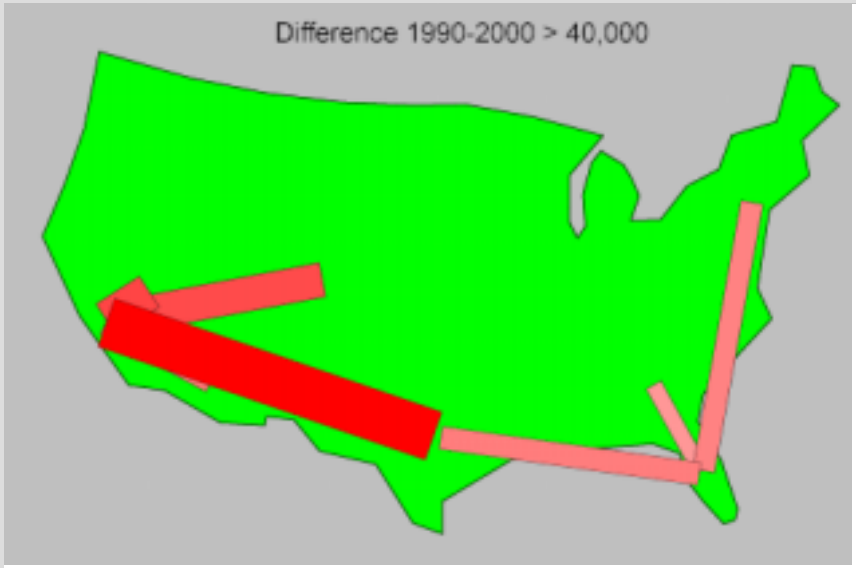


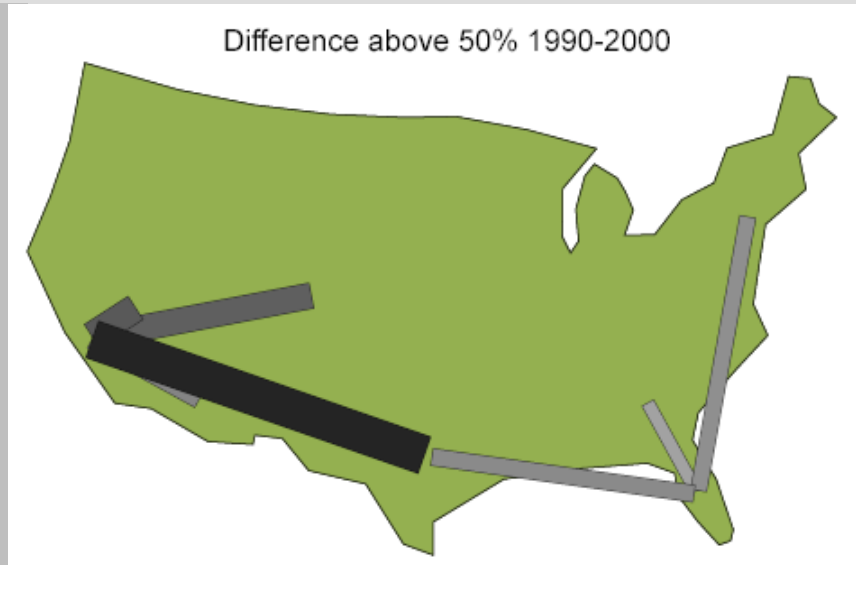
1995-2000

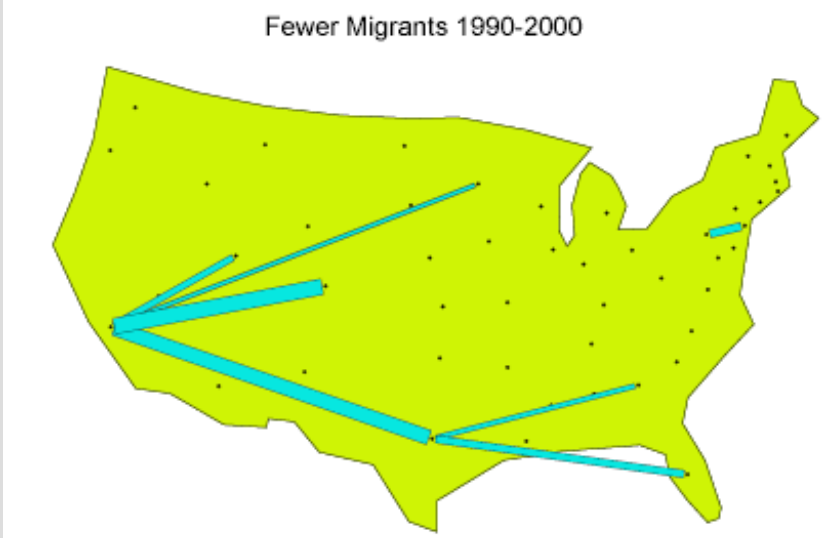


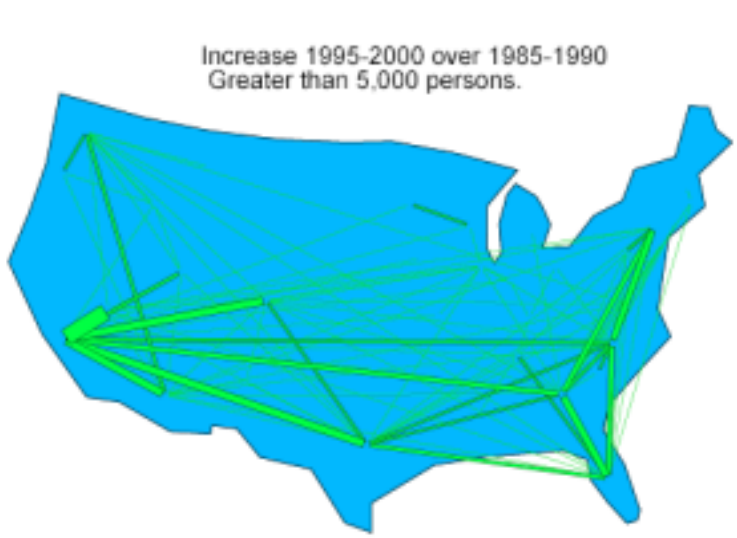
Difference between 1985-1990 and 1995-2000 Migration

US Census information





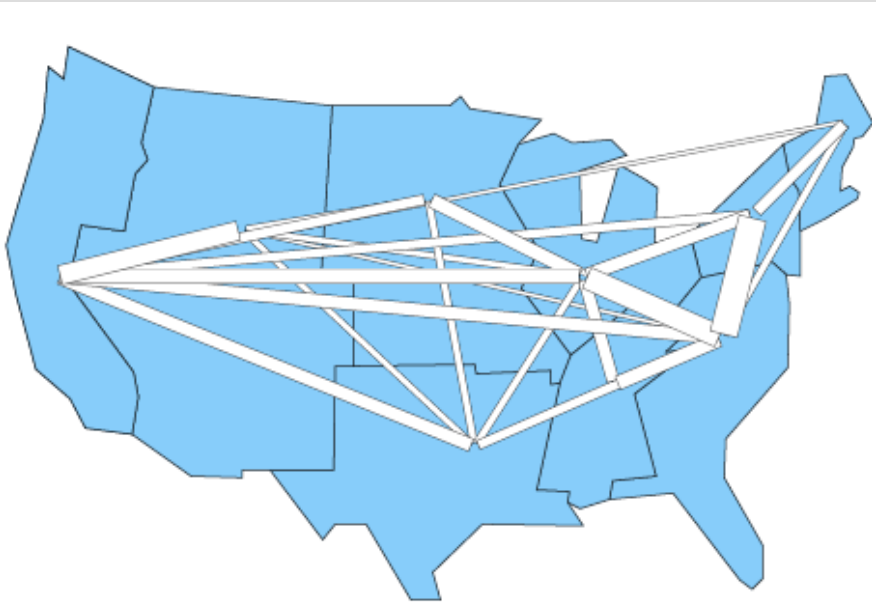


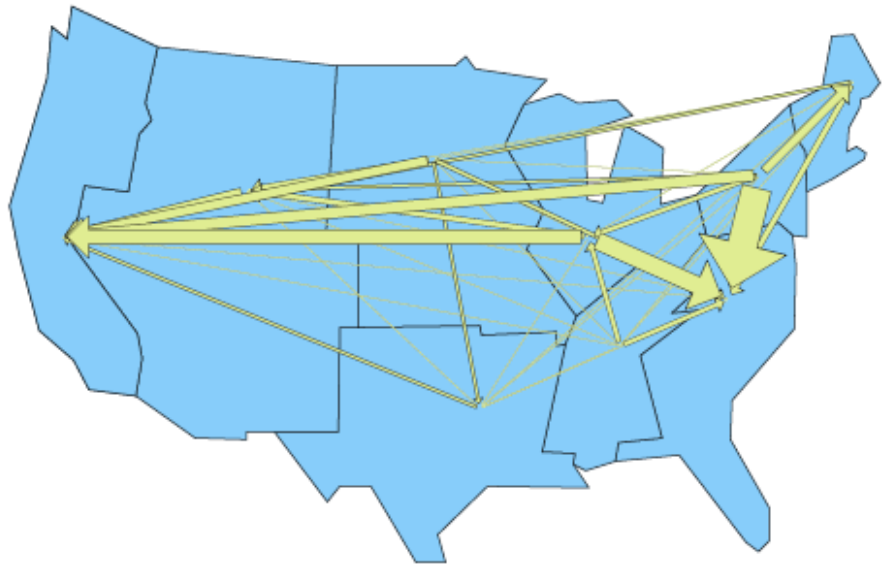


Migration by Census Divisions

Top: 1965-1970 Migration, Total and Net

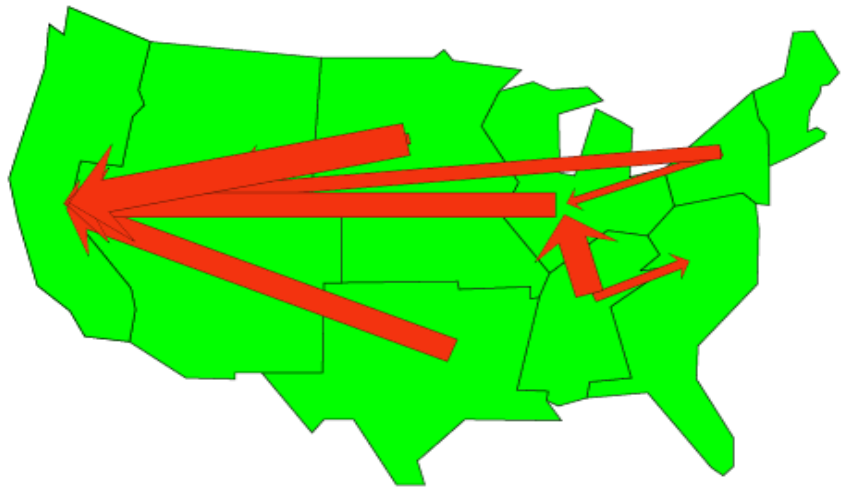
Bottom: Birth to 1970 Residence, Total and Net





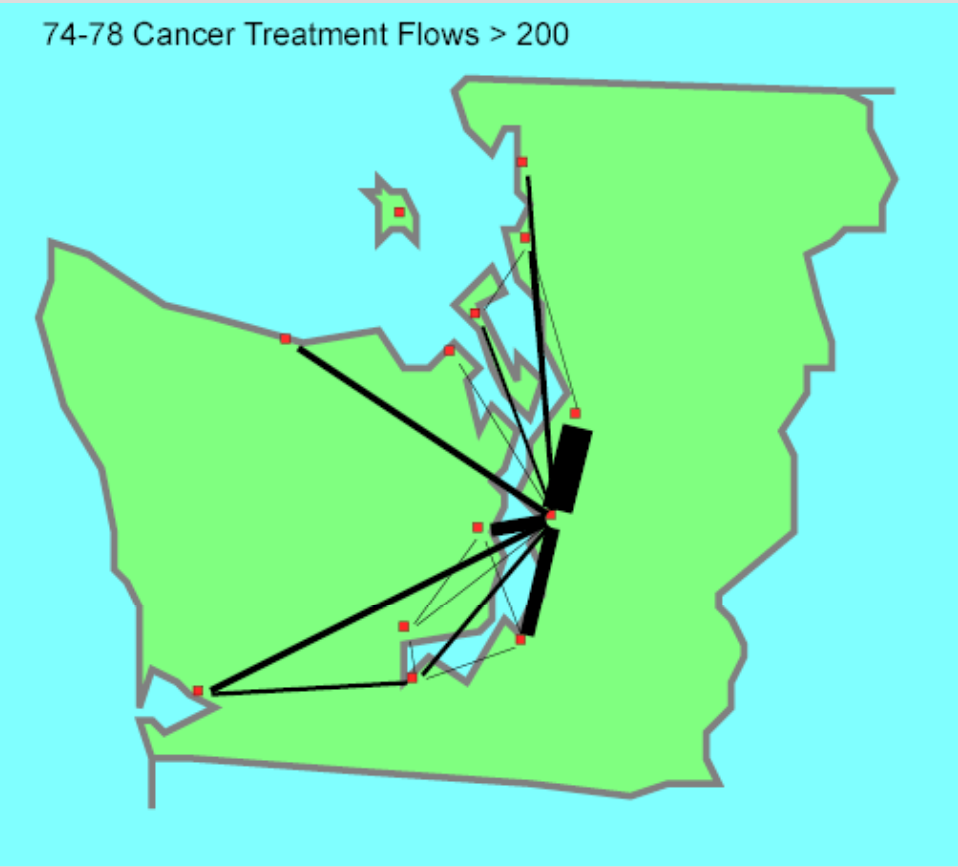
Flow Map: Birth to 1970 Residence

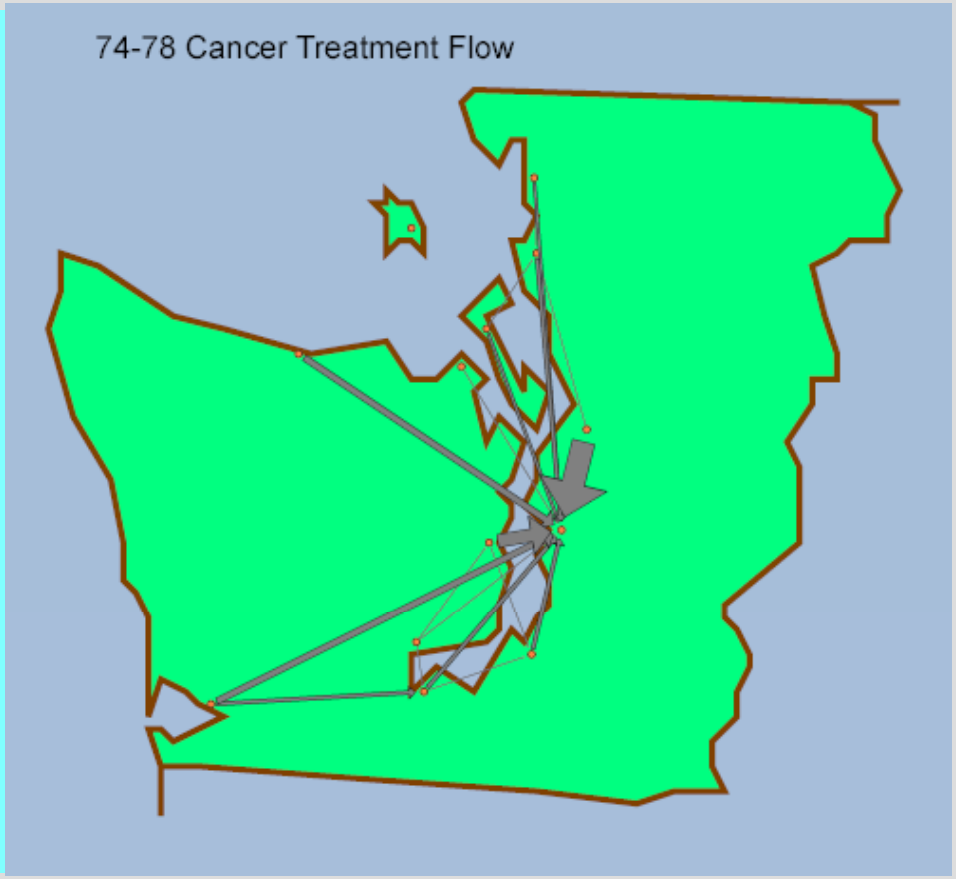
Flow: Birth to 1970 Residence



Gross and Net Moves

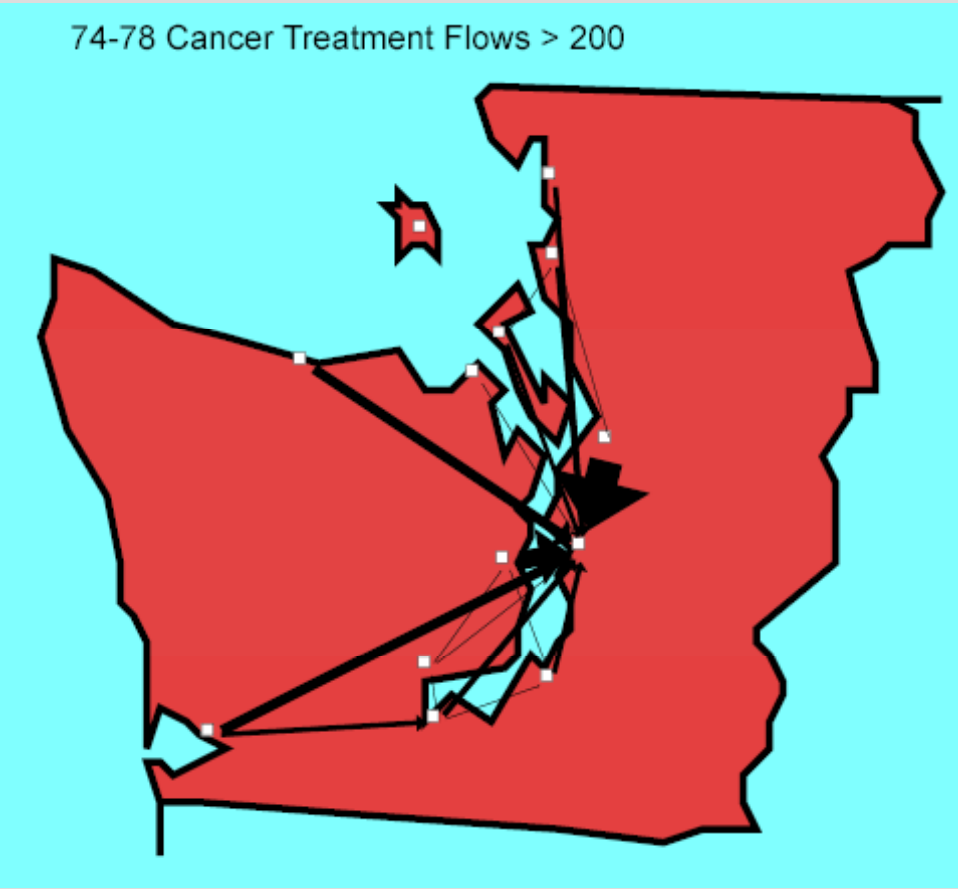
$M_{ij} + M_{ji}$ and $|M_{ij} - M_{ji}|$
in Western Washington state.

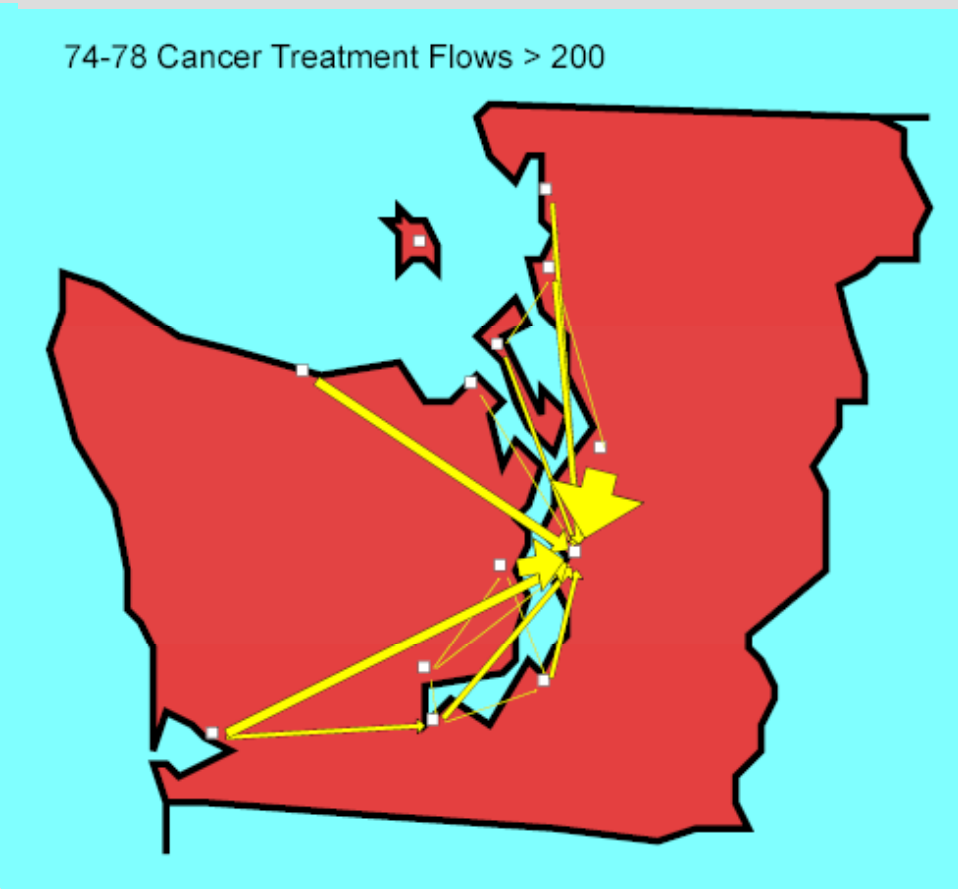




Variations in style

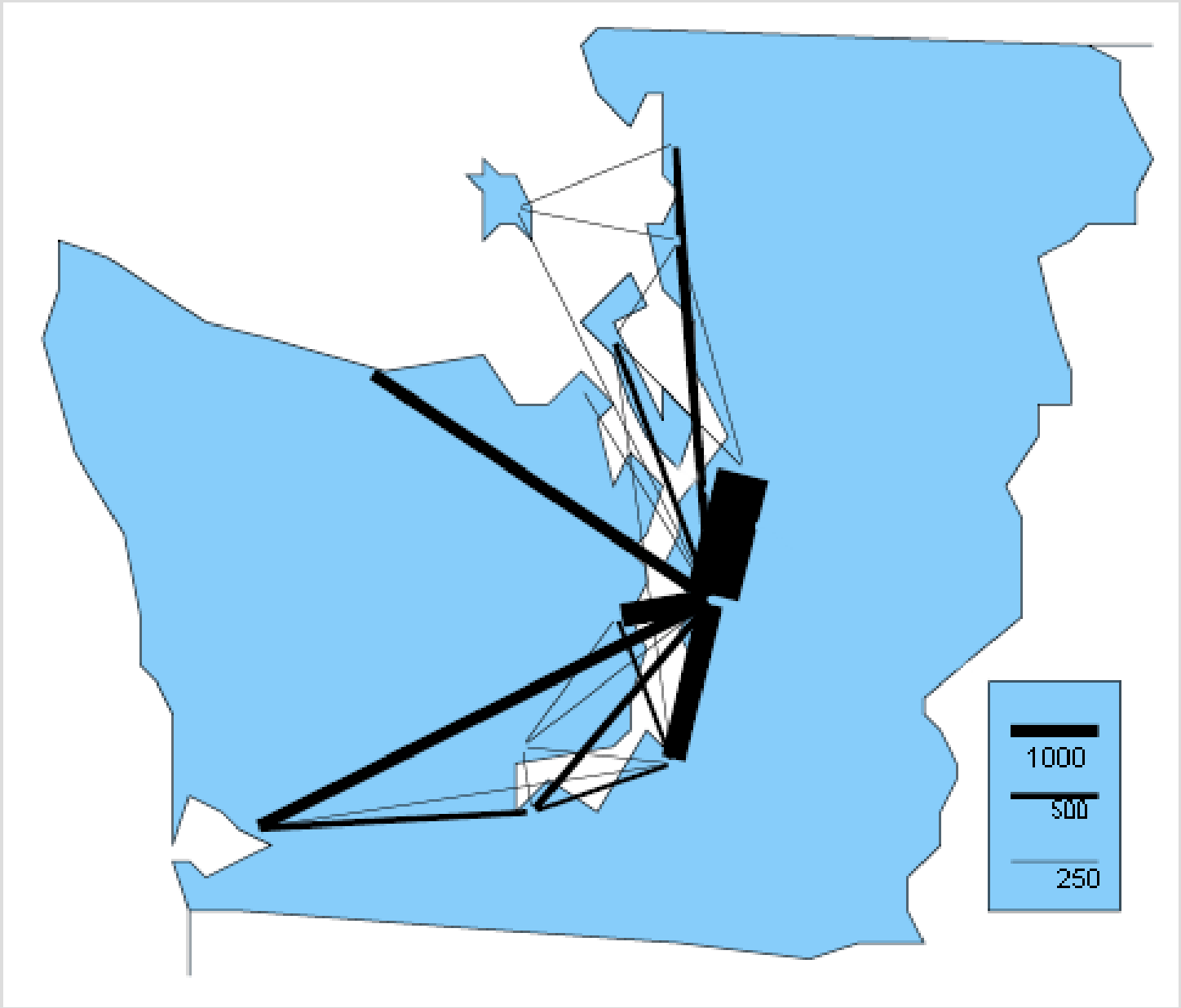
With islands, showing centroids, and title.



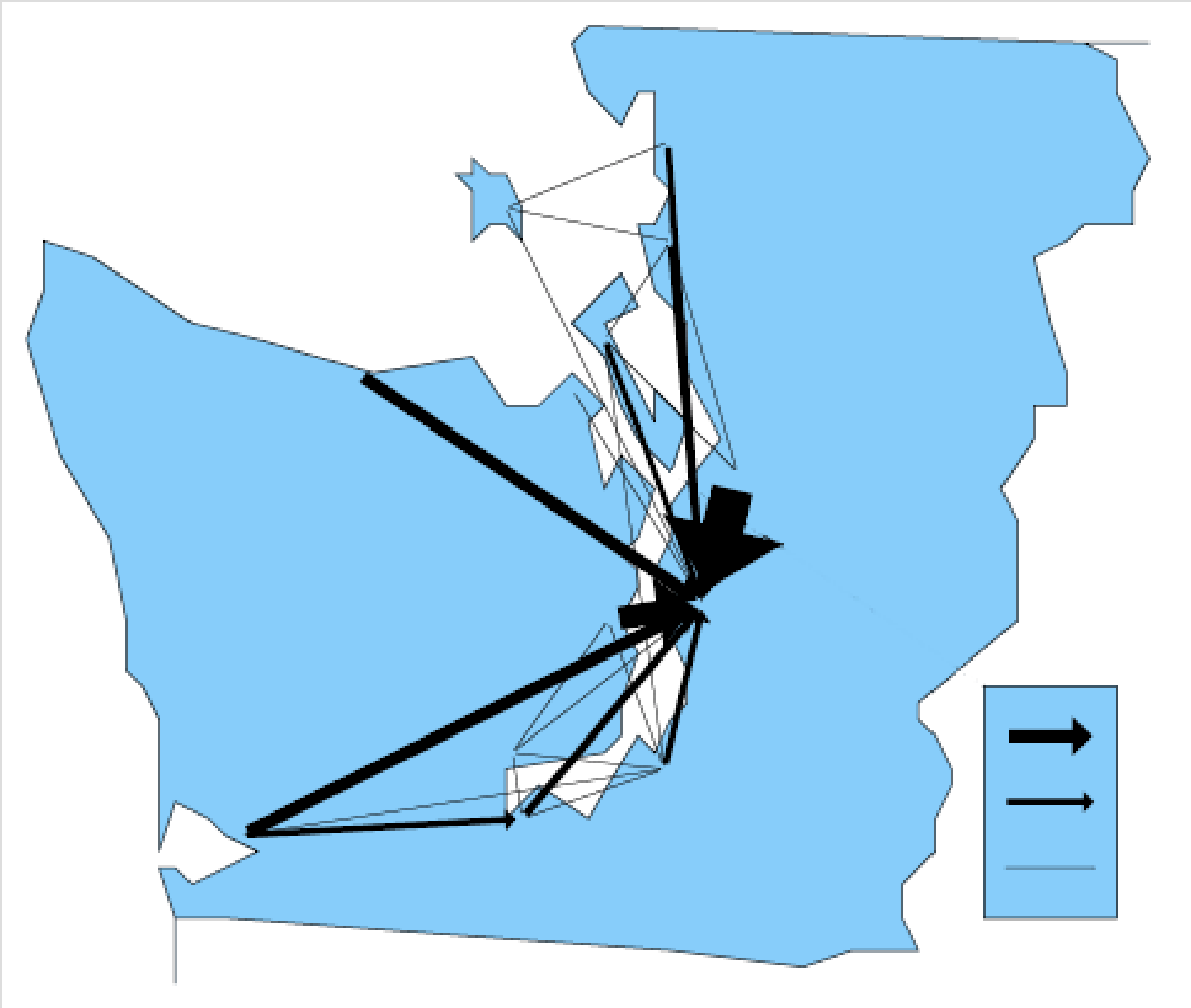


Legend Box

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



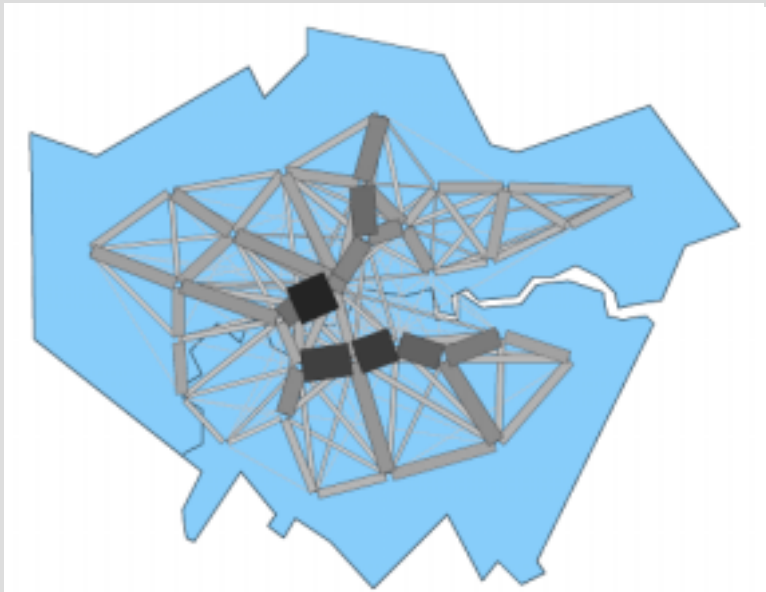
Legend box for net moves

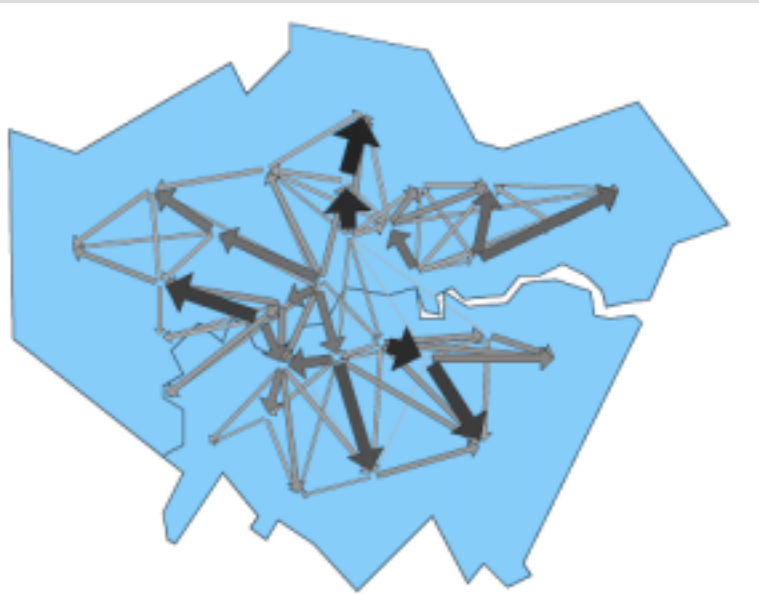


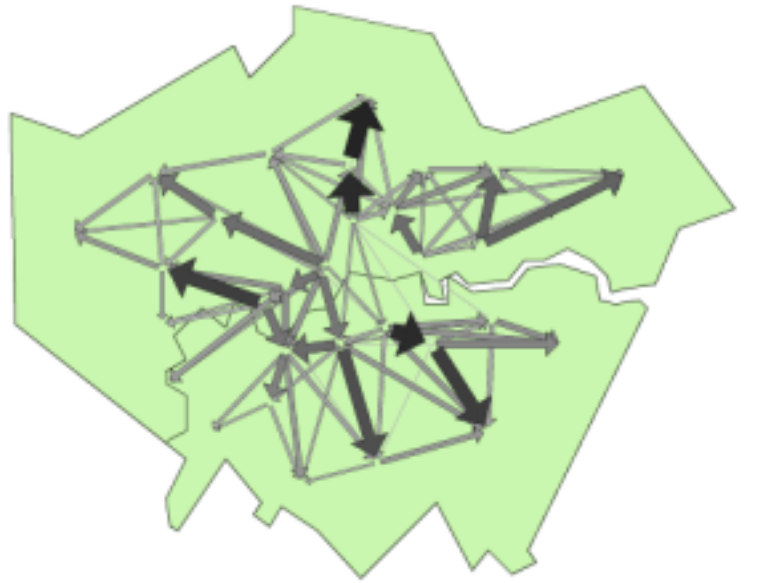
London 1965-1966 Inter-borough migration

from 33 boroughs.

Exploration of map styles, especially colors,

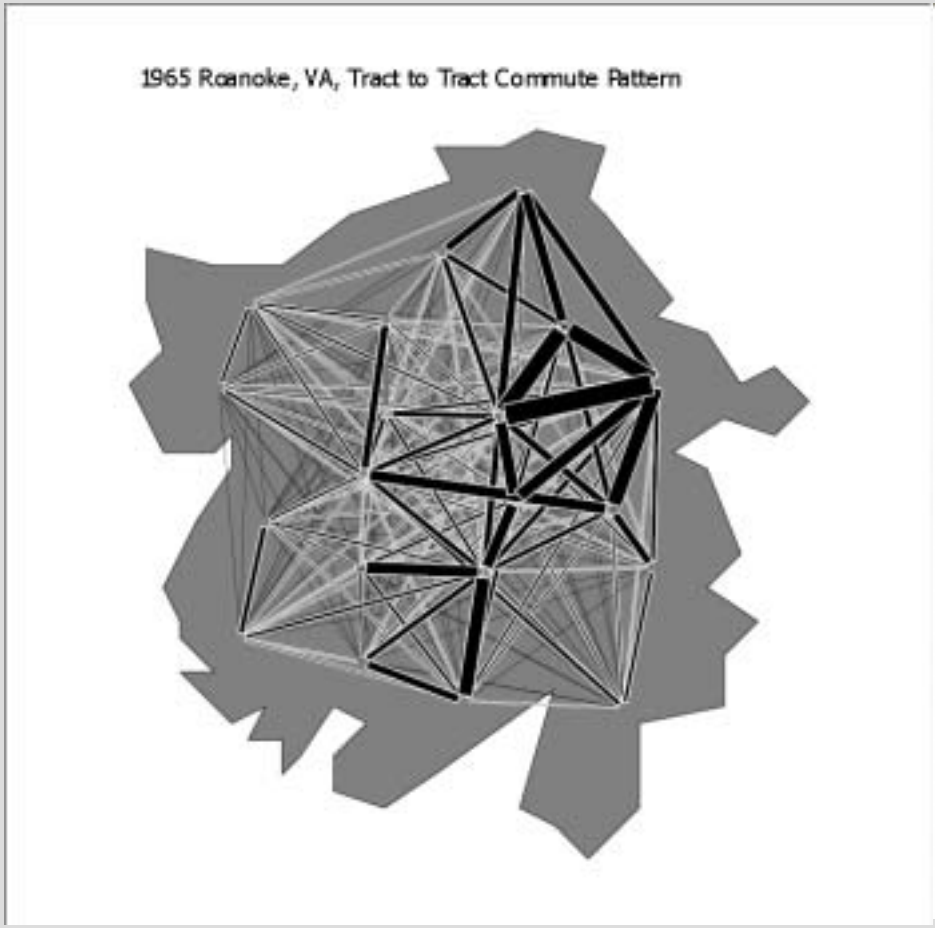






Commuting Pattern in Roanoke, VA, 1965

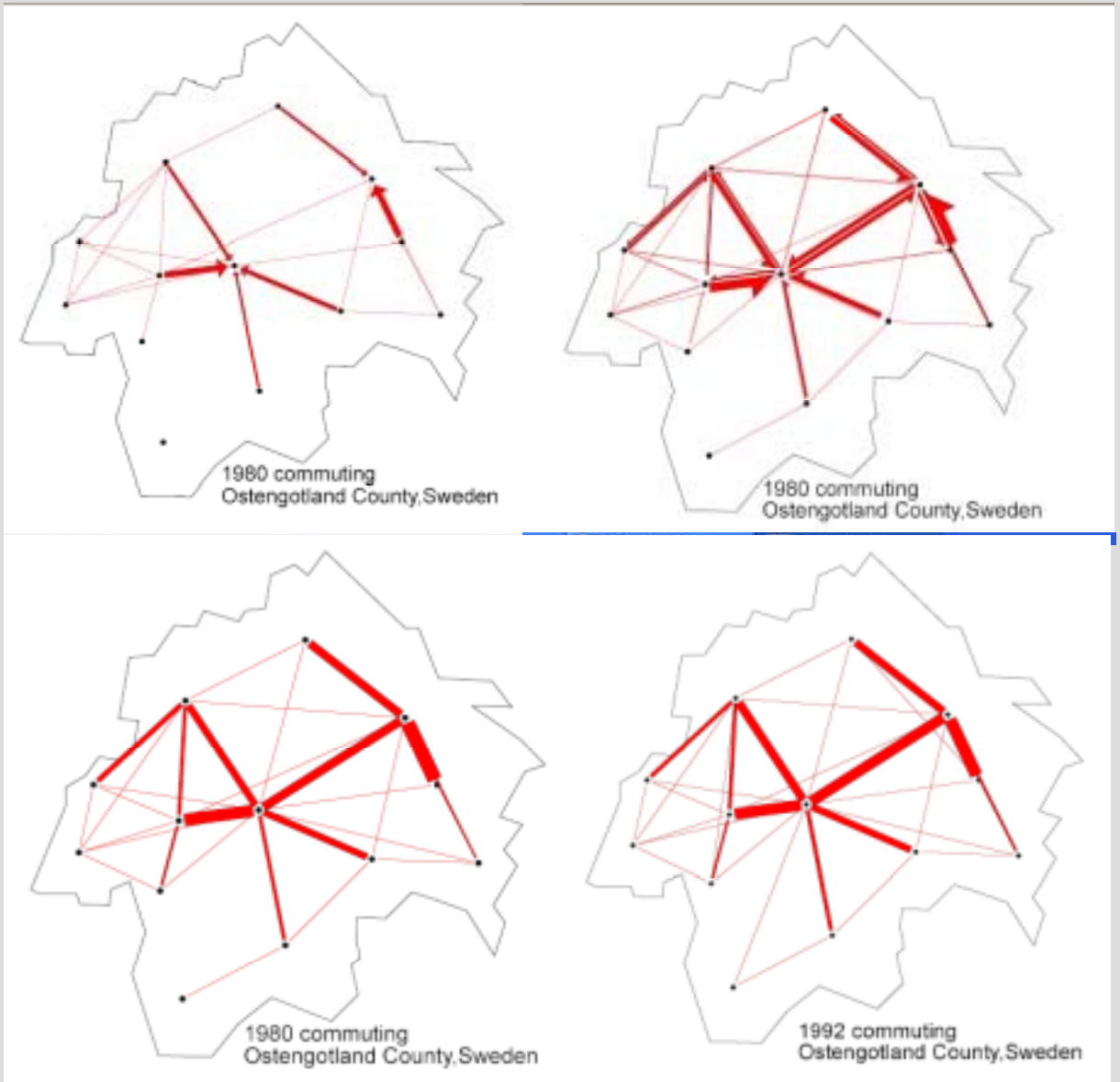
By Census Tract



Commuting in Östengötland, Sweden,

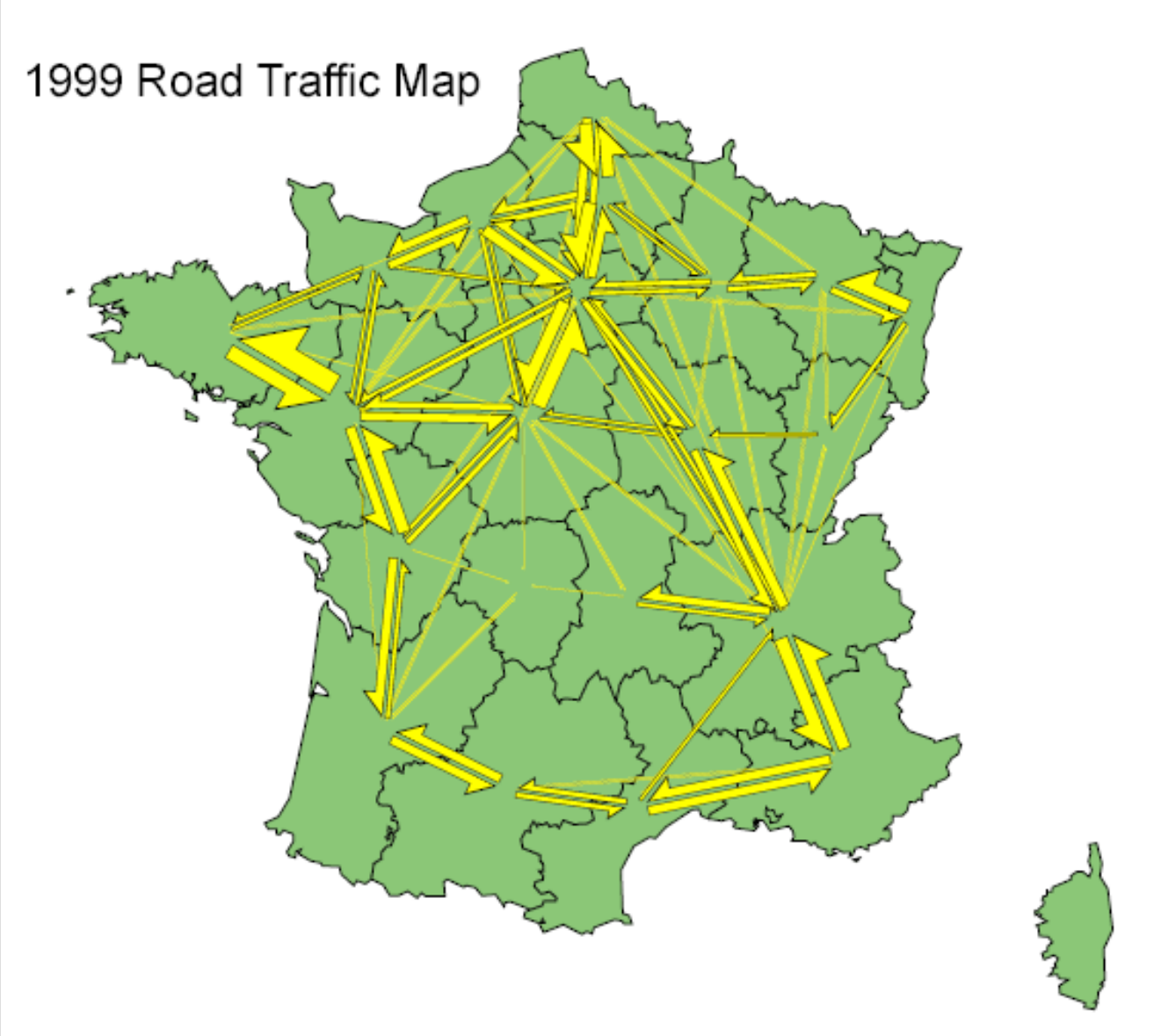
1980 (net, two-way, and total) & 1992 (total)

From P. Åberg (1998)



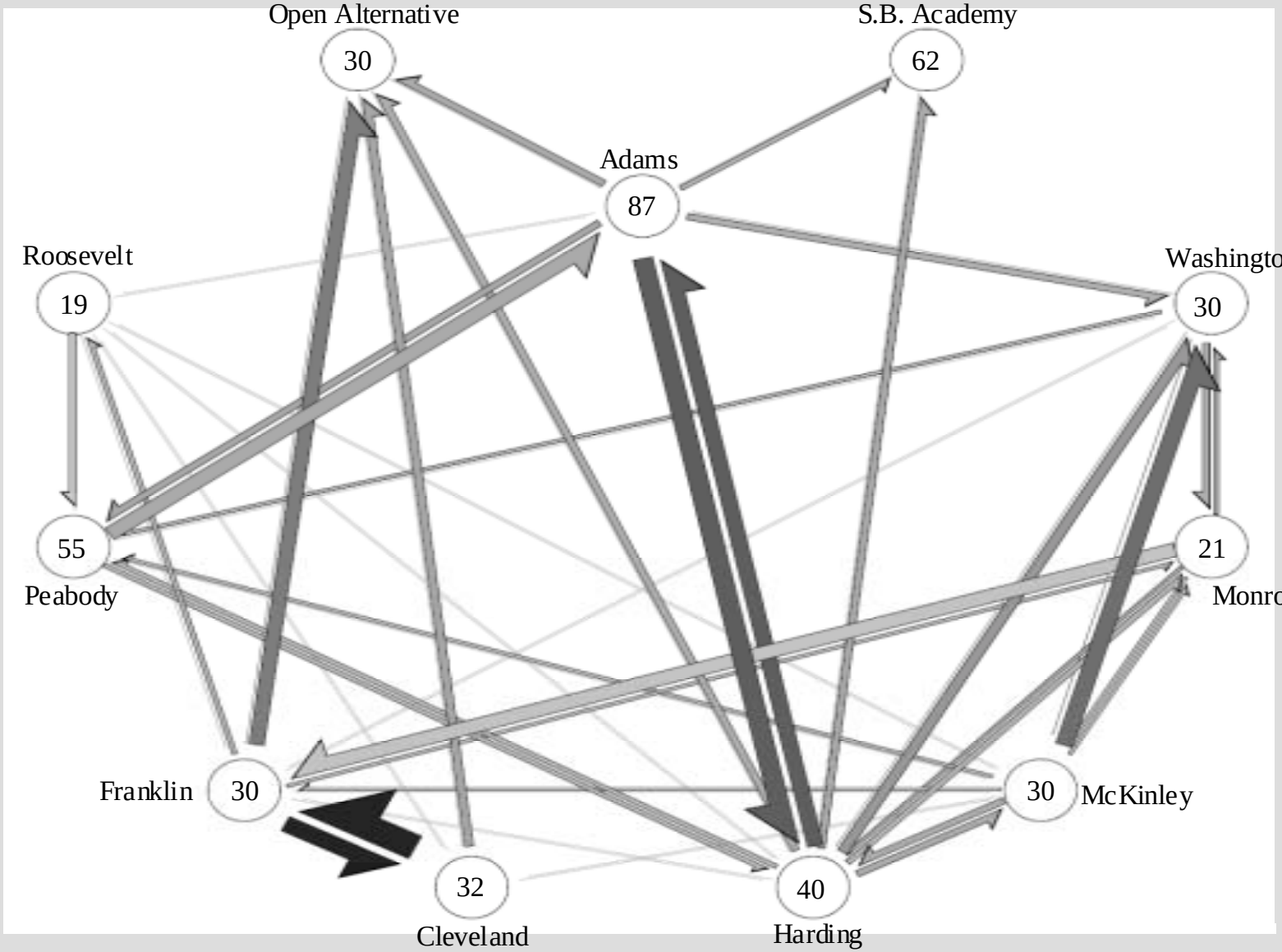
Movement between French Regions

Data courtesy of Mr. C. Calzada of Paris



Transfers between eleven schools in Santa Barbara

School locations adjusted for clarity. Courtesy of Dr. Stuart Sweeney.



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.

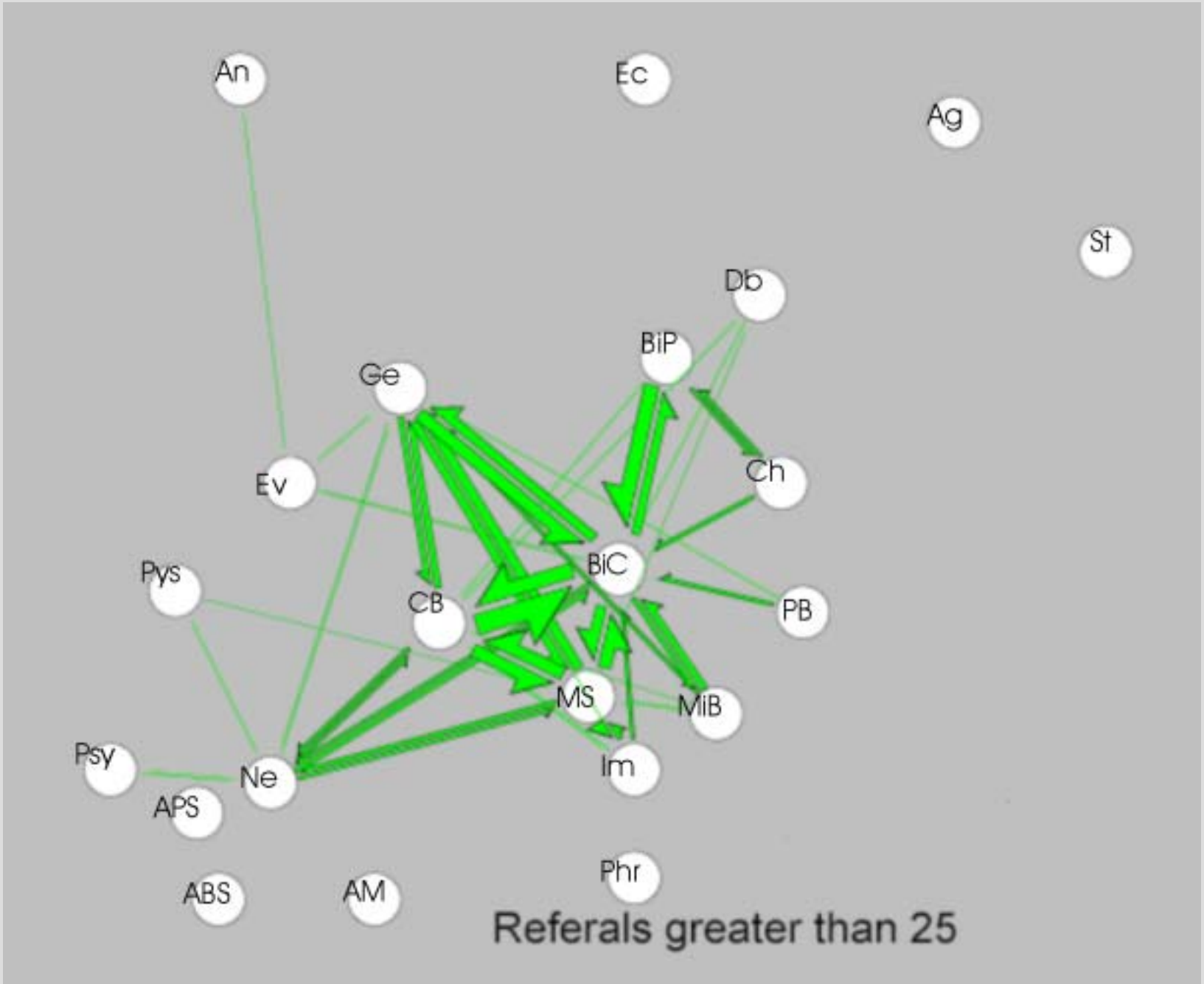
Two-way flows above 25 referrals are shown.

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-Microbology
Ne-Neurobiology
Phr-Pharmacolgy
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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