

MAPPING THE ENVIRONMENT

Mapping Ecoregions With ArcView GIS 3.x



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Teachers May Photocopy These Modules For Instructional Use.

What's It Like Where You Live?

One of the first things to know when you study ecoregions is what it's like where you live. In particular, knowing the temperature and precipitation that are "normal" for your city will help you to understand what types of plants and animals can live there.

In this exploration, you will see what is "normal" in your area and what other regions share similar temperature and precipitation.

Preparing your map:

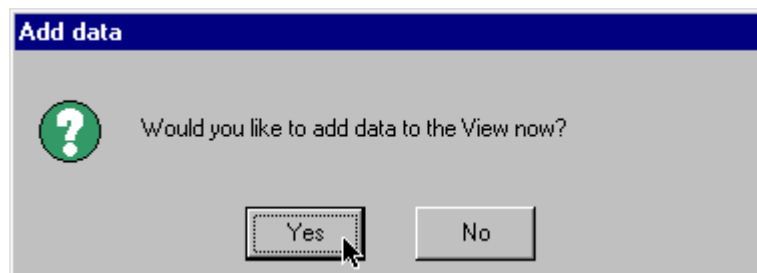
To start, you need a base map, which you will later use to add climate data.



Start ArcView as you normally do, and create a new view:

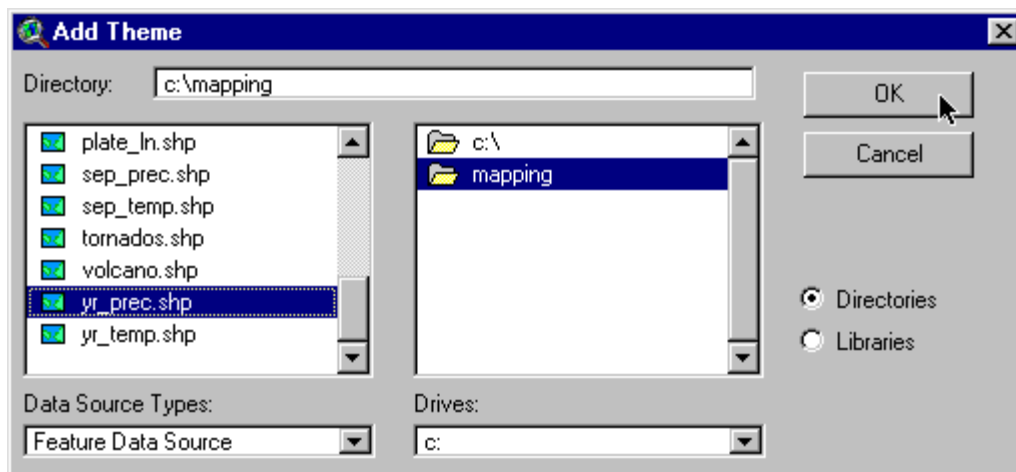


When you are asked, indicate that you want to add data:



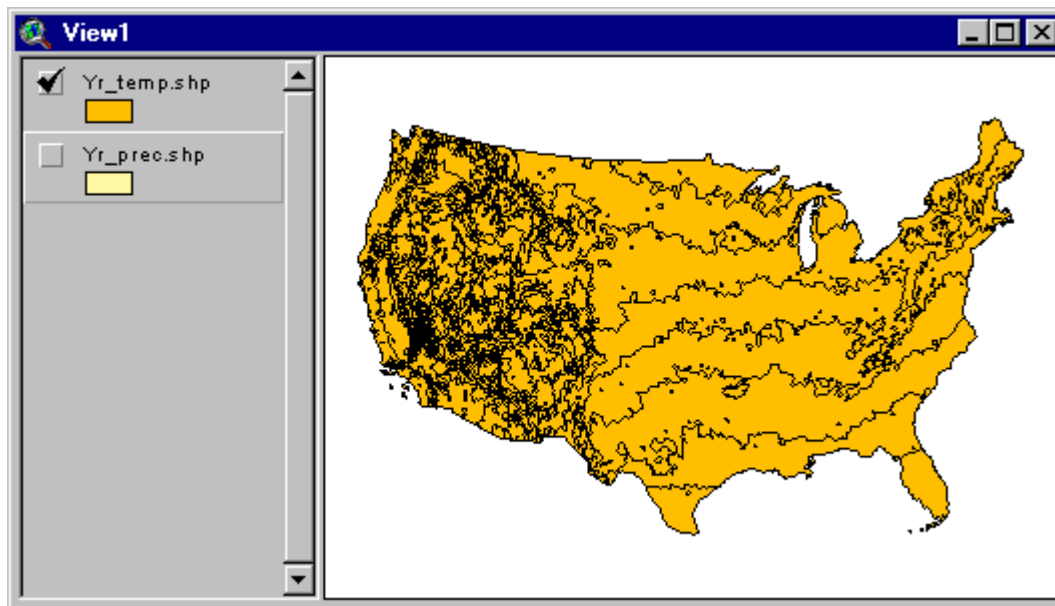


Navigate to the **mapping** folder and select the “yr_prec.shp” file to map the average annual precipitation in the continental United States:



To add temperature data, click on the **Add Theme** button  and select the “yr_temp.shp” theme. This theme will allow you to display the average annual temperature for regions in the continental United States.

To start, let’s explore temperature patterns. Be sure to turn the “yr_temp.shp” theme on to make it visible:



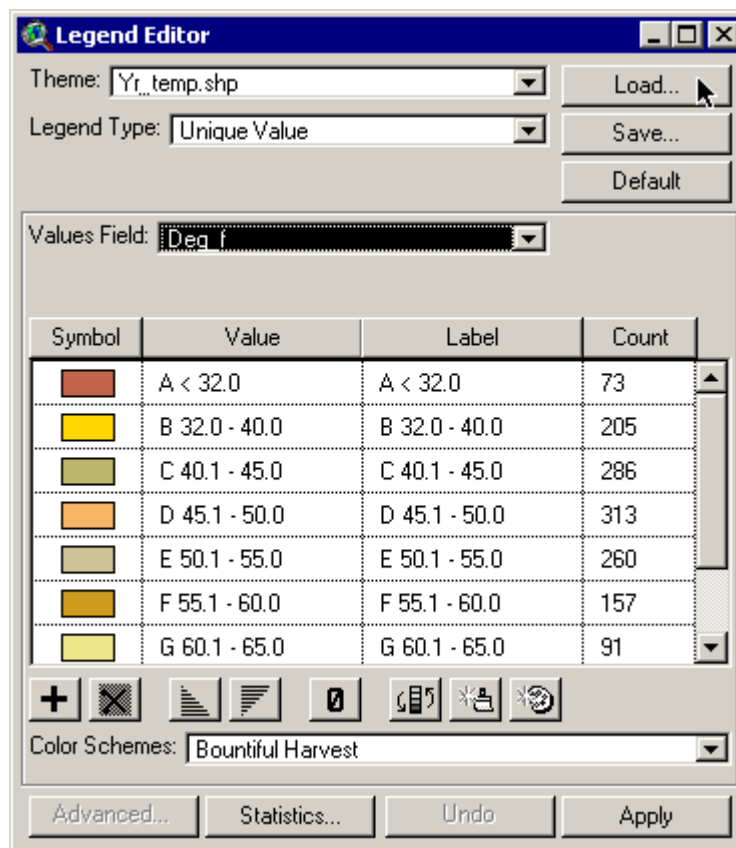
This map does not currently show useful information, since all regions are coded with a single color.



To adjust the temperature map, double-click on the theme name “yr_temp.shp” to open the Legend Editor.

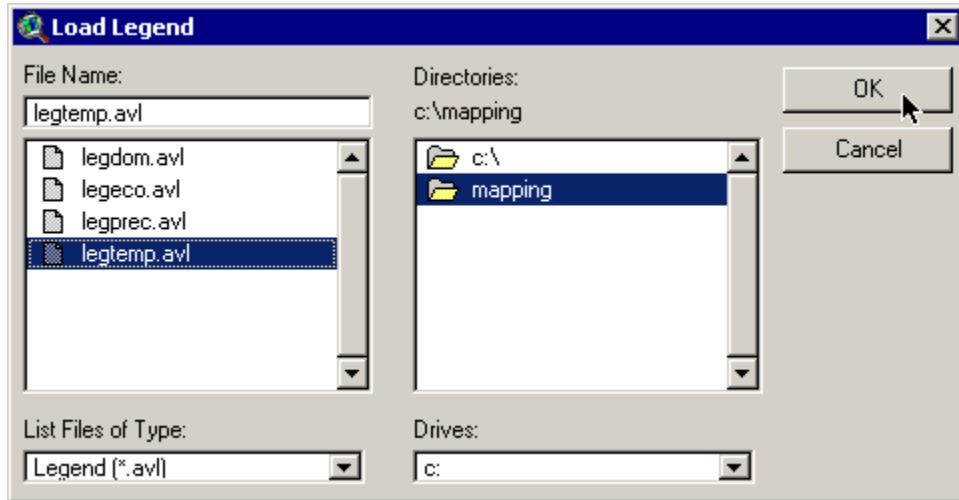
Change the Legend Type to **Unique Value**, with **Deg_f** as the Values Field. You can adjust the color scheme as well, if you’d like (see page 19 in the module *A Quick Guide to Viewing Data* for instructions). You can use your own colors or use the legend included with this module.

To use this module’s temperature legend, first click on Load...:

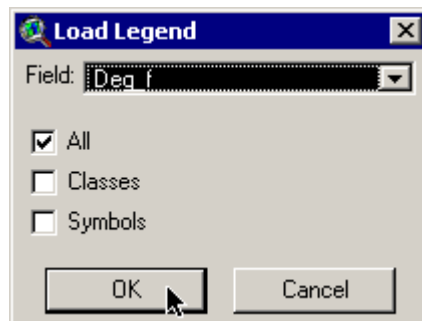




In the Load Legend dialog box, choose “legtemp.avl” from the **mapping** folder and then click .

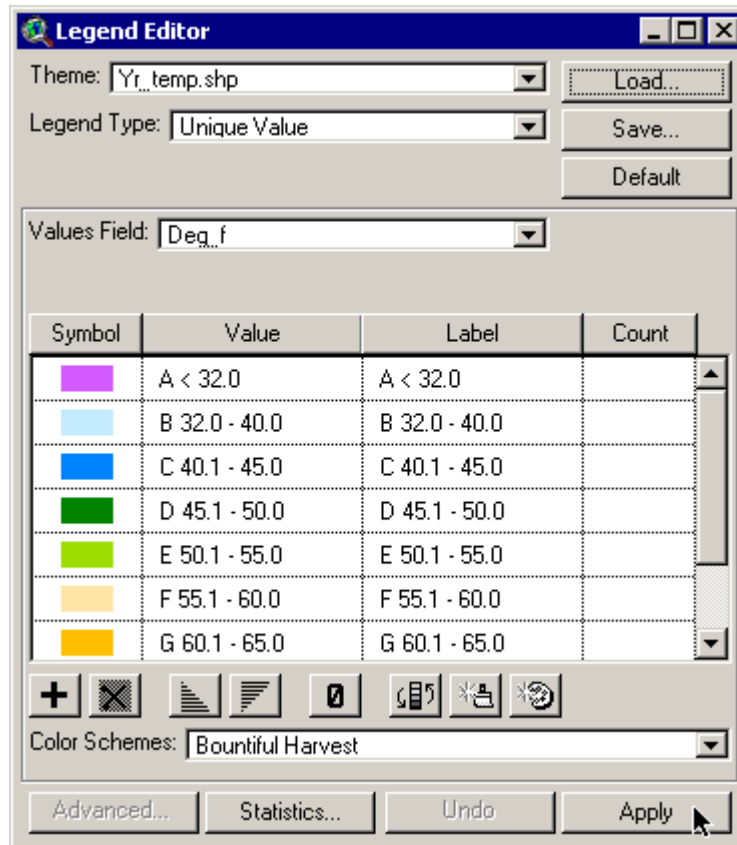


Click  in the dialog box that appears:

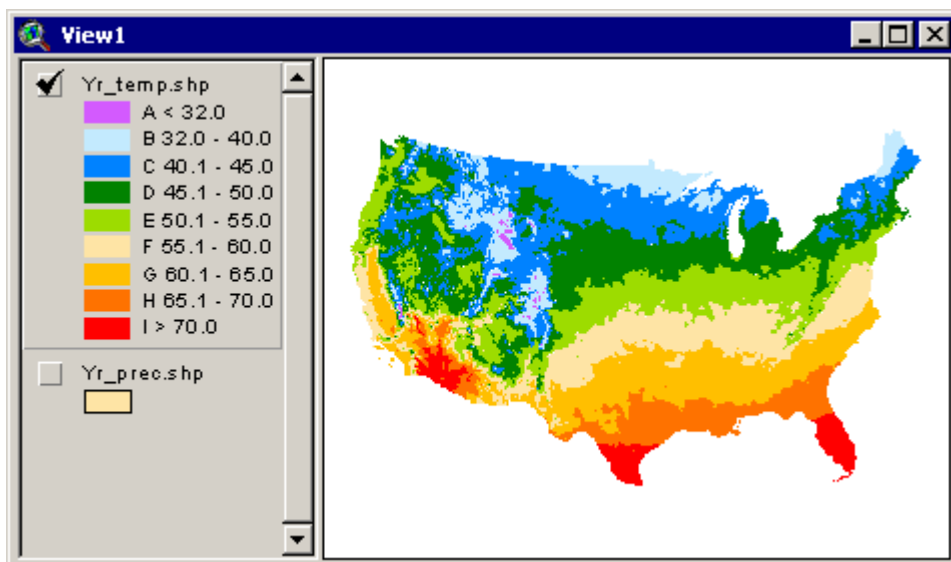




In the Legend Editor, click **Apply** and then click **X** to close the Legend Editor:



Your map now shows nine different temperature ranges across the continental United States. Notice the ranges associated with each color listed in the Table of Contents on the left side of the screen.



Which region of the country shows the most variation in temperatures? What might cause this change in such a comparatively short space?




Prepare your precipitation map in the same way:

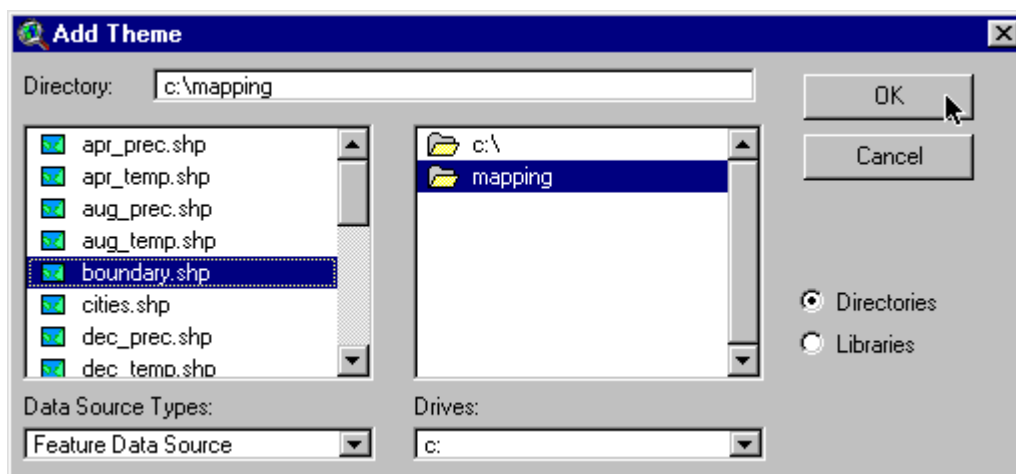
- Double-click on “yr_prec.shp” to open the Legend Editor.
- In the Legend Editor, change Legend Type to **Unique Value** and change the Values Field to **Inches**.
- To use this module’s precipitation legend, click the **Load...** button
- Choose legend “legprec.avl” and click **OK**. Click **OK** in the dialog box that appears.
- In the Legend Editor click **Apply** and then click **X**.

When you are done, each map layer should show temperature or precipitation ranges across the continental United States without showing borders between ranges.

As a final step in preparing your map, add boundary regions to show the outlines of the states within the United States and Mexico, and the province boundaries in Canada.




To do this, click on the **Add Theme** button  and navigate to the **mapping** folder. Select the “boundary.shp” file by double-clicking on it or clicking once and then clicking **OK**.

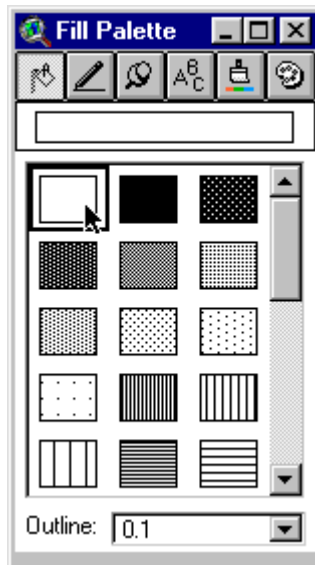


Notice that the boundary theme covers your temperature and precipitation themes. If you simply slide the boundary theme to the bottom, you could see temperature or precipitation, but not the boundaries. To see both the boundaries and the climate data, you’ll need to make the boundary layer transparent except for the actual borders. Then you will be able to see through the boundary theme as if it were a window, with the window panes forming the state and province boundaries.

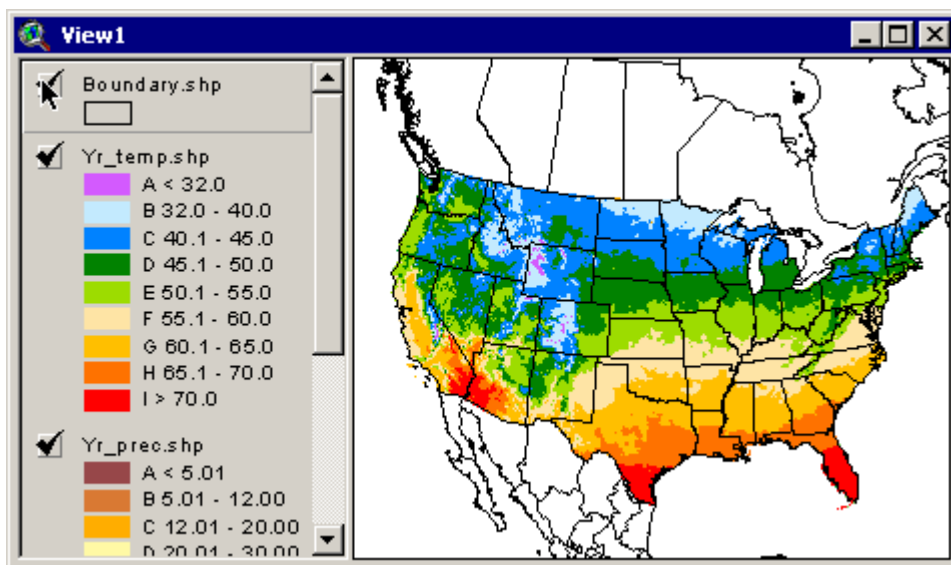


To adjust the boundary theme, double-click its name in the Table of Contents to open the Legend Editor. In the Legend Editor, double-click the Symbol box. This opens the Fill Palette.

In the Fill Palette, click on the  square (the upper-left choice). This will make the boundary theme fill transparent.



Click  in the Legend Editor and then close the Fill Palette and Legend Editor by clicking on their  buttons. See how your map now displays. Be sure the boundary theme is on top and is checked:



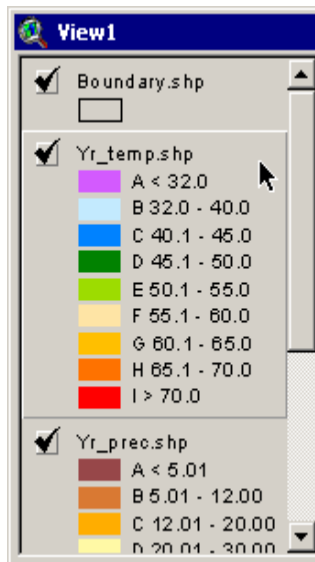
Investigating your region:

Now that you have temperature and precipitation maps prepared, you are ready to explore what it's like where you live.




Be sure the map of average annual temperature and the state and province boundaries are visible. If not, click the small check boxes next to those theme names in the Table of Contents to turn them on.

Be sure the "yr_temp.shp" theme is "active". It should look highlighted, or slightly raised. If it is not, click once on its name in the Table of Contents to make it active.

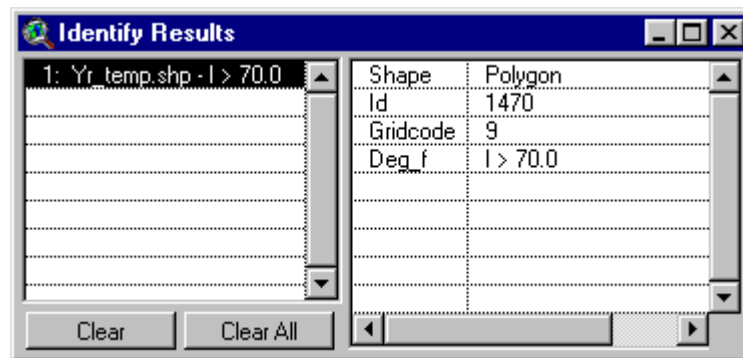
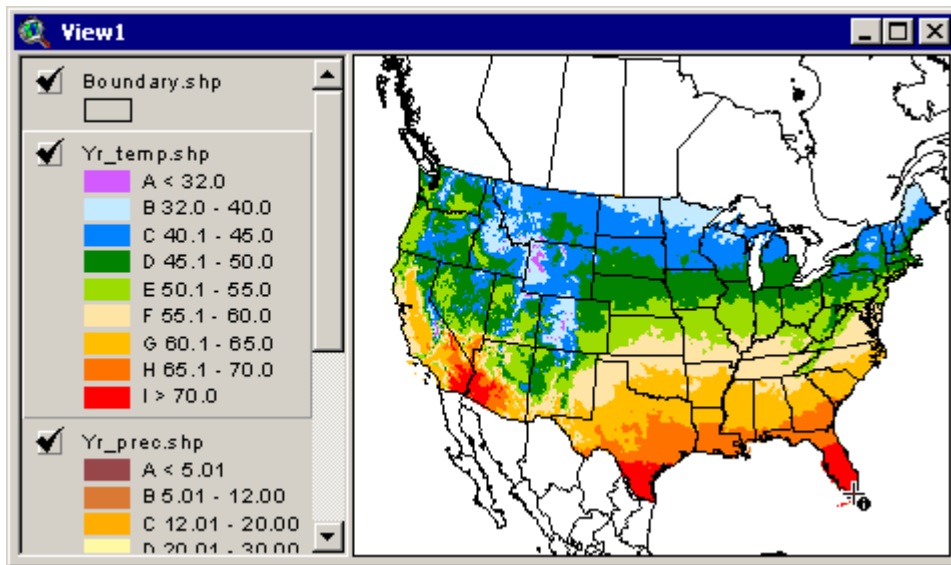


Next, locate your home area on the map.

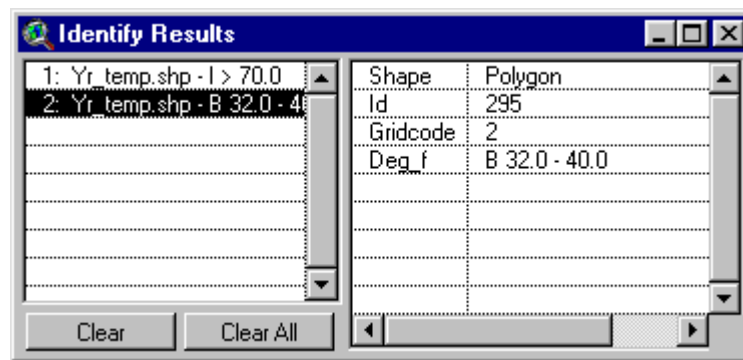


Using the **Identify** button , click on the map near where you live. A new window will pop up, showing temperature information about that area.

In this case, clicking near Miami (on the southeastern coast of Florida) shows an average annual temperature (Deg_f) greater than 70 degrees Farenheit:



A similar check of temperatures near the northeast tip of Minnesota shows a considerably colder average annual temperature:



Can you find places in the continental United States that have even colder average annual temperatures?

Looking for similar conditions:


Now that you can identify average temperatures for your region, you are ready for deeper investigations. For example, what other regions in the continental United States have an average annual temperature similar to yours?

If you haven't already done so, be sure to note the average annual temperature for your home region. Once you have done that, you are ready to have the computer identify areas with similar temperatures.



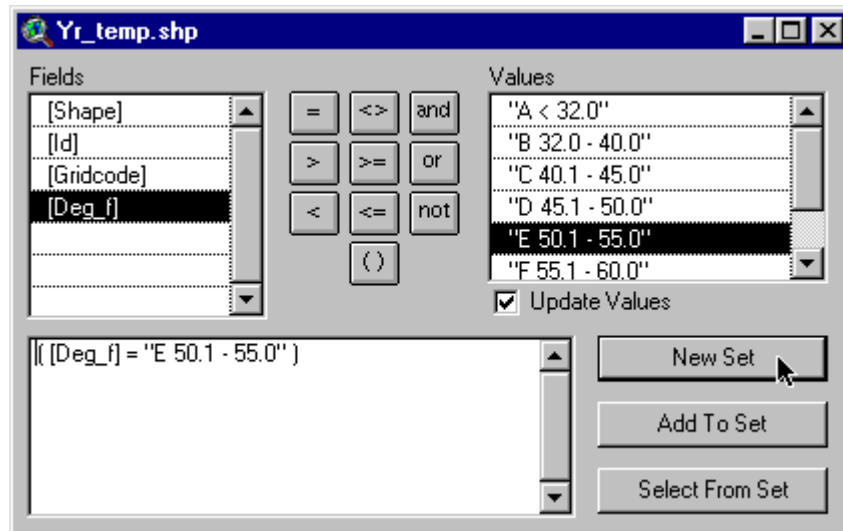
Click on the **Query Builder** button , which will bring up a new dialog box:

When the box opens:

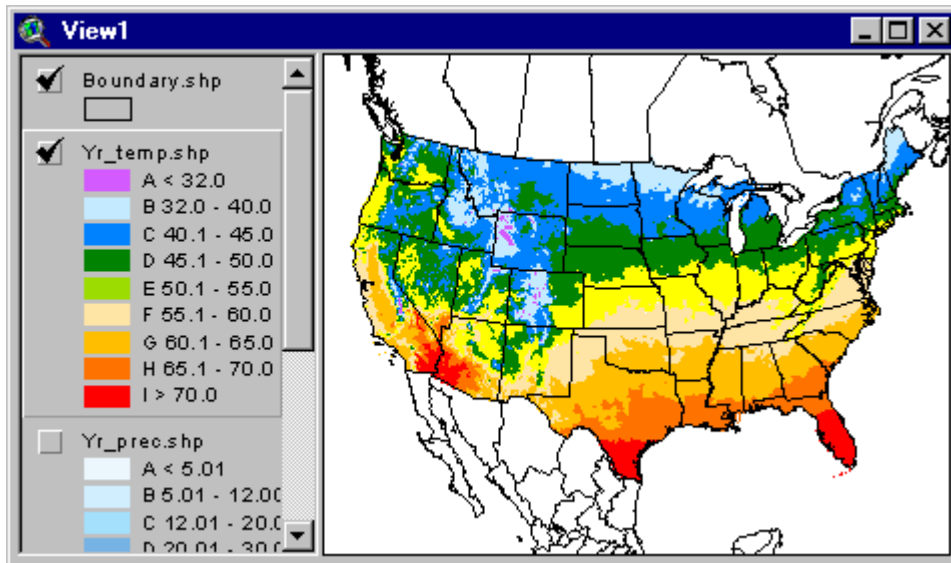
1. Double-click on the **Deg_f** field.
2. Click once on the **Equals** button .
3. Double-click on the Values field that matches your area's temperature band.

When the box is complete, click on  to select the appropriate regions.

For example, the average annual temperature in Cincinnati (in southern Ohio) is between 50.1 and 55 degrees Fahrenheit. To select cities with similar conditions, the Query Builder dialog would be completed like this:



You will now see the regions with similar temperatures highlighted in yellow:



Notice in this case that the “band” of yellow is not consistently at the same latitude. What conditions might account for the variations you see? What other information would you need?

What patterns do you see in the temperature bands that include your area?

Where are the hottest parts (on average) of the continental United States? The coldest?



Before trying to make a new selection, be sure to clear your selection by clicking the the **Clear Selected Features button .**

*These maps show average annual temperatures. To extend your investigation, you may want to load a map theme showing a specific month (such as “jul_temp.shp”). These themes are located in the **mapping** folder where you found the other themes.*

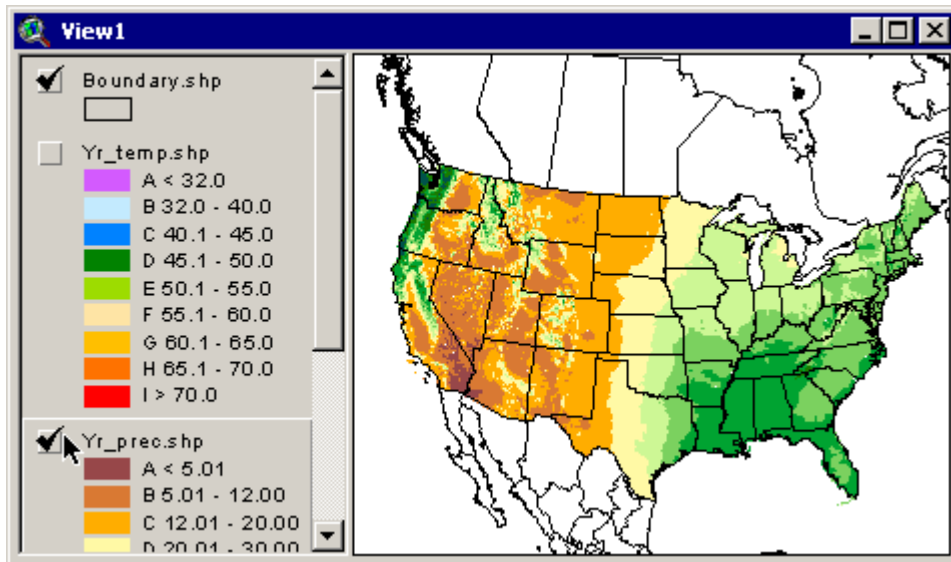
Exploring precipitation patterns:

Just as you were able to explore patterns in average annual temperatures, you can explore patterns in precipitation in your region and across the continental United States.



Turn off the “yr_temp.shp” theme by “unchecking” the box next to its name in the Table of Contents, and turn on the “yr_prec.shp” theme.

Your map should now show average annual precipitation patterns:




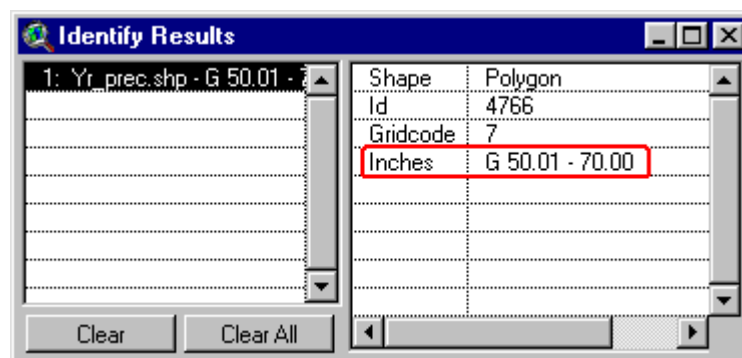
Before looking more closely at your local area, try to describe the broad national patterns. In particular, notice what happens in a few major areas:

1. Moving inland from the Gulf of Mexico.
2. Moving from west to east starting in the Rocky Mountain chain.
3. Moving inland from the northwest coast, comparing the coast to the inland regions of the same states.

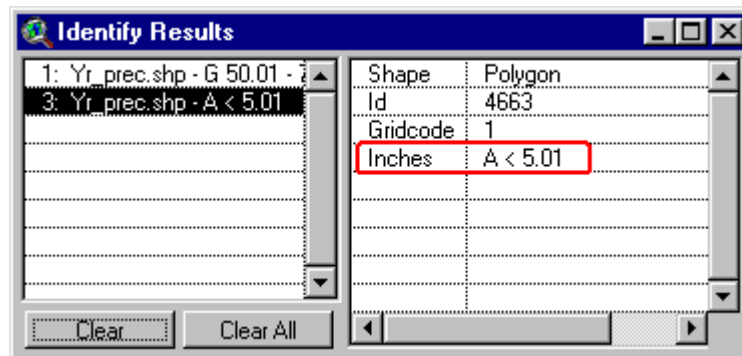



Before trying to identify the average annual rainfall in your region, be sure the “yr_prec.shp” theme is “active”. If not, click once on its name in the Table of Contents to make it active.

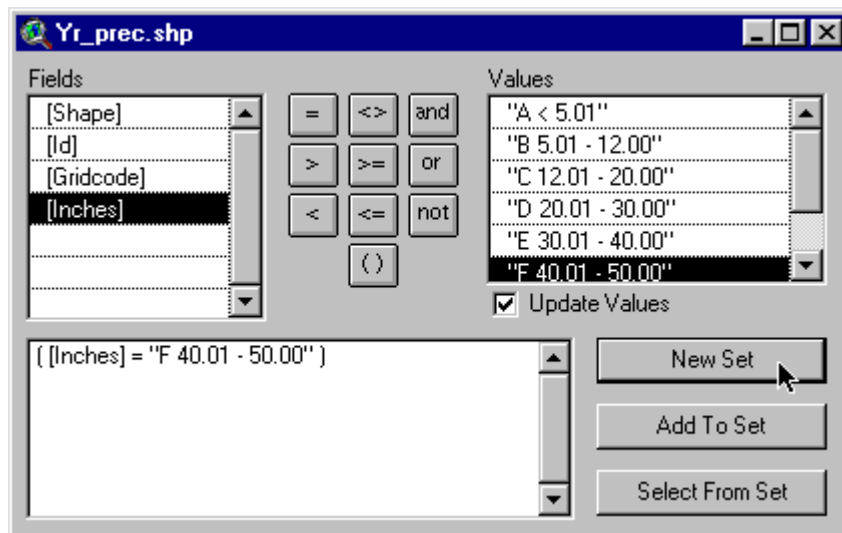
Now you are ready to use the **Identify** button  to identify the average annual precipitation in your region and in other parts of the country. In this case, clicking on southern Louisiana shows that the area around New Orleans is comparatively “wet”, receiving 50-70 inches of precipitation per year:




In contrast, the area in southwestern Arizona on the California border receives less than 5 inches of precipitation per year:



Once you have identified your region's precipitation, you can use the Query Builder  to identify areas with similar precipitation.




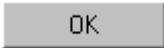
You can also see which regions share a particular characteristic. For example, which areas are the wettest? Which are the driest?

Before trying to make a new selection, be sure to “clear” your previous selection by clicking the Clear Selected Features button .

In Which Ecoregion Do I Live?

Scientists have a number of different ways of classifying ecological regions, or ecoregions. Many of these systems even have variations within them, depending on the level of detail needed for a particular purpose. In this investigation, you will identify your home area using a system developed by Robert Bailey of the U.S. Forest Service. This system is based largely—but not exclusively—on ecoregions determined by temperature and precipitation patterns.

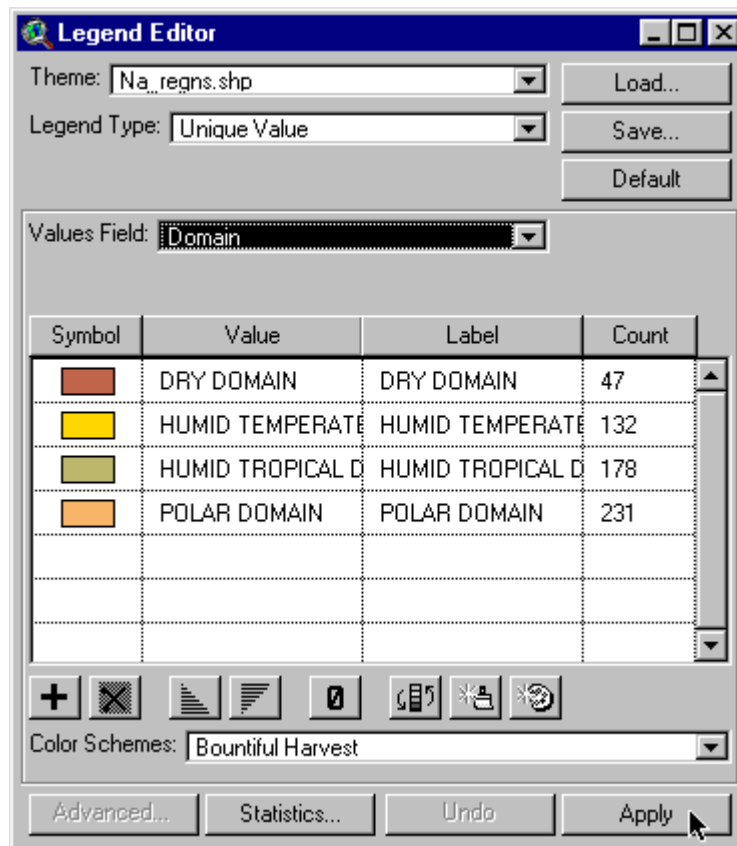


To map ecoregions, click on the **Add Theme** button  and navigate to the **mapping** folder. Select the file “na_regns.shp” by double-clicking on it or by clicking once on the file name and then clicking .

When the theme is first turned on, it will show all regions coded with the same color.



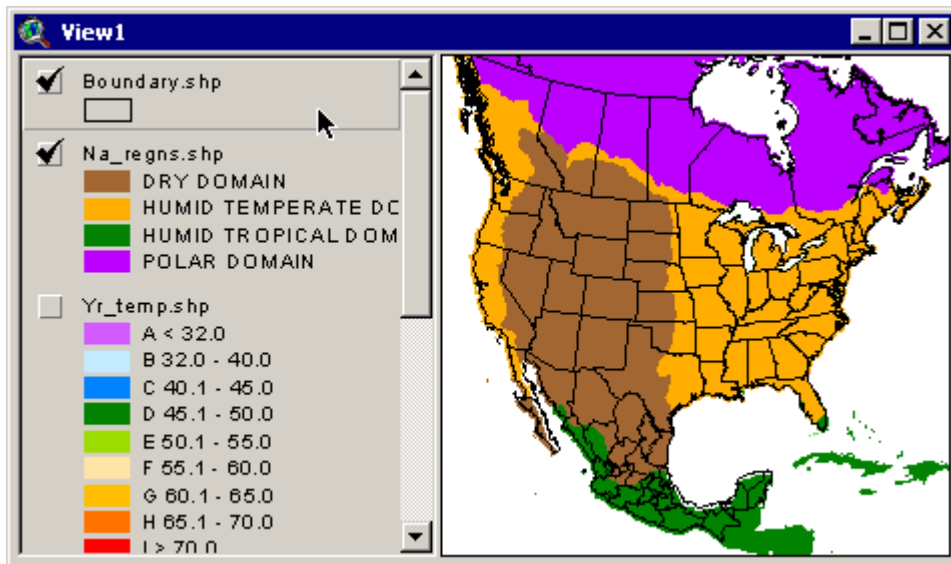
To show individual regions, open the Legend Editor by double-clicking on the “na_regns.shp” theme name in the Table of Contents. Change the Legend Type to **Unique Value** and the Values field to **Domain**:




If you wish, you can load the domain legend that is included in this module. Follow the instructions on pages 4-6, however choose “legdom.avl” for the legend.



Click **Apply** to see your map. You will likely want to “slide” the “boundary.shp” theme to the top by clicking on it, holding the mouse button down, and sliding the boundary theme to the top of the list in the Table of Contents:



Because there are very slight overlaps between map layers, it would be a good idea to turn off the “yr_temp.shp” and “yr_prec.shp” themes when you are not using them for your analysis.

Notice that three of the four domains in Bailey’s ecosystem classification are found within the continental U.S.. If you click on the **Zoom to Full Extent** button , your map will show all of North America, and you can see that all four domains are contained in the United States. The polar domain can be found in Alaska and northern Canada.

To help you in making your interpretations, here’s a summary of the terms Bailey uses¹:

Polar: “low temperatures, severe winters, and small amounts of precipitation...” (p. 51).

Humid Temperate: “Pronounced seasons, with strong annual cycles of temperature and precipitation...” (p. 63).

Dry: “...annual losses of water through evaporation at the Earth’s surface exceed annual water gains through precipitation...” (p. 85).

Humid Tropical: “Every month of the year has an average temperature above 18 C, and no winter season.” (p. 105).

In which ecoregion domain do you live?

Based on what you explored previously with the temperature and precipitation maps, does Bailey’s classification surprise you?

¹ From Bailey, R.G. (1998) *Ecoregions: The Ecosystem Geography of the Oceans and Continents*. New York: Springer-Verlag.

Looking more closely:

The domain level for ecoregions provides a handy way to split an area into broad regions, but it doesn't allow for very detailed analysis beyond whether an area is dry or humid, and whether it is polar, temperate, or tropical. Therefore, each of the domains can be divided into smaller units called divisions.

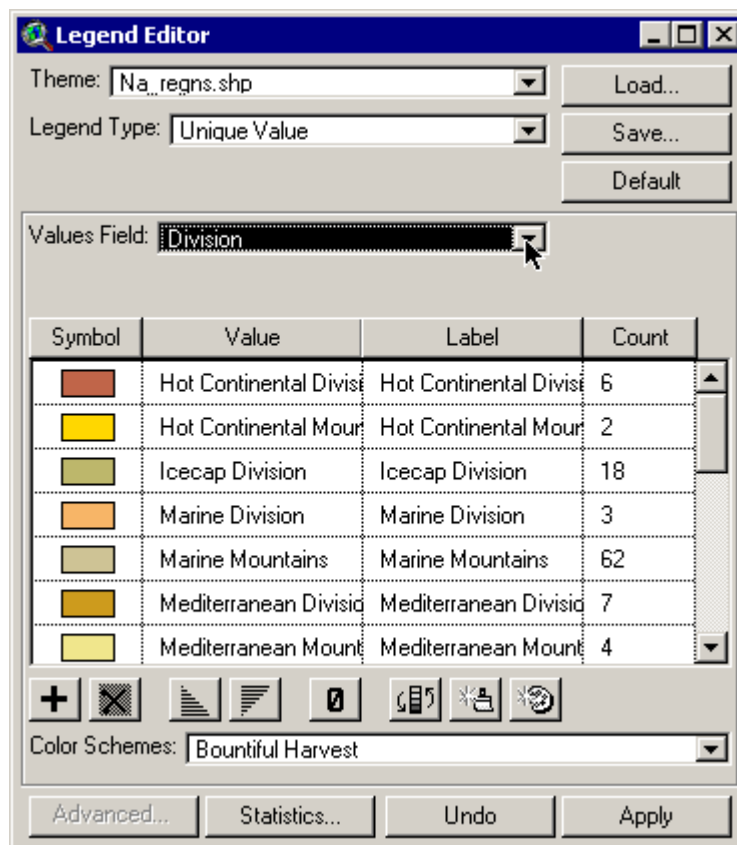
For example, the dry domain can be divided into desert and steppe, with desert being drier than steppe. Desert and steppe, in turn, can either exist in a temperate or in a tropical/subtropical area. To account for the influence of elevation, these areas are further divided into the "basic" classification and a comparable "mountainous" regime. Thus, Bailey's system ultimately recognizes eight divisions relating to the dry domain. (See the diagram on page 19.)

Similarly, other divisions are created as special cases of the polar, humid temperate, and humid tropical domains that exist at Bailey's most general level. There are 30 divisions found worldwide; 28 of them (all except Ice Cap Mountain and Prairie Mountain divisions) can be found in North America, stretching from the tundra mountains near the arctic circle to the savannas and rainforests of Central America. As you might imagine, this diversity of ecoregions allows for a similarly great diversity of plants and animals.



To explore divisions, reopen the Legend Editor for the "na_regns.shp" theme by double-clicking on the theme name in the Table of Contents.


Keep the Legend Type as **Unique Value**, but select **Division** as the Values field.

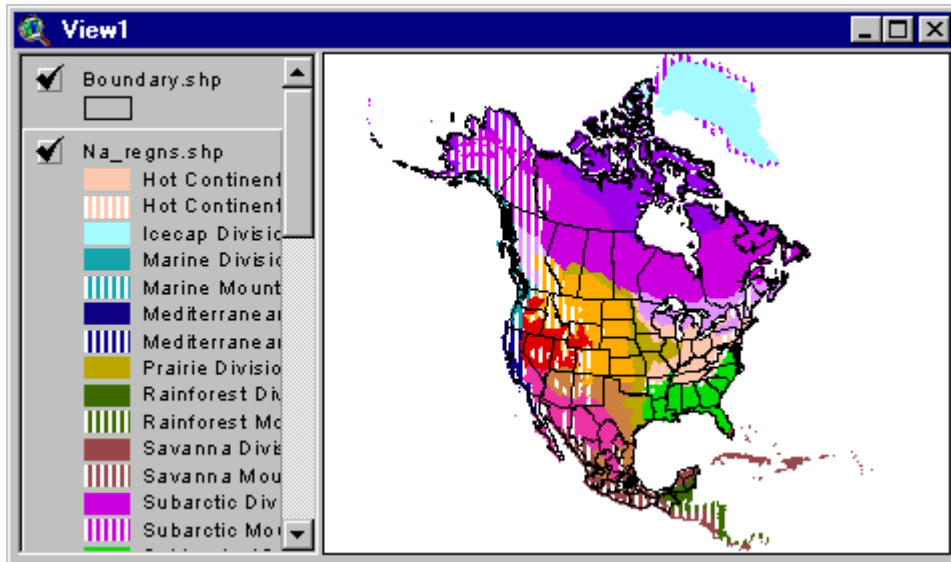



This will code the ecoregion divisions. As before, you will probably want to adjust the colors.



To apply the color scheme shown here, follow the instructions on pages 4-6, but choose “legeco.avl” for the legend.

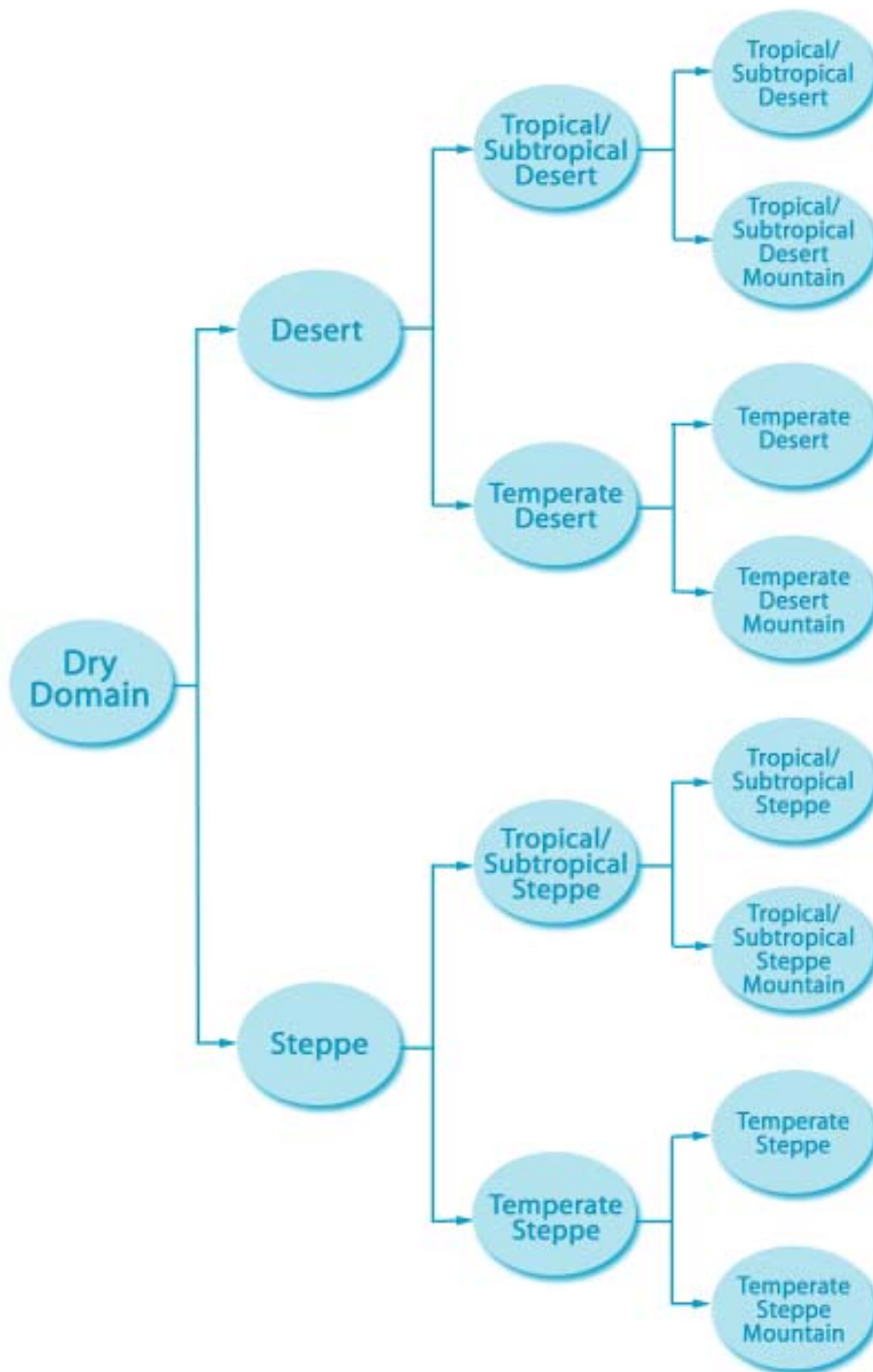
When you are done preparing your data, you should have a map that looks like this (If necessary, click on the Zoom to Full Extent button  to see all of North America.):



As you did before, you can identify the divisions near your home by making “na_regns.shp” the “active” theme and using the Identify button  to click on a portion of the map.

Extra Challenge:

For those who want to conduct a particularly detailed investigation, the North American ecoregion classifications can be subdivided further into 59 provinces. This is best done for analyzing a smaller area containing only a few provinces, since a continent map with 59 different colors would be difficult to interpret.



Ecoregion Divisions within the Dry Domain

What's the Climate in my Ecoregion?

Now that you have a sense of how climate varies across the continental United States, and how ecoregions can be used to describe specific areas, you are ready to describe your home ecoregion in more detail.

To do this, you need to decide how detailed you want to be. These procedures work for either domain or division levels of analysis. You may find success in province-level analysis, but some less populated provinces may not have enough climate data to allow comparison with other provinces.

Once you have decided the level of your investigation (domain, division, or province), construct a map as you did before. While removing the ecoregion outlines will help visually, they will not affect your analysis.

You will also need to add a layer showing cities. These cities use data from 248 monitoring sites maintained by the National Weather Service, part of the National Oceanic and Atmospheric Administration.





To add the cities, click on the **Add Theme** button  and navigate to the **mapping** folder. Select the file "cities.shp" by double-clicking on it, or by clicking once on the file name and then clicking .

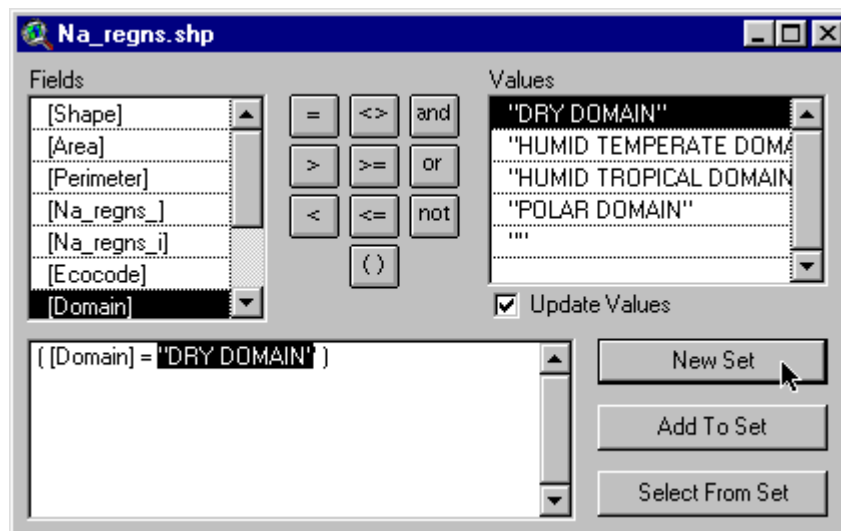
As a first step, choose the domain or division you will investigate. In these examples, the dry domain will be investigated, and then compared with the humid temperate domain.



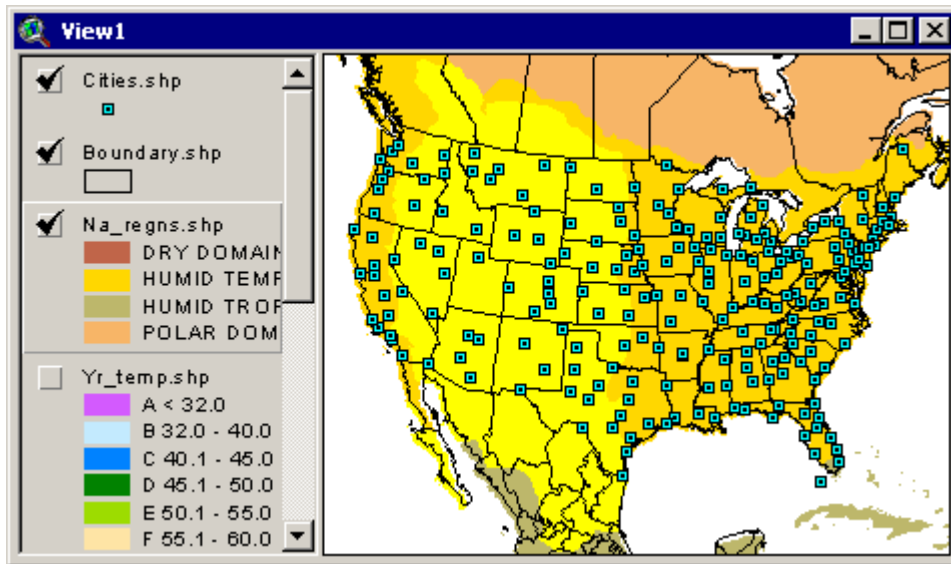
With your map theme showing and the "na_regns.shp" theme "active", click on the **Query Builder** button .

In the dialog box that appears, tell the program that you want it to highlight the domain or division in which you are interested:

1. Double-click on the field in which you are interested (in this case, **Domain**).
2. Click once on the **Equals** button .
3. Double-click on the Value you want to investigate (in this case, **Dry Domain**).
4. Click on .



The domain or province will now be “selected” by the program and highlighted in yellow:

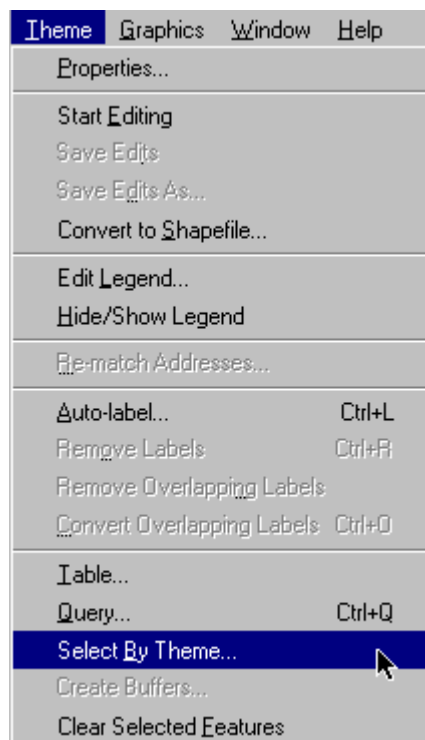


Now that you have defined an ecoregion to study, you are ready to gather climate data from cities within that ecoregion.



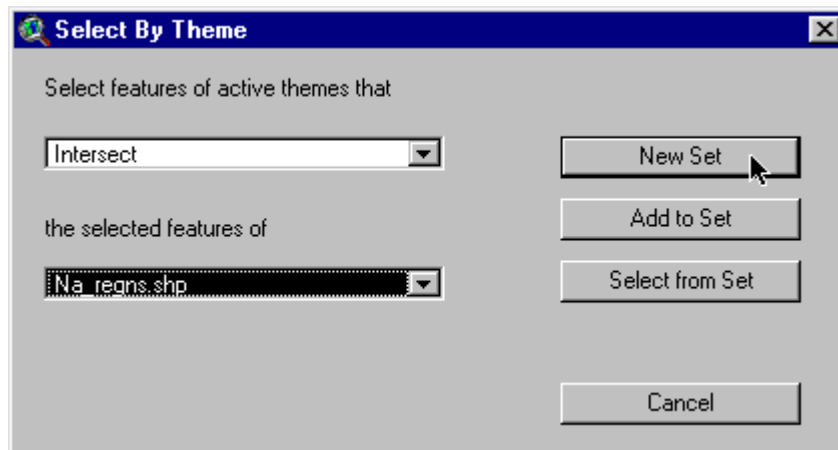
Make the “cities.shp” theme active.

From the Theme menu, choose **Select by Theme...:**






In the dialog box that appears, select features of active themes (in this case, "cities.shp") that **Intersect** the selected features of the **Na_regns.shp** theme:



Click on .

All cities within your chosen ecoregion will now be highlighted, and shown in yellow.



Next, open the Theme Table for cities by clicking on the **Open Theme Table** button . This will open a table representing all 248 cities with climate data:

Attributes of Cities.shp						
Shape	Mean_month	State	Stips	Lat	Long	F6
Point	BIRMINGHAM AP	AL	01	33.5	-86.8	
Point	HUNTSVILLE	AL	01	34.7	-86.6	
Point	MOBILE	AL	01	30.7	-88.1	
Point	MONTGOMERY	AL	01	32.4	-86.3	
Point	ANCHORAGE	AK	02	61.2	-149.2	
Point	ANNETTE	AK	02	55.0	-131.6	
Point	BARROW	AK	02	71.3	-156.8	
Point	BETHEL	AK	02	60.8	-161.8	
Point	BETTLES	AK	02	66.9	-151.6	
Point	BIG DELTA	AK	02	64.1	-145.8	
Point	COLD BAY	AK	02	55.2	-162.7	
Point	FAIRBANKS	AK	02	64.8	-147.6	



To group all of the highlighted cities together, click once on the **Promote** button .

In the case of the dry domain, 63 of the 248 cities in the data set are highlighted:

ArcView GIS 3.2a

File Edit Table Field Window Help

63 of 248 selected

Attributes of Cities.shp

Shape	Mean_month	State	Stips	Lat	Long	P01	P02	P03	P04	P05
Point	FLAGSTAFF	AZ	04	35.2	-111.6	2.04	2.09	2.55	1.48	0.7
Point	PHOENIX	AZ	04	33.5	-112.1	0.67	0.68	0.88	0.22	0.1
Point	TUCSON	AZ	04	32.2	-110.9	0.87	0.70	0.72	0.30	0.1
Point	WINSLOW	AZ	04	35.0	-110.7	0.45	0.52	0.55	0.26	0.3
Point	YUMA	AZ	04	32.7	-114.6	0.35	0.22	0.21	0.14	0.0
Point	BISHOP	CA	06	37.4	-118.4	1.11	0.95	0.39	0.26	0.2
Point	ALAMOSA	CO	08	37.5	-105.9	0.26	0.29	0.45	0.49	0.6
Point	COLORADO SPRING	CO	08	38.9	-104.8	0.29	0.40	0.94	1.19	2.1
Point	DENVER	CO	08	39.8	-104.9	0.50	0.57	1.28	1.71	2.4
Point	GRAND JUNCTION	CO	08	39.1	-108.6	0.56	0.48	0.90	0.75	0.8



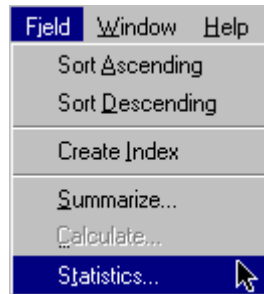
To determine the average annual precipitation—a key measure in a dry area—scroll to the right until you see a column for Pyr (precipitation: yearly). Click once on the **Pyr** column heading to choose that column in the data table:

Attributes of Cities.shp

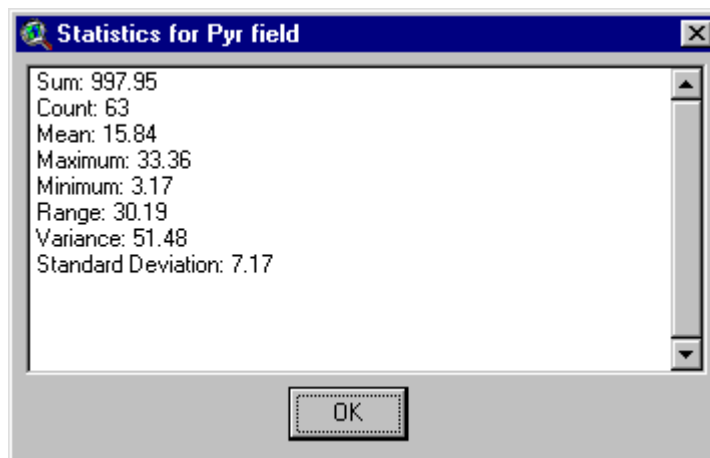
P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	Pyr	T01	T02	T03
2.55	1.48	0.72	0.40	2.78	2.75	2.03	1.61	1.95	2.40	22.80	28.7	31.5	35.0
0.88	0.22	0.12	0.13	0.83	0.96	0.86	0.65	0.66	1.00	7.66	53.6	57.7	62.0
0.72	0.30	0.18	0.20	2.37	2.19	1.67	1.06	0.67	1.07	12.00	51.3	54.4	58.0
0.55	0.26	0.31	0.31	1.20	1.39	0.91	0.91	0.57	0.66	8.04	31.9	39.0	45.0
0.21	0.14	0.04	0.02	0.26	0.64	0.31	0.29	0.24	0.45	3.17	56.5	60.7	64.0
0.39	0.26	0.29	0.18	0.23	0.18	0.24	0.13	0.57	0.84	5.37	37.8	42.4	46.0
0.45	0.49	0.64	0.67	1.19	1.12	0.89	0.70	0.43	0.44	7.57	14.7	22.4	32.0
0.94	1.19	2.15	2.25	2.90	3.02	1.33	0.84	0.47	0.46	16.24	28.8	32.0	37.0
1.28	1.71	2.40	1.79	1.91	1.51	1.24	0.98	0.87	0.64	15.40	29.7	33.4	39.0
0.90	0.75	0.87	0.50	0.65	0.81	0.82	0.98	0.71	0.61	8.64	25.0	34.5	43.0




From the Field menu, select **Statistics...**:



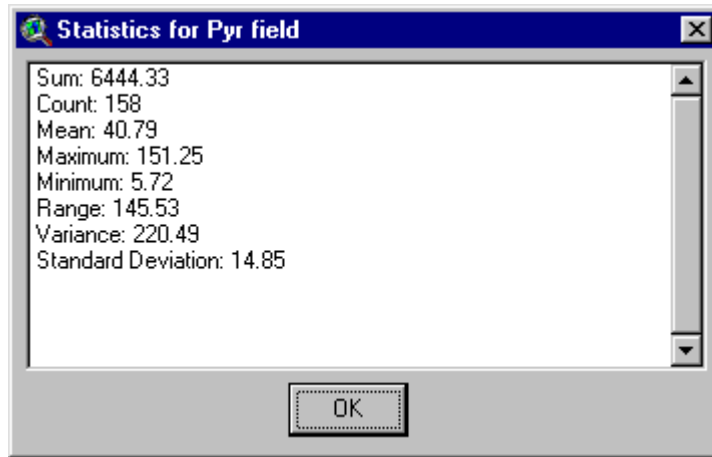
The mean value for annual precipitation in the dry domain is just under 16 inches (15.84), with a range of 30.19 inches (from 3.17 up to 33.36 inches):



*To make a comparison with another ecoregion, repeat these steps, selecting another domain or division. Before you do that, be sure to de-select both the previous cities and the previous region by making each theme “active” and then clicking on the **Clear Selected Features** button .*

After conducting a similar investigation of the precipitation in the humid temperate domain, it becomes clear that the dry domain lives up to its name, receiving considerably less precipitation.

The data for the humid temperate domain shows the following results:




Notice that there is some overlap in amounts of precipitation between the dry and humid temperate domains. Remember that the definition of the dry domain was not based solely on the amount of precipitation, but on the overall water budget. Those areas which have more evaporation than precipitation are considered “dry” in Bailey’s ecoregions.

What other patterns can you find when you compare domains or divisions?

ArcView Skill: Removing Outlines


Often removing some outlines from maps help make the map easier to read.

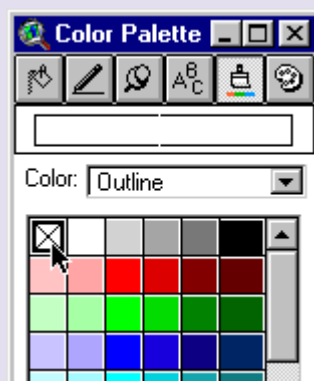
To remove the outlines, open the Symbol Window by going to the Window menu and select Show Symbol Window....

Click on the Color Button  to change the window to the Color Palette. Leave the Color Palette open—you will use it in a moment.

Now, reopen the Legend Editor by double-clicking on the file name in the Table of Contents.

Click once on the Symbol box of the value you want to select. Shift-click any other values you want to select (remember, "shift-click"ing means to hold the shift button on your keyboard down while you click on a selection). When you are done, the selections will be highlighted in black:

In the Color Palette you opened earlier, select Outline and then click on the  square (in the upper-left corner), which will give your selections a transparent outline:



Close the Color Palette. Be sure to click  in the Legend Editor.

Notice the change in your map.