

MAPPING EXERCISE

Thematic Mapping: The Dot Density Map

The dot density map is a very popular form of thematic mapping. The technique is simple and straightforward: a dot is used to represent a specific number of items (e.g., one dot representing 500 persons), and the symbol is repeated until the total number of items in an area is accounted for (e.g., 100 dots representing 50,000 persons). The strength of this technique is that it allows the reader to visually infer density without using derived tabulated data.

When employing this technique, consider the following guidelines:

- ✓ Employ an equal-area projection constructed at small or intermediate scales. For situations where dots are randomly placed in statistical areas (as in this exercise), try to keep these areas small. A good rule of thumb for mapping the United States: use counties (or smaller units) when mapping the country; use census tracts (or smaller units) when mapping at the state level. The larger the map scale you use, the more locational error is introduced with respect to dot placement.
- ✓ Choose a *dot value* that allows you to have two or three dots in the statistical area with the smallest value and coalescence of the dots in the statistical area with the highest value. You can achieve coalescence when using small dot values by increasing the *dot size*.
- ✓ Use a dot value that is easily understood (e.g., 10, 50, 1,000).
- ✓ If possible, avoid mapping phenomena with extremely large ranges. A small dot value, chosen to allow statistical areas with small values to have two or three dots, will create symbol overload at the high end of the range. A large dot value, chosen to allow coalescence at the high end of the data range, will result in statistical areas at the low end having no dots (as their values are smaller than the dot value).

In this exercise, you will:

- ✓ Browse an attribute table
- ✓ Select fields to display using the dot technique
- ✓ Adjust dot size and dot value
- ✓ Change the background properties of the dot map layer
- ✓ Create a map layout

The Dot Map

- Start ArcMap (**Start All Programs >ArcGIS >ArcMap**); if there is an icon on the computer desktop, you can start ArcMap by double-clicking it. You will be shown a window asking whether you want to open a new empty map, a template, or an existing map.
- Make sure the **An existing map:** radio button is selected and click OK. If you did not see this window, click **File >Open**.

- Browse to where you saved the **DotDensity.mxd** project and open it. You will see a map of the lower 48 states of the U.S.

- There are two map layers in the Table of Contents: States Agriculture and County Agriculture. Because the States Agriculture layer is above the County Agriculture layer in the Table of Contents, the counties layer is obscured in the data view.

Now let's look at the data associated with each state.

- **Open the attribute table** for the **States Agriculture** layer.

Notice that the fields in the attribute table the same as those in the County Agriculture layer, but the data are enumerated at the *state level*.

FID	Shape	STATE	Farms	Broilers	CattleCalv	HogsPigs	SheepLambs
0	Polygon	Minnesota	60639	4969119	2209397	644067	154652
1	Polygon	Washington	36639	4712035	1100191	30299	64470
2	Polygon	Montana	27670	1044693	2398764	172951	305753
3	Polygon	Maine	26017	7693	1999648	23252	255650
4	Polygon	North Dakota	30619	29910	1873191	138838	114002
5	Polygon	Maine	7196	22323	89831	4637	9363
6	Polygon	Massachusetts	77131	5545047	3338122	5300383	83489
7	Polygon	Oregon	46033	3983293	1360005	20941	237076
8	Polygon	South Dakota	31736	97090	3999577	1379596	376468
9	Polygon	Michigan	53315	693568	990204	597460	89341
10	Polygon	New Hampshire	3363	28979	39912	2718	7423
11	Polygon	Vermont	8571	30753	283619	2019	14743
12	Polygon	New York	37285	859111	1453398	81886	839301
13	Polygon	Wyoming	8422	2158	1297042	114047	459682
14	Polygon	Iowa	30855	1730091	3235945	15488581	249600
15	Polygon	Nebraska	48955	584353	6200947	2933620	97373
16	Polygon	Massachusetts	6075	-99	50791	11434	9592
17	Polygon	Illness	73027	38037	1559610	4994786	66078
18	Polygon	Pennsylvania	58105	21588819	1632649	1226645	102890
19	Polygon	Connecticut	4191	41195	54247	3232	5591
20	Polygon	Rhode Island	698	-99	538	2981	1422
21	Polygon	California	78631	3229341	5234177	163465	731568
22	Polygon	Utah	15282	3762	876951	670047	316934
23	Polygon	Nebraska	2969	321	66263	69	77913
24	Polygon	Ohio	77797	5878909	1246812	1422966	149936
25	Polygon	Indiana	60298	3823936	962674	3479579	81620
26	Polygon	New Jersey	8624	30724	41747	14162	15236
27	Polygon	Colorado	31369	9119	2858351	783487	382933
28	Polygon	West Virginia	20912	1250399	624163	12773	38691
29	Polygon	Missouri	106797	3351287	4489495	2909609	76915
30	Polygon	Kansas	64414	18536	6321138	1520996	81145
31	Polygon	Delaware	2391	4594977	20037	11775	1029

Figure 1. Attribute table for the States Agriculture layer.

- **Close the States Agriculture attribute table.**
- Now **open the attribute table** for the **County Agriculture** layer (right-click the layer name and select Open Attribute Table).


The attributes for each county are displayed. Note that the six fields at on the right-hand side of the table are data from the 2002 U.S. agricultural census: the total number farms, broilers (which are meat chickens), cattle and calves, hogs and pigs, and sheep and lambs by county. The data are from comes from the 2002 Agricultural Census. Values of -99 are for counties where totals were withheld to avoid disclosing data for individual farms.

FID	Shape	STATE	COUNTY	FIPS	Farms	Broilers	CattleCals	HogsPigs	SheepLambs
0	Polygon	MI	Lake of the Woods	27077	206	123	4281	-99	-99
1	Polygon	VA	Valhalla	53073	1465	162657	112417	234	691
2	Polygon	MT	Valley	30105	743	-99	81852	512	4000
3	Polygon	MT	Flathead	30029	1075	179	14831	3344	599
4	Polygon	ID	Boundary	16021	432	-99	5215	310	563
5	Polygon	MT	Phillips	30071	525	-99	71835	-99	4072
6	Polygon	ND	Rosette	38079	523	0	26700	142	723
7	Polygon	MT	Lewistown	30063	310	584	3160	239	323
8	Polygon	ND	Bothreau	38009	879	0	21338	147	926
9	Polygon	MT	Gleicher	30035	472	6700	41003	20088	535
10	Polygon	MT	Hill	30041	936	-99	22010	-99	861
11	Polygon	MT	Elaine	30005	588	-99	63645	9081	8161
12	Polygon	MT	Danahy	38018	384	0	16199	286	274
13	Polygon	ND	Pembina	38067	524	0	8787	4816	170
14	Polygon	MI	Kiltson	27069	659	150	15096	1789	607
15	Polygon	ND	Tourant	38095	418	0	13221	-99	541
16	Polygon	ND	Cavalier	38019	607	0	4838	2690	-99
17	Polygon	VA	Okanogon	53047	1486	360	43602	283	3480
18	Polygon	VA	Stevens	53065	1260	1704	30009	1144	2244
19	Polygon	VA	Pend Oreille	53051	263	-99	5001	17	209
20	Polygon	VA	Ferry	53019	207	-99	8891	-99	911
21	Polygon	MT	Lewistown	30061	397	13903	13008	15384	22
22	Polygon	ND	Devise	38023	532	0	19638	-99	-99
23	Polygon	ND	Dunlap	38013	455	-99	14005	128	307
24	Polygon	MT	Todd	30101	495	845	15945	15949	1774
25	Polygon	ND	Rendell	38075	353	0	7089	156	1113
26	Polygon	MI	Rosseau	27135	1236	245	23091	2684	1453
27	Polygon	MT	Shenando	30091	636	235	26978	1511	1110
28	Polygon	ID	Bonner	16017	743	190	6241	181	853
29	Polygon	ND	Vesard	38101	866	-99	44120	1210	1137
30	Polygon	MI	Koochiching	27071	258	141	5789	45	365
31	Polygon	VA	Shang	53057	872	220	36059	207	766

Figure 2. Attribute table for the County Agriculture layer.

- **Close the table.**

Let's create a dot density map of corn acreage with the **States Agriculture** layer.

- **Double click** on **States Agriculture** to open the **Layer Properties window** (or right-click States Agriculture and select Properties).
- Click the **Symbology** tab.
- In the **Show** window (on the left side of the Symbology window), click **Quantities** and **Dot Density**.
- In the **Field Selection** window, **Farms** and then click the right arrow  to add it to the window to the right. ArcMap automatically assigns a color to the symbol.
- Double-click the dot symbol (displayed next to the field name) and change the **dot color** to a shade of **dark blue**.

You should have the following window:

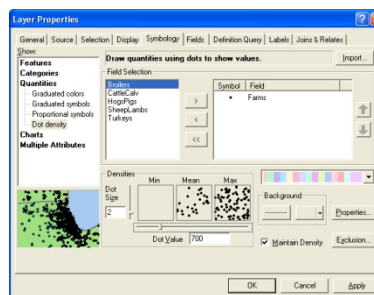


Figure 3. Selecting the Farms field to display in the dot density map.

- In the **Densities** window, note that the dot size is **2** and the dot value is **700** (because the dot value is automatically calculated, you may have a different value).

- You will now change the dot size and dot value. When you make these changes, **press the TAB button on the keyboard (not the Enter button)** to register the change in the display window and then click on the **APPLY button (not the OK button)** to update the map. Keep the dot size at 2 but change the **Dot Value** to **100**. If you accidentally hit Enter or pressed OK, the Layer Properties window closed. Reopen the window if it closed.
- Note the two buttons beneath **Background** to the right of the Densities display area. The left button allows you to control the symbol properties for the outline (line thickness, color and pattern) and the right specifies the fill color. Currently, the background is set to a gray outline with a width of 1.00 and no fill color.
- Leave the outline as it currently is and click the right button to change the **background fill color** to **gray 10%**.
- To the right of the Background buttons is the **Properties...** button. **Click it** to open the **Dot Density Symbol Properties** window.

There are two properties that can be adjusted in this window (**note: you will not be adjusting these properties at this time**): Dots and Masking.

- ✓ The Dots window has two options: **Non-fixed Placement** and **Fixed Placement**.
 - When Non-fixed Placement is selected, dots will be randomly placed **each time** the map is refreshed.
 - The Fixed Placement option keeps the dots in the same location when the map is refreshed.
- ✓ **Masking** refers to using other layers to control where the dots are placed. If you turn on “Use Masking,” you can specify two items: the layer to use as the Mask and whether the dots should be included in or excluded from this layer
 - *Exclude dots from these areas* is used when you have a layer that contains areas where you want no dots to appear. For example, if you have a lakes layer, selecting this as the masking layer will prevent dots from being drawn inside the lake polygons.
 - *Place dots only in these areas* is used when you want to further refine the placement of dots. For example, you may have data in a county layer that occurs only in urban areas. If you have a polygon layer that is of urbanized areas, you can specify that the dots from the county layer appear only in areas that are within the urbanized area (it is important to note that if there is no overlap—e.g., no urbanized area within a particular county—the county information will default to its normal random pattern for the entire enumeration unit area).

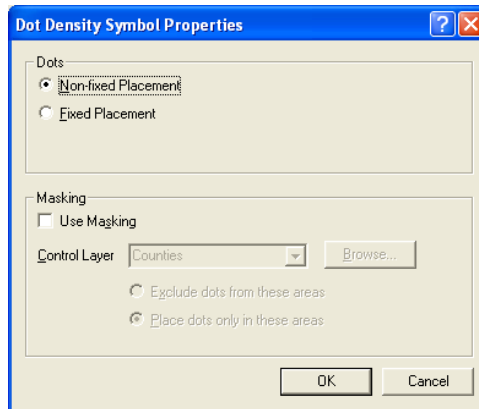


Figure 4. Dot Density Symbol Properties window.

- Click **cancel** to close the dot density symbol properties window without making changes.
- Now click OK to close the Layer Properties window. Your map should now look like the following:

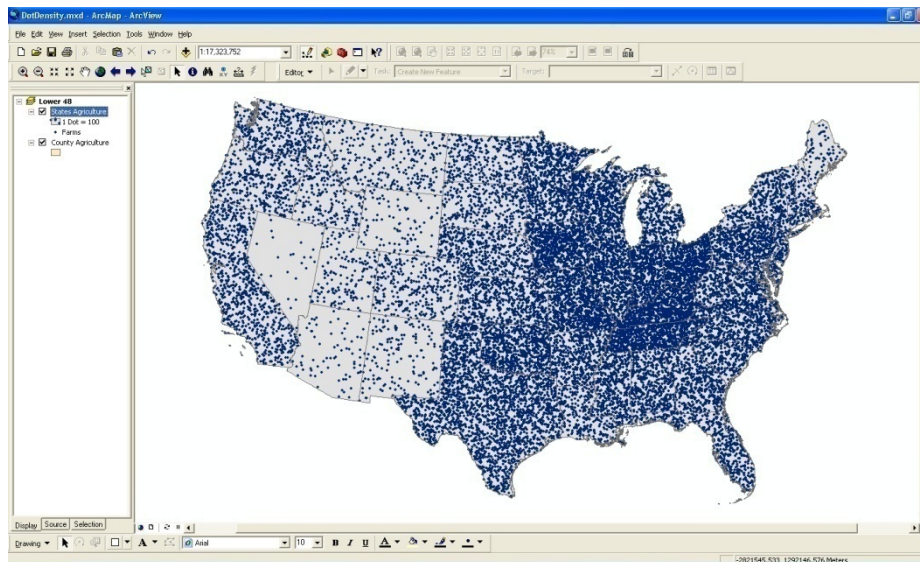


Figure 5. The dot map of farms at the state level.

Note how the dots are randomly distributed throughout the *entire area* of each state. In some states, particularly Iowa and Illinois, the dots have become one large agglomeration and it appears that farms are *uniformly distributed* throughout the state.

When making dot-density maps, you can accomplish the overall pattern you want not only by adjusting the dot value, but also the dot size.

- Re-open the Layer Properties window and **experiment with the dot size and value**. First, increase then decrease both values at the same time, then increase one while decreasing the other. Click **Apply** each time and note how the appearance of the map changed. *Coming up with the best dot map often involves experimentation with dot sizes and values.*

i As you experimented with dot size and value, you may have noticed the effect of random dot placement in the states with few farms such as Arizona and Nevada. When enumeration unit areas are large and the populations in these areas are small, such a random placement can introduce a great deal of inaccuracy in the map. As stated previously, with computer-generated dot mapping, it is best to use the smallest enumeration unit possible to achieve a more accurate portrayal of a distribution. That way, the dot is placed more closely to the *actual location* of the feature being mapped.

- When you are satisfied with your dot size and value, click OK to close the Layer Properties window.

Let's now map farms at the county level to see why small enumeration units are desirable.

Before viewing the county-level map, you need to switch the states agriculture layer from a dot map to a map with just the outlines of the states.

- Open the properties window. In the symbology tab, click **Features** in the left-hand column. The **Single symbol** subtype will be automatically selected.

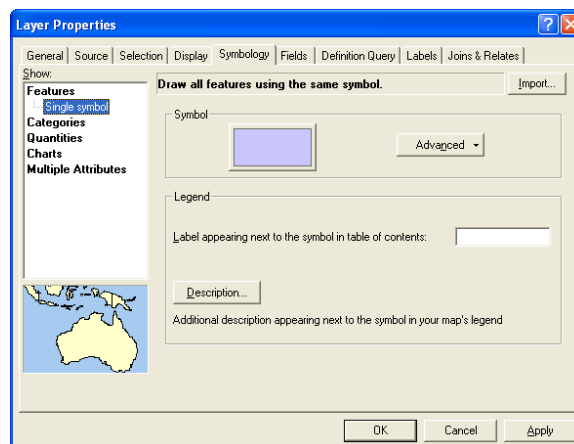


Figure 6. Displaying the map features with a single symbol.

- Click on the symbol (purple box), and make the fill color **No Color**, the Outline width **1.00**, and the outline color **Black**. Click **OK** twice to register your changes. You should now see the county boundaries in light gray with the state boundaries in black.
- Open the properties window for the **County Agriculture** layer, either by double-clicking the name in the Table of Contents or right-clicking the layer name and selecting Properties.
- As you did with the state agriculture layer, select the **Symbology** tab and specify the **dot density** map.
- Set the Field to **Farms** and **change the color of the dot to dark blue**.

- If the dot value is not 100, change it to this value. Make the dot size **2**.
- Change the Background properties so there is no fill and the lines are **Gray 30%**.
- Click **Apply** and close the properties window. Your map should look similar to the following:

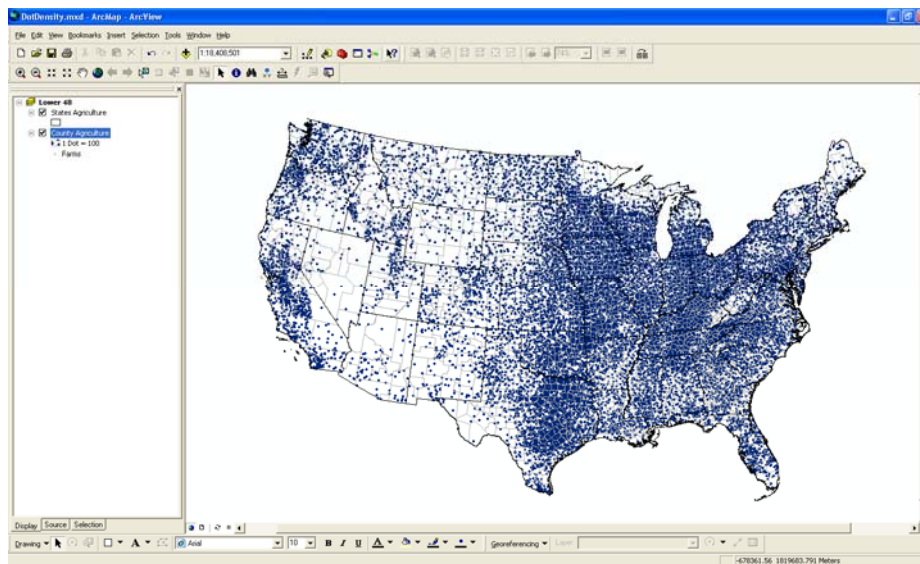


Figure 7. The dot map of farms at the county level.

You should notice that the patterns on this map are quite different that those on the map using states as the enumeration unit areas. In the state of Texas, for example, there are more farms in the eastern one-third of the state instead of over the entire state as the States Agriculture map implies. *The dot distribution is more accurate when mapping with the smaller enumeration unit areas.*

i In the map you just created, you symbolized the borders of the enumeration unit areas (counties). Not every dot map should do this as borders for these areas can become visually distracting. As a general rule, include borders of areas *at least* one level up in the hierarchy of administrative unit areas for reference. In the United States, a common hierarchy is: Country—State—County/Parish—Census Tract—Census Block Group—Census Block.

The map symbols in the data view do not appear ideal: the state borders seem a little thin and the dots seem a little large. When you are constructing a map layout for publication, you most often assemble the map elements in the Layout View rather than the Data View. It should be noted that symbology sometimes is displayed differently between the two views.

- Switch the Layout View (**View >Layout View**) and note the appearance of the borders and dots. Note how the dots appear relatively smaller and the borders are more pronounced—especially in areas where there dots coalesce.

i If you are publishing (for print or digitally) your map from the Layout View, check the appearance of the map symbols in this view *as you construct the map*. Experienced users of ArcMap will switch back and forth between the views several times.

- Switch back to the Data View (**View >Data View**).
- As you did with the States Agriculture layer, open the **Layer Properties** window for County Agriculture and adjust the **dot size** (note, dot sizes can go as small as 0.5) and **dot value** until you have a pattern that you are satisfied with. Remember, you ideally want to have two or three dots in the counties with the fewest farms and coalescence of dots among counties with most.
- Now that you have worked through representing the farms layer as a dot map, **make a dot map using one of the other fields** in the county agriculture layer. Be careful to choose a good dot size, dot value, and dot color for your map.

When you have this map to your satisfaction, you will create the layout.

CREATING THE LAYOUT

- Switch to the **Layout View (View >Layout View)**.
- Make the orientation **Landscape**, which is appropriate for a mapped area with a larger horizontal dimension than a vertical dimension. Make sure that you (1) set the printer to the default printer, (2) select the “Use Printer Paper Settings” check box and (3) select “Show Printer Margins on Layout” in the Page and Print Setup.

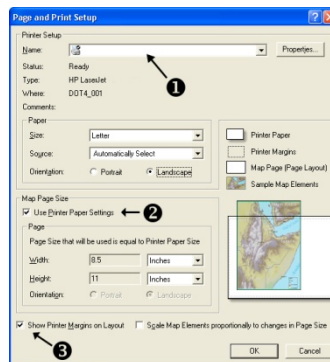


Figure 8. Page and Print Setup.

- **Turn off the border** around the data frame (mapped area). To do this, right-click the data frame to open the **Properties window**, switch to the **Frame tab** and change the border to **none**.

i Maps that are graphically intensive—and your map may have thousands of dots on it—can oftentimes take several seconds to display in the Layout View. To speed up the drawing of the map, consider doing one of two things. If you have one layer that contains most of the symbols (like the county agriculture layer in your dot map), simply turn off that layer while you are making adjustments to the layout. When you are done, turn the layer back on. Alternately, you can switch to **draft mode** in your layout. In draft mode, frame graphics are replaced by image placeholders. Use the **toggle draft mode** button on the Layout toolbar to switch between the draft mode and the graphics display.



Figure 9. Toggle Draft Mode button.

- Resize the data frame (a green dashed box will appear when the data frame is selected) to fit within the dimensions of the page inside the print margins. You may need to resize your map to fit within the data frame box.

i Be careful to use the correct zoom tools when you are in the Layout View. The pan and zoom buttons on the Layout toolbar (Figure 10) allow you to pan and zoom within the *entire layout*.



Figure 10. Zoom buttons on the layout toolbar.

The pan and zoom buttons on the Tools toolbar (Figure 11) allow you to pan and zoom around within a *data frame*.



Figure 11. Pan and zoom buttons on the Tools toolbar.

In other words, use the Layout tools if you want to see the map title, legend or mapped area in greater detail. Use the Tools pan and zoom tools to adjust your view within the mapped area.

- **Insert a neatline (Insert >Neatline)** with the following properties: Gap: **15**; Place **Inside Margins**; Roundness: **0%**; Thickness: **2 points**.
- At the top of the layout, inside the neatline and add a title (**Insert >Title**). Your title for this map should contain three elements: “Contiguous United States” (*never* use simply “United States” on maps that do not portray Alaska and Hawaii!), your map subject (cattle and calves, broilers, etc.) and the year that the data were collected (2002 for this

map). Make the title sufficiently large as this is the most important text element in your layout.

Legends in dot maps contain up to three elements: First, a statement indicating the value of the dot; Second, a statement indicating the size of the enumeration unit and the method of dot placement; Third, a set of at least three squares that illustrate low, medium, and high densities. Because ArcMap does not generate the third element as part of its Legend designs, you will include only the first two.

- In the lower third of the layout, insert the following text: “**One Dot Represents [your dot value] [feature]**” (**Insert >Text** or use the New Text button on the Drawing toolbar).



If you are dealing with a feature that occurs in specific units (e.g., acres, tons, bushels), make sure the units are included in the statement. For example, “One Dot represents 50,000 Acres of Cropland.”

- Pick a location for this statement where there is plenty of available space. Select a font size that is noticeable but not too large (generally between 12 and 16 points for an 8.5”x11” map, depending on available space and the number and size of other layout elements).
- Below the statement of dot value, insert the following text: **Dot placement is random using county-level data.** Make this text **smaller** than the statement of dot value (generally between 8 and 10 points for an 8.5”x11” map). Center-align these two statements to each other.
- In the bottom left-hand corner, inside the neatline, add **Data Source: USDA National Agricultural Statistics Service, 2002.** Make this the same size as your statement of random dot placement.
- In the bottom right-hand corner, inside the neatline, add the cartographer’s information (two lines, right-aligned):

Your name
Today’s date

To print a hard-copy of the map:

- Click on the **print button** or select **File >Print** (you may also print preview using **File >Print Preview**)

To create a PDF document (for digital submissions):

- Export the map by selecting **File >Export Map...**
- Change the **Save as type:** to **PDF (*.pdf)**. Change the file name to include your name.

- The Resolution should be **300** dpi and the **Output Image Quality** should be **best**. Keep these settings unless directed otherwise.

Exercise Questions

1. What dot display goals should you try to achieve for statistical areas at the highest and lowest ends of the data range?
2. What problems might you encounter while assigning a dot value for phenomenon with a very large data range?
3. How do you change the dot size and value in ArcMap?
4. What is Non-fixed Placement of dots?
5. What is Fixed Placement of dots?
6. How can you prevent dots from being drawn in areas where you want no dots to appear (e.g., dots not being drawn in locations where there are water bodies)?
7. How can you confine dot placement to be only *inside* specific areas (e.g., fish count data at the county level being drawn dots only in locations where there are water bodies)?
8. What is a disadvantage of drawing the of enumeration unit area borders at the same level as the dots (e.g., placing dots at the census tract level and drawing the census tract boundaries)?
9. By default, ArcMap draws the borders of the unit areas you use to for the dots. How do you display the dots without displaying the borders for these areas?

10. Why should your enumeration unit area be as small as possible when using this technique in ArcMap?