FEATURE MAPPING

Tutorial

Feature Mapping

with

TNTmips®

Before Getting Started

This booklet introduces techniques for interpreting surface features from images. Feature Mapping helps you interactively identify sample areas of the features you wish to map. It next searches for and highlights all the areas in the image that may contain these features. You then use the interactive tools to decide which highlighted areas should be retained. This booklet will lead you step by step through a series of exercises to familiarize you with all the basic tools in the powerful Feature Mapping process in TNTmips®.

Prerequisite Skills This booklet assumes you have completed the exercises in the *Displaying Geospatial Data* and *Navigating* tutorial booklets. Those exercises introduce essential skills and techniques, such as how to select and view raster, vector, CAD, TIN, and database objects stored in Project Files. You should know how to pan and zoom display objects and how to use the standard File / Object Selection process. This booklet does not present these basic skills again.

Sample Data The exercises presented in this booklet use sample data distributed with the TNT products. If you do not have access to a TNT products CD, download the data from MicroImages' web site. The first set of exercises uses objects found in the SECT27R Project File in the FEATMAP data collection in the LITEDATA directory. The second set of exercises uses objects found in the BEREA data collection (also in LITEDATA) in the BEREAPCA and BEREAMSS Project Files.

More Documentation This booklet is intended only as an introduction to the functions in Feature Mapping. Consult the TNT online reference manual, which contains more than 50 pages on Feature Mapping, for more information.

TNTmips and TNTlite™ TNTmips comes in two versions: the professional version and the free TNTlite version. This booklet refers to both versions as "TNTmips." If you did not purchase the professional version (which requires a software licens key), TNTmips operates in TNTlite mode, which limits the size of your project materials and does not allow export.

Feature Mapping is not available in TNTedit, TNTview or TNTatlas. All exercises in this booklet can be completed in TNTlite using the sample geodata provided.

Merri P. Skrdla, Ph.D., 21 May 2002

It may be difficult to identify the important points in some illustrations without a color copy of this booklet. You can print or read this booklet in color from MicroImages' web site. The web site is also your source of the newest Getting Started booklets on other topics. While there, you can download an installation guide, sample data, and the latest version of TNTlite.

http://www.microimages.com

Welcome to Feature Mapping

Photointerpretation is a primary reason for converting remotely sensed imagery to digital form. Classification of the information contained in the imagery is one of the major applications of image interpretation. The human brain is a tremendously powerful analytical tool that automatically classifies much of the information received without conscious effort. This interpretation is, however, limited to three components translated into a screen image in the visible portion of the spectrum. People can also learn to interpret visible representations of other regions of the spectrum, such as color-infrared photography that shifts and records photoinfrared, red, and green radiation into the RGB color space.

Remotely sensed images often contain many more bands than can be translated into a single RGB representation, all of which may be important in distinguishing one ground cover type from another. Automated image processing lets you make use of all of this information. TNTmips offers automatic classification (both supervised and unsupervised), Feature Mapping, and manual interpretation. Automatic classification methods are designed for use with high quality imagery that has uniform properties throughout, such as satellite imagery. Aerial photography and particularly aerial videography contain artifacts not found in satellite imagery, such as vignetting. Video images also contain significant noise. Feature Mapping was developed specifically to assist in classification of these lower quality images. The goal of Feature Mapping is to identify, mark, and measure features in a set of processing rasters by combining your knowledge of the study site with TNTmips' processing power.

Vocabulary: Darkening at the edges and corners of an optical image is called **vignetting**. The radiometric properties of a feature at the edge or corner of an image may, thus, be different than at the center.

STEPS

- ☑ launch TNT
- ☑ select Process /Raster / Interpret /Feature Map from the main menu

Pages 4–10 provide a simple exercise to acquaint you with how this process works. Pages 11–14 introduce additional Feature Mapping concepts using the same sample data. Pages 15–26 introduce a more complex example and additional features of the process.

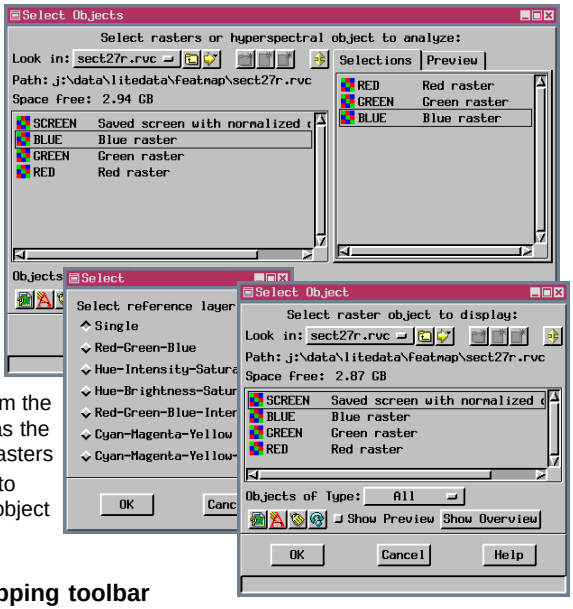
Analysis and Reference Rasters

Vocabulary: Analysis rasters define an n-dimensional space used for identification of cells that "match" sample cell values. **Reference rasters** are used to create the displayed image and may or may not be included as analysis rasters.

You are prompted to select analysis and reference rasters when you launch the Feature Mapping process. The number of raster objects that can be included for analysis is not limited by the Feature Mapping process; practical considerations determine the optimal number of rasters to use. The greater the number of rasters to be analyzed, the longer the time required for the classification step that identifies the prototype cells that fall within the range defined by the sample cells.

STEPS

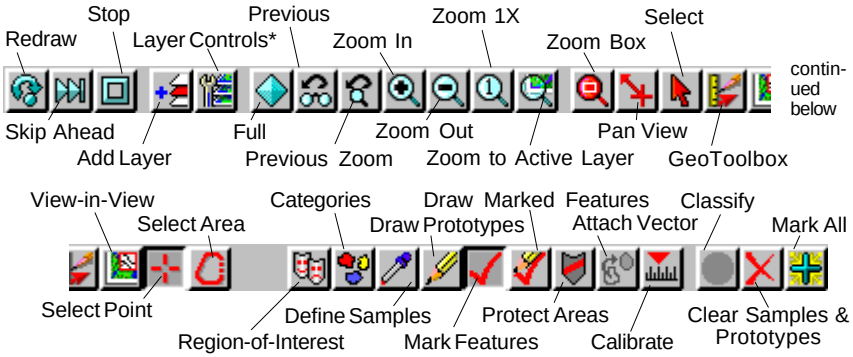
- ☑ select the RED, GREEN, and BLUE objects from the SECT27R Project File, then click [OK]
- ☑ check that the Single radio button in the Select window is on, and click [OK]
- ☑ select SCREEN (from the same file as the analysis rasters
- ☑ click [OK] to complete object selection



The analysis rasters *are not used* for display unless also selected for reference.

*Access to the Layer Controls lets you use any number of additional objects, including vectors, for reference.

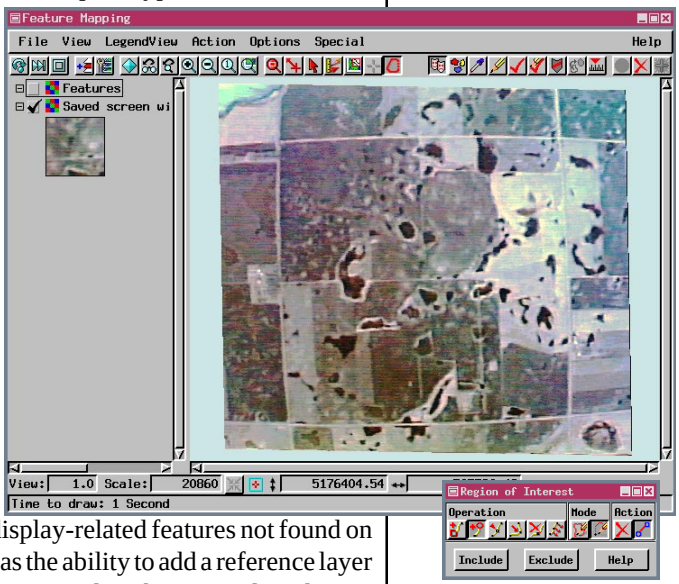
Feature Mapping toolbar



Feature Mapping View Window

The reference raster is automatically displayed at Full View, and Region of Interest drawing is the selected action once the analysis and reference rasters are chosen. We will save discussion of Region of Interest drawing for later and move directly to defining samples. A low quality video image is used to map water features in this first Feature Mapping task. Remember that the red, green, and blue components of the video are selected for analysis, but you are viewing an 8-bit composite color raster object for reference. The values of the cells in the reference image are not even considered when the computer searches for prototype features.

Vocabulary: A **sample point** is a cell you identify as representative of a particular feature class. Cells identified by the computer that fall within the range of values defined by the sample points are called **prototype features**, or simply prototypes. Once you confirm that a prototype belongs to the same class as the sample points, it becomes a **marked feature**.



The Feature Mapping window has both menus and a toolbar. Most of the toolbar icon functions are duplicated on the menus. This booklet usually refers to the icons when both are available.

The toolbar provides some display-related features not found on the menus, such as the ability to add a reference layer and open the layer controls. The primarily red icons near the middle are the tools, most of which are familiar from all display processes. The Select Point and Select Area tools work in tandem with the selected action. The actions make up the group of icons to the right of the tools. In some cases, changing the selected action changes the selected tool. The last group of icons are commonly used Feature Mapping functions (see facing page).

STEPS

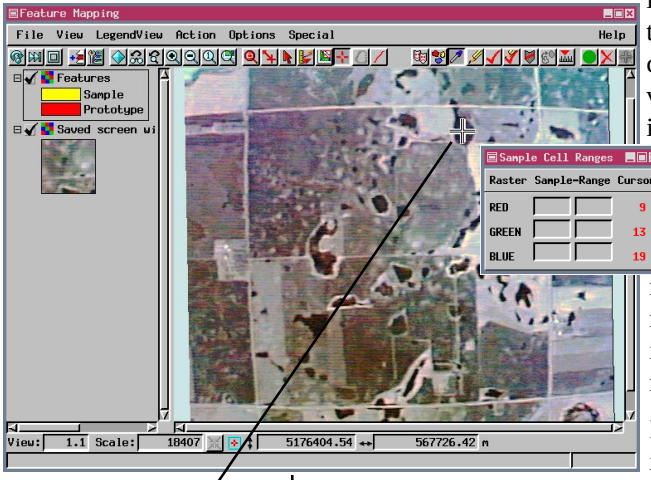
- ☑ click on the Define Samples icon 
- ☑ turn on the Options / Show Values check button

Defining Sample Cells

STEPS

☑ click on Zoom 1X icon 

When the Show Values option is toggled on, the value for the cell beneath the cursor in each processing raster is shown to the right of the current range of values. Cell values included within the sample range are shown in black and those outside the sample range are shown in red. Cells included in the sample set are redrawn in yellow.



☑ position the cursor over the teardrop shape water feature that crosses the road near the top

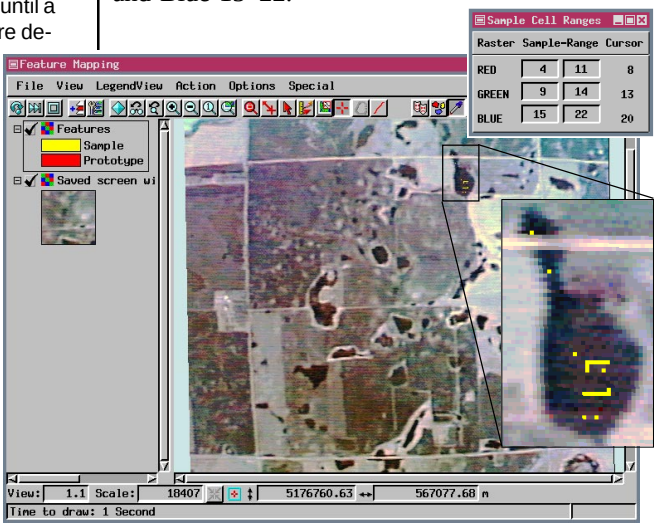
☑ hold down the left mouse button and drag within the confines of the water feature until a number of cells are defined as samples

☑ release the mouse, click on Classify,  and look for cells within the feature not included in the sample range (not redrawn in prototype color)

☑ click the left mouse button if any are found (cursor value shown in red)

If you accidentally include sample points outside the water, you can remove them from the sample set by holding down either the <Shift> or <Ctrl> key and clicking on the cell again.

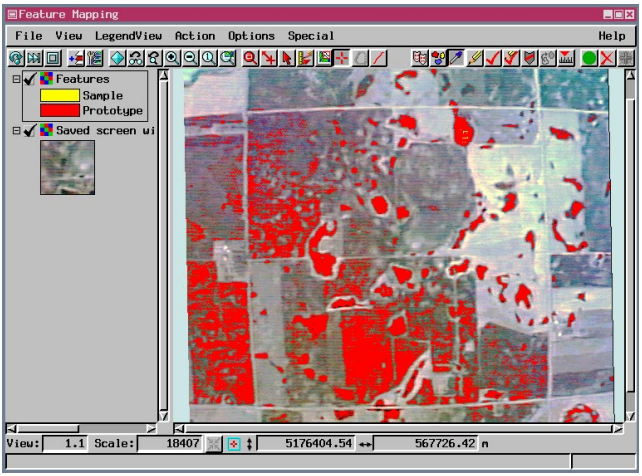
The value range needed to identify all the cells in this feature as prototypes is Red 4–11, Green 9–14, and Blue 15–22.



Identifying Prototype Features

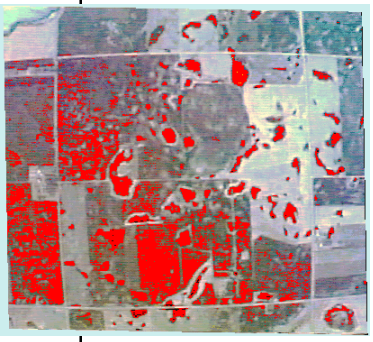
You probably noted when you choose to define samples that an additional layer appeared in the LegendView, which shows the sample and prototype colors currently selected. As you add feature classes, their assigned drawing styles will also be added to this layer's legend.

☑ click on the Classify icon 



After you click on the Classify icon, the message "Processing… Please wait…" appears in the message line. The prototype cells are drawn in red after the processing is complete. These cells are the ones with values in the three bands selected for analysis that fall within the range defined by the sample cells (which, in this example, means a red value from 4 to 11, a green value from 9 to 14, AND a blue value from 15 to 22). The computer has identified the cells that satisfy the sample range you established; it is now up to you to decide how many of these prototypes actually belong to the feature class you are mapping.

☑ click on the Full View icon to see the full extent of prototype features 



You can see that the ponds and standing water were very effectively identified from just a few sample points of that feature type. When feature class identification is not so thorough, you can add more sample points after the classification step and classify again.

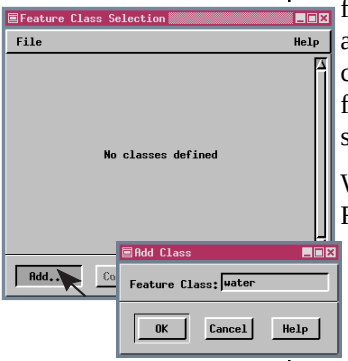
Many extraneous cells have also been identified as prototypes. We will discuss methods for handling this situation later. For now, let's mark all features so you can save your progress.

Note: You can also initiate classification by pressing the right mouse button over the viewing area when in Define Samples mode.

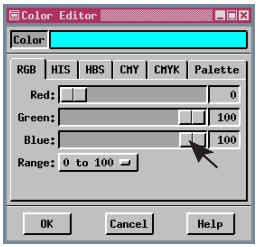
Adding a Feature Class

STEPS

- ☑ click on the Mark Features icon 
- ☑ click on [Add] in the Feature Class Selection window that opens*
- ☑ enter the name for the feature class (water) in the Add Class window that opens
- ☑ click on [OK] to complete naming the class



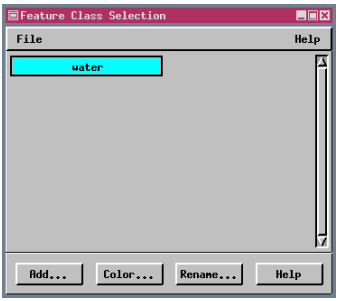
- ☑ adjust the color used for marked feature display to cyan (100% green, 100% blue)
- ☑ click on [OK] to complete color selection



* If you have used the Feature Mapping process before, the last used styles will be shown. Choose File/New, then return to step 2.

When you are done identifying prototypes for a particular feature class, it is time to mark the features. A feature map has two components: the raster object that shows all cells belonging to the same feature class in the same color and an associated style object that specifies the color and the name for the class. This style object is the same as that used for assignment of display styles for vector, CAD, and TIN objects. These styles will remain associated with the features if you vectorize your feature map. Marking features is a sequential, exclusive process. Once a feature is marked as belonging to a class, it cannot be assigned to another class unless it is first unmarked (removed from the initially assigned class).

When you click on the Mark Features icon, the Feature Class Selection window opens. You need to create a feature class for marked feature assignment before any features are marked. You can add more than one class by repeating the steps on this page. A different color selection is offered for each class as it is added. You can accept this color or adjust it if you have a particular color scheme in mind. You can also open a feature class style object created in a previous feature mapping session to provide the same color scheme and class names if you are marking the same types of features in a new map.

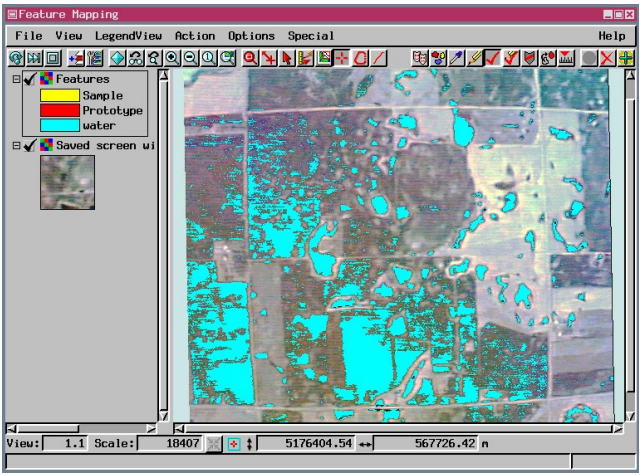


The Feature Class Selection window is only open when Mark Features or Draw Marked Features is the selected action.

Marking All Features

The Mark All function is a shortcut for converting all prototypes to marked features. The alternative method is to click on each feature you want to mark with the Select Point tool or to draw a polygon with the Select Area tool and mark those prototypes that fall at least partially within the area inscribed. Because features can be unmarked later, marking all features and saving the features raster is a quick means to save your progress to this point so you can exit the process and resume later.

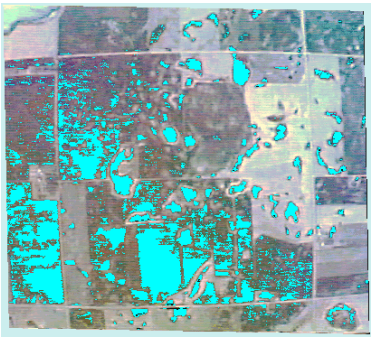
- ☑ click on the Zoom 1X icon 
- ☑ click on the Mark All icon 



- ☑ click on the Full View icon and note that all prototypes, not just those in the previously visible area, have been marked 

Prototype features are redrawn in the color assigned to the selected feature class as they are marked so you can watch the progress toward completion.

You can use the Mark All function when either Mark Features or Draw Marked Features is the selected action, and you have a feature class selected. This option is available on the Special menu as well as from an icon.



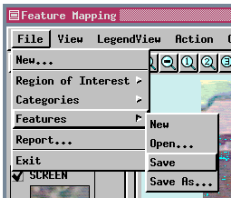
You probably noticed that the water feature class was added to the Features layer in LegendView. If LegendView is not on, choose LegendView / Show / Left (or Right).

Mark All converts all prototype features, *not just those visible in the view window*, to marked features.

Saving Results

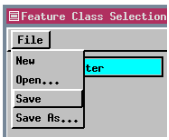
STEPS

☑ to save the features raster created, select File / Features / Save, save it in the SECT27R Project File or in a new Project File; click on the New Object icon in the Select Object window and accept the default name



☑ to save the features style object, the Feature Class Selection window must be open, which means the Mark Features or Draw Marked Features action must be selected (if you forget to save this or any object in the Feature Mapping process, you will be asked if you want to save it when you exit)

☑ choose File / Save As in the Feature Class Selection window and name a new object in the same file as above



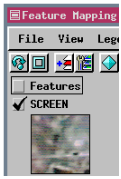
In the exercises so far in this booklet, you have created two different objects for the water features that can be saved. The raster containing marked features and the style object containing feature class information can be saved for further use in the Feature Mapping process or in other processes such as Spatial Data Display or raster-to-vector conversion via automatic boundary tracing. Next you will learn how to use the mouse to mark and unmark features, how to create regions of interest, generate a report, mark features in multiple classes, and create categories. Before moving on, let's consider saving the objects created thus far.

All activities that involve saving or opening raster objects, in this case the features raster, are handled from the File menu in the Feature Mapping window. Feature style objects are saved from the File menu in the Feature Class Selection window. A features style object is also automatically saved as a subobject of the features rasters to which it corresponds. The purpose of saving style objects separately is so they can be used for subsequent feature maps of imagery with the same types of ground cover. It is unlikely that a more advanced user would save a style object for a single feature class, but to get familiar with the procedure, go ahead and save this one.

Only marked features can be saved, so using the Mark All function is a good strategy when you're ready to quit for the day without first deciding which of the prototypes identified by the computer is a member of the desired class. You can exit the Feature Mapping process now if you want to take a break from this tutorial.

Resuming the Process

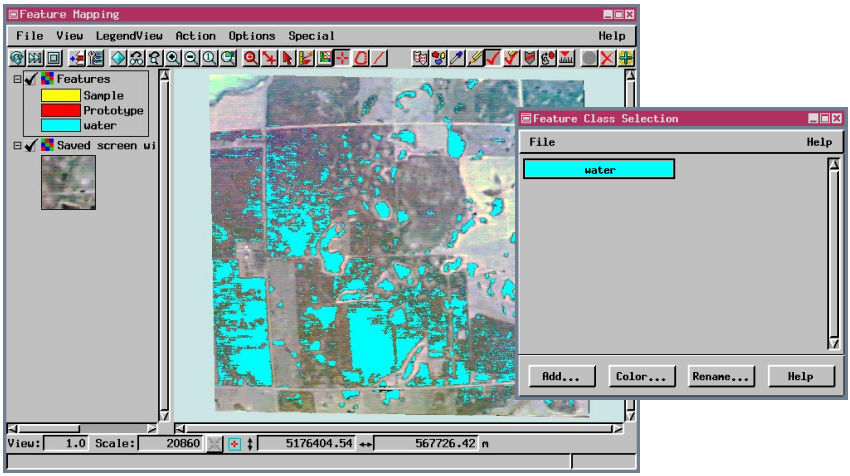
To resume the process, choose Feature Mapping from the main menu, select the same rasters for analysis (the select process should default to this file), and choose either the same or another raster(s) for the reference image. To get your saved features raster back into the process for further manipulation, choose Open from the Features cascade on the File menu, and select the saved features raster. The features raster initially comes in as a hidden layer because the Region-of-Interest tool is active, but is automatically shown when you choose the Mark Features tool.



The one thing lost when you Mark All, Save, and then resume is the identity of the sample points, because they were marked features at the time you saved. If you find you need to define more sample points in order to identify all members of a feature class after saving and resuming, you can return to defining samples for the class. If you used Mark All as a shortcut for saving your progress rather than because all prototypes were features you ultimately want marked, it is best to finalize marking of the prototype features before defining new sample points.

STEPS (if you exited)

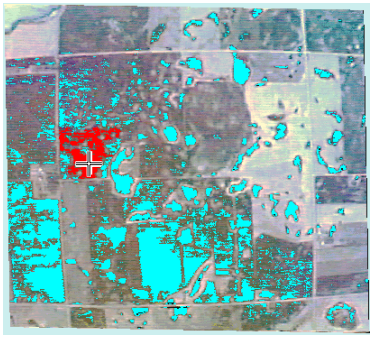
- ☑ launch the Feature Mapping process
- ☑ select the same analysis rasters selected previously (see page 4)
- ☑ select the 8-bit composite color raster (SCREEN) from the same file for the reference image
  - ☑ choose File / Features / Open and select the features raster saved on page 10
  - ☑ click on the Mark Features icon 



Unmarking Features

STEPS

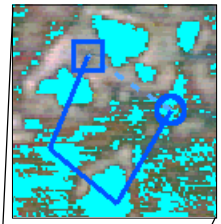
- ☑ click on the Select Point tool and position the mouse cursor over a feature you want to unmark
- ☑ hold down the <Shift> key then click the left mouse button



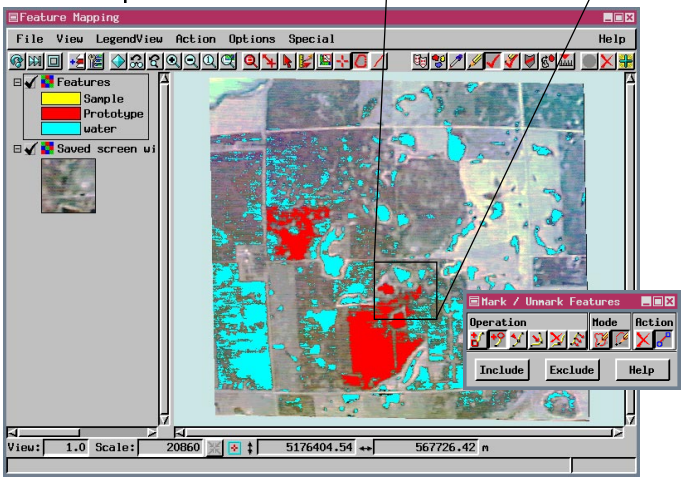
Features can be unmarked using either the Select Point or Select Area tool. You can unmark all features in the selected class by drawing a polygon around the full extents of the rasters being classified and clicking on the Exclude button in the Mark / Unmark Features window. You might want to unmark all features if you had marked them with hole filling turned off (discussed later) or if you used Mark All to save prototypes as we did.

Individual features are unmarked as a whole; you cannot unmark part of a feature. Features that are even partly within the area inscribed by the Select Area tool are unmarked when you click on the Exclude button, as is any feature you shift-click on with the Select Point tool.

- ☑ click on the Select Area tool and draw a polygon that includes at least part of a feature you want to unmark
- ☑ click the Exclude button
- ☑ click on the Full View icon if you have zoomed in
- ☑ draw a polygon outside the extents of the reference raster
- ☑ click on [Exclude]



Polygon drawn to unmark features as shown below.

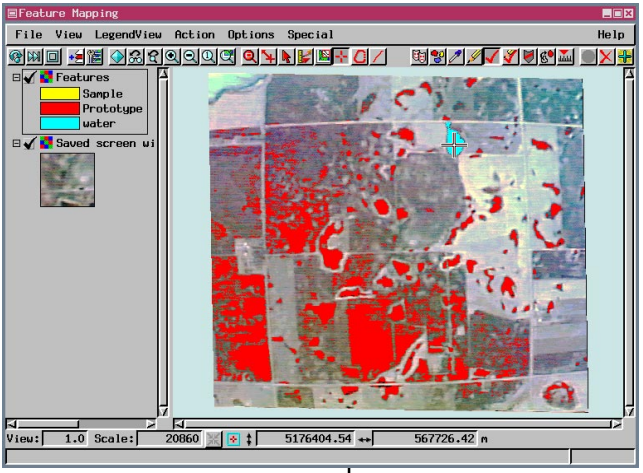


Marking Features with the Mouse

When creating the sample set, only the Select Point tool is active; both the Select Point and Select Area tools are available when marking features. The Select Point tool is initially chosen when you elect to Mark Features. This tool lets you mark features one at a time.

STEPS

☑ click on the Select Point icon and position the cursor over a prototype feature and click the left mouse button

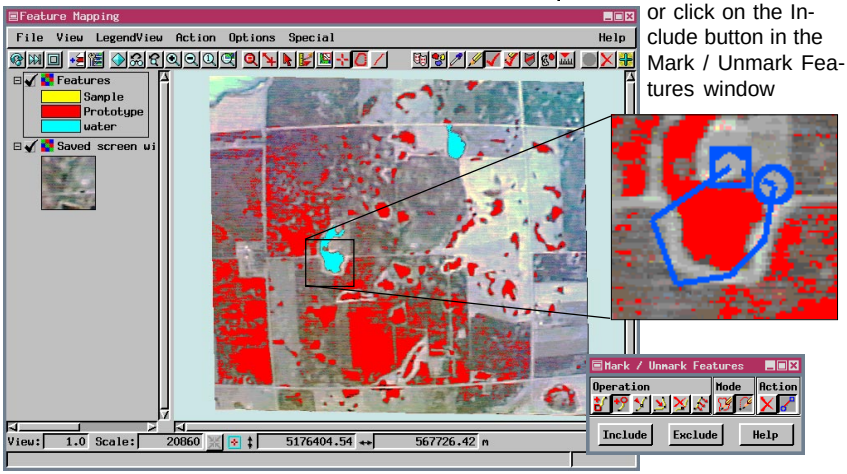


The Select Area tool marks all prototype features that fall within the polygon you draw. A partial feature cannot be marked; all contiguous prototype cells are marked when any part of the feature is included. Cells that fall within the Select Area polygon can be included in the selected feature class by clicking on the Include button in the Mark / Unmark Features window or by right-clicking when the mouse is over the image.

☑ click on the Select Area tool

☑ draw a polygon that includes some prototype features

☑ right-click over the view or click on the Include button in the Mark / Unmark Features window

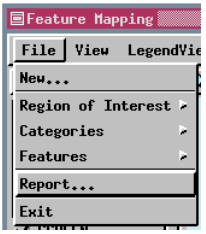


Generating a Report

STEPS

- ☑ mark five features as shown
- ☑ select Report from the File menu
- ☑ enter summary data information and click [OK]
- ☑ click on the New File icon in the Select File window 
- ☑ name the report file
- ☑ use Edit / Text Files (or another text editor) to view the report

The Feature Mapping process provides a report about all marked features and the unclassified area as well. Using Mark All with the features identified by the sample points described earlier results in 1972 features. Five features were marked for illustration in this exercise.



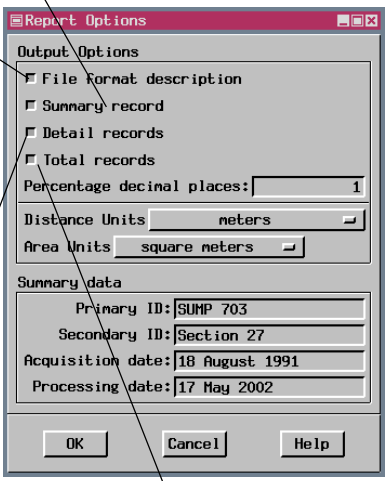

```
FD   SUMP 703   Section 27   18 August 1991   17 May 2002   4746506.47   245760   100.0
```

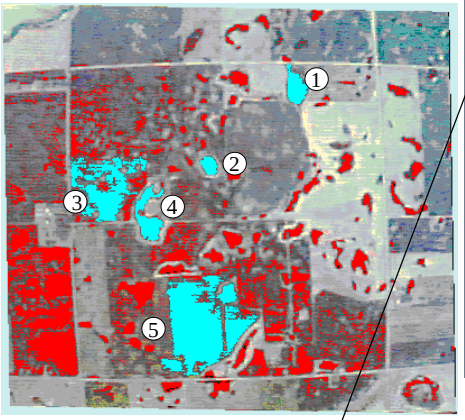
Total area processed

Number of cells in area processed

Percentage of total raster processed

A description of the contents of each field in every record type in the report is included when this button is on.





Type of Record

Class

Feature Number

Feature Centroid line column

Area

Boundary Length

Cells in Feature

Boundary Cells

```
FS   water   1   334   93     13171.86     3667.89     682     821
FS   water   2   233   188     5909.96     1652.70     306     370
FS   water   3   113   216     52822.65     16987.62     2735     3810
FS   water   4   162   250     19004.57     5460.14     984     1223
FS   water   5   221   378     131274.43     35844.56     6797     8014
```

Class

Total Area

Total Boundary Length

Average Area

Average Boundary Length

Percent of Area

Total Number of Boundary Cells

```
FT   Unclassified 1   4524323.00     0.00   4524323.00     0.00   95.3   234256     0
FT   water          5   222183.47   63612.91   44436.69   12722.58   4.7   11504   14238
```

Number of Features in Class

Total Number of Cells

Defining a Region of Interest

You can define a region of interest at any time in the Feature Mapping process by changing to the Region of Interest tool. A region of interest is saved (File / Region of Interest / Save) as a binary raster, which can be used as a mask in any TNTmips process.

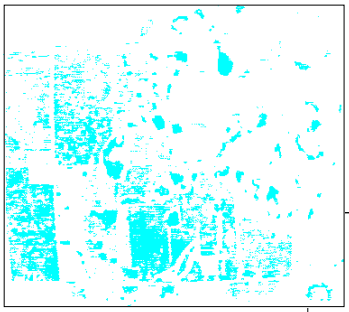
All features and prototypes are hidden from view when you select the Region of Interest tool so you have an unobstructed view of your reference raster while drawing.

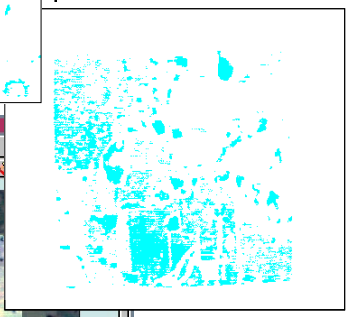
Areas included in the region of interest are drawn just as before while areas excluded are drawn at half normal intensity. The defined region of interest limits the area considered for any subsequent classification activities and for reports generated.

STEPS

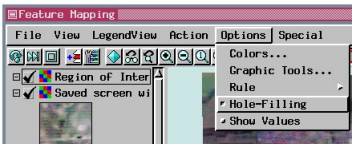
- ☑ click on the Region of Interest icon 
- ☑ change the line drawing mode to Stretch in the Region of Interest window 
- ☑ position the mouse cursor at the road intersection at the upper left of the reference raster
- ☑ click and hold the left mouse button as you drag the cursor to the right, following the road
- ☑ release the mouse button to insert vertices as necessary to follow the road
- ☑ turn right at each intersection and continue drawing until you are near enough to the start that the closing segment follows the road well
- ☑ right-click or click on the Include button

Features after Mark All without (right) and with (below, right) region of interest. Note that marked features are absent along the edges that were excluded from the region of interest.





Filling Holes

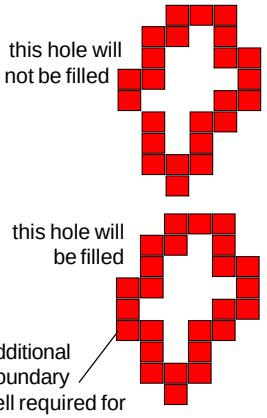


Whether to leave the holes in prototype features when marking depends largely on the purpose of the feature map. If you are mapping the number of acres planted with a particular crop, you will likely want to fill the holes that may arise from emergent weed patches. If you want a report that details the land area devoted to the mature crop, the holes should remain when the features are marked.

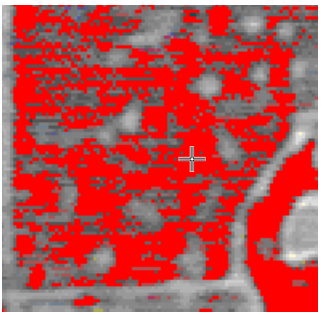
A hole can be any size or shape. Whether a hole is filled depends on the extent to which the hole is surrounded by prototype cells. Hole filling requires prototypes on eight sides (includes diagonals). So if there is a diagonal gap at even one point between the hole and the prototype, the hole will not be filled. Hole filling is on by default.

STEPS

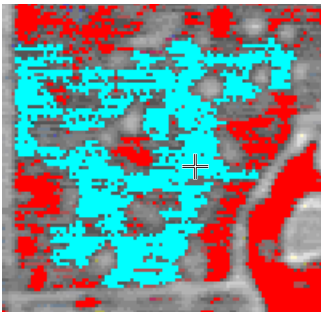
- ☑ change to Full view if zoomed in, and click on Mark Features 
- ☑ draw a polygon around the full extents of the reference image
- ☑ click on the Exclude button in the Mark / Unmark Features window
- ☑ mark a feature with and without hole filling



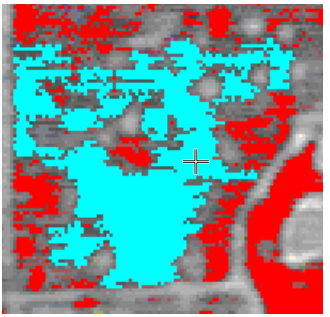
prototypes



hole filling **off**



hole filling **on**



More Complex Feature Mapping

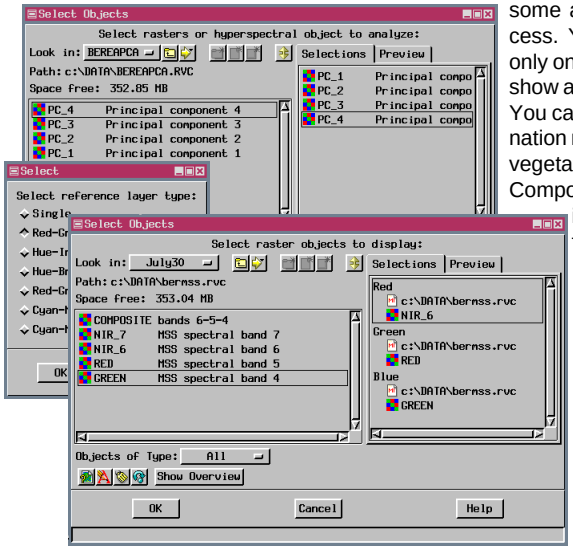
The number of analysis rasters is not limited in Feature Mapping, but the time for the classification step increases with the number of rasters. You should consider dimensional reduction techniques for multi-temporal or hyperspectral imagery.

The remaining exercises make use of MSS imagery collected on six different dates throughout the growing season to create a crop map. Two of the four components from each date (Bands 5 and 7) were used to generate a Transformed Vegetation Index (TVI, Process / Raster / Combine / Predefined). The six resulting rasters were then subjected to Principal Components analysis (Process / Raster / Combine / Principal Components). The first four principal components account for 93 percent of the total variance in the six-dimensional space defined by the TVI raster objects. The dimensionality has thus been reduced from 24 to four for analysis.

STEPS

- ☑ select File / New to start another feature map
- ☑ locate and select the four principal components generated for Berea (BEREAPCA Project File) for analysis
- ☑ click on [OK] to complete selection of rasters for analysis
- ☑ click on the Red-Green-Blue radio button in the Select window
- ☑ select band 6 (NIR_6) as red, band 5 (RED) as green, and band 4 (GREEN) as blue (JULY30 folder of the BEREAMSS Project File)
- ☑ click on [OK] to complete reference raster selection

Applying some method that reduces the number of raster objects in a set is known as **dimensional reduction**. The intent is to retain most of the information in the original set by some analysis or combination process. You might, for example, retain only one raster from the bands that show a high degree of correlation. You can also use some other combination method, such as generating a vegetation index or using Principal Components Analysis to retain the information of interest in fewer raster objects.



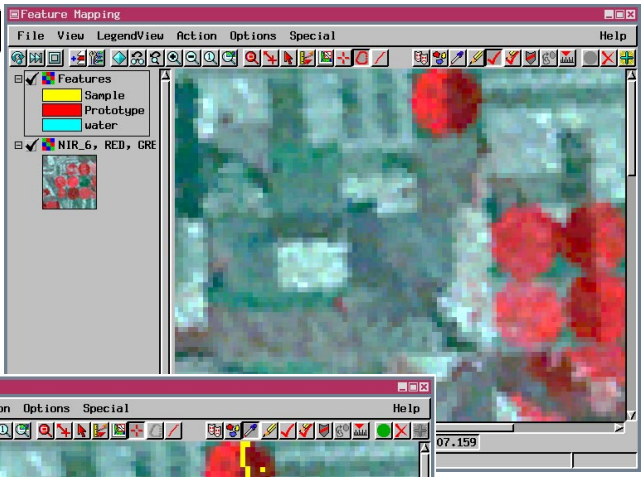
The reference image is color-infrared produced from three of the original MSS bands. None of these bands are used directly as analysis rasters.

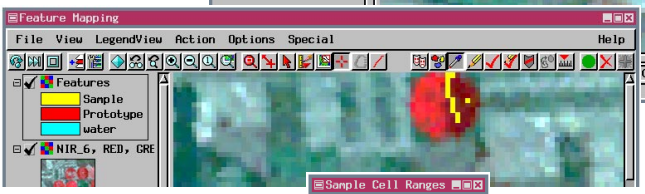
Define Samples and Classify

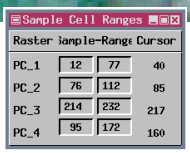
STEPS

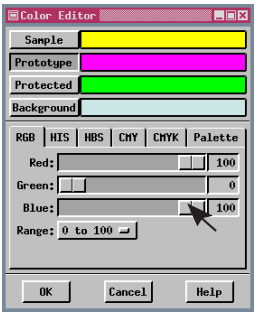
- ☑ with the cursor over the View, type a <3> then a <+>, and scroll to the top middle of the raster
- ☑ click on the Define Samples icon 
- ☑ turn on the Show Values option
- ☑ define sample cells on the right (darker) half of the center-pivot irrigated field (red circle) at the top of the reference image until the sample range includes all values (cursor values shown in black for other cells in this part of the field)
- ☑ select Colors from the Options menu, click on the Prototype button, and use the sliders to change the color to magenta (100% red, 100% blue)
- ☑ click on [OK] to complete color adjustment
- ☑ click on the Classify icon 

There are a multitude of crop types on both dry and irrigated land in this 7.5' MSS scene of the Berea Creek West map quadrangle in Box Butte County of western Nebraska. Using a color-infrared image for reference introduces a problem we didn't encounter when working with the video image. If we leave red as the color assigned to prototype features, it will be very difficult to distinguish prototypes from unclassified cells in most irrigated fields. The colors for sample cells, prototypes, and protected areas, as well as the display background color can all be set from a single menu selection.









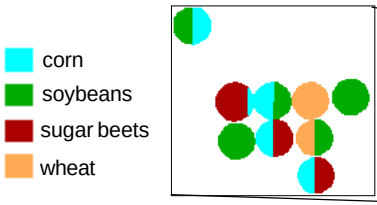
Dealing with Messy Prototypes

Ground truth information for the crops makes it clear that many areas would be erroneously labeled as corn if we used Mark All. Clearly, features should be marked individually, which poses no problems in areas where extraneous prototypes aren't contiguous with legitimate corn fields. The pivot where the samples were defined has only a few extraneous cells, and they are not touching the prototypes we want marked as corn in the right half of the pivot. So there's no problem marking this feature; just click on the prototype with the Select Point tool and Mark Features selected. Successful marking of other prototypes requires the introduction of two new skills: protecting areas and drawing prototypes.

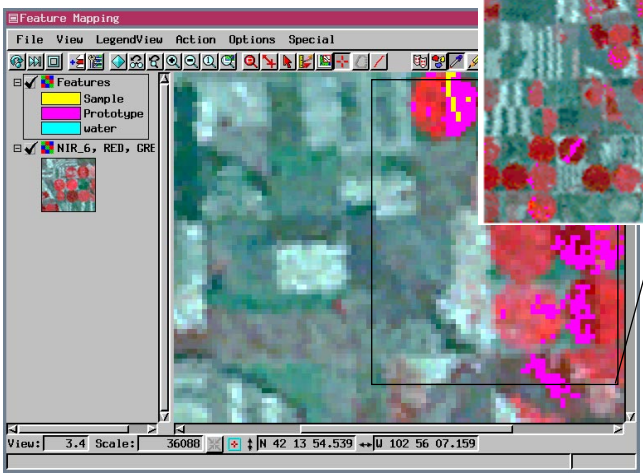
Vocabulary: A **pivot** is the circular crop area irrigated by a single center pivot irrigation system.

STEPS

- ☑ click on the Mark Features icon 
- ☑ select New from the File menu in the Feature Class Selection window
- ☑ add a feature class and name it "corn"
- ☑ position the Select Point tool over the prototype feature at the top center of the reference raster (right half of pivot) and click



crop map for pivots in area outlined



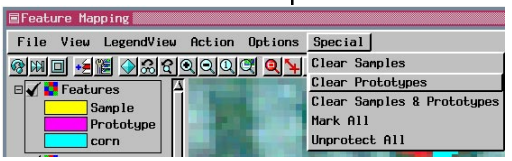
Clearing Prototypes

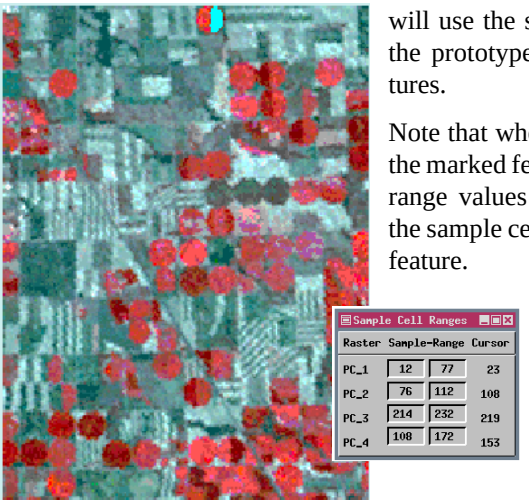
When you use Clear Prototypes to remedy a problem, you need to take some other action, such as removing some sample points or protecting areas, or you will get the same prototypes the next time you click on the Classify icon.

☑ select Clear Prototypes from the Special menu

You've marked one feature as corn, and now it's time to take the steps necessary to mark the other features in the same area cleanly. Additional sample cells are needed to identify all pivots or partial pivots growing corn. But first let's take the steps necessary to keep the corn separated from other crops in the area outlined on the previous page. The first technique we will use is protecting areas to prevent marking cells of other classes that initially formed continuous prototypes with the correctly identified corn.

Feature Mapping involves a number of mutually exclusive cell identifications. I have already mentioned that once a feature is marked and assigned to a feature class, it is excluded from consideration for other feature classes. Similarly, cells that are prototype features or marked features cannot become protected areas unless their feature status is first removed. You can remove prototype status using the drawing tools with Draw Prototypes as the selected action (choose Exclude instead of Include with the Select Area tool or hold the <Shift> key with the Select Point tool), but for this example we will use the special function that removes the prototype status of all unmarked features.





Note that when the prototypes are cleared, the marked feature remains, and the sample range values are unchanged even though the sample cells are now part of the marked feature.

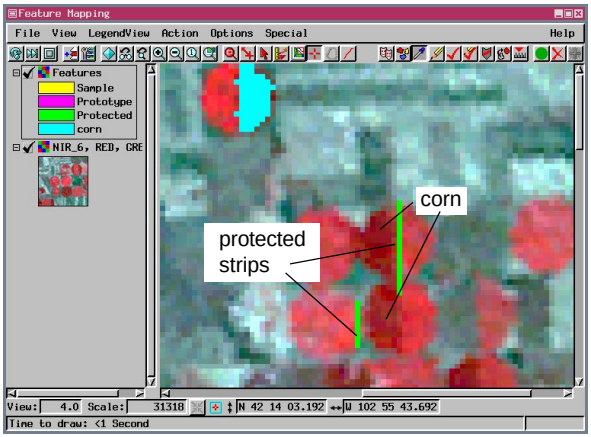
Protecting Areas to Separate Classes

Remember that Feature Mapping is an interactive process that keeps you, the "expert," in the loop to make decisions about the validity of computer identified prototype features. Protected areas are excluded from consideration in subsequent classification steps.

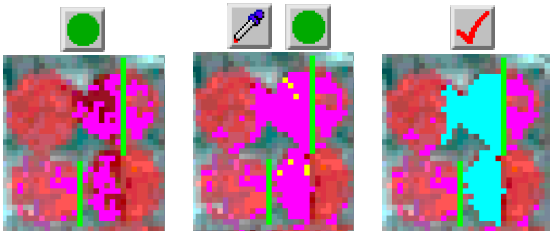
The misclassification of cells that can be prevented by protecting areas can occur in two ways. In some cases, as in the current example, cells adjacent to the feature class of interest are also identified as prototypes by the sample range defined. To prevent these adjacent cells from becoming part of the correctly marked feature for neighboring cells, you need to provide a protective strip at the boundary between cell types so the marked feature does not spill beyond its actual boundaries. This problem is generally not apparent until after the classification step, so you need to use the Clear Prototypes function before proceeding. In other cases, areas requiring protection are not identified as prototypes but are completely surrounded by prototype cells. These areas will become part of the marked feature if hole filling is on. Such areas can be protected without having to clear prototypes.

STEPS

- ☑ click on the Protect Areas icon 
- ☑ at 6X zoom (as on page 18), locate the pivots below and just to the right of the marked feature
- ☑ using the Select Point tool, draw two protective strips as shown (over first column of lighter cells in the upper right pivot and at first column in the left pivot next to the boundary between the lower pair)



- ☑ click on the Define Samples icon 
- ☑ click on the Classify icon 
- ☑ add more sample points, then click on the Classify icon  and repeat until the corn is well defined 
- ☑ click on the Mark Features icon 
- ☑ click on the corn (prototype between the two protected strips)

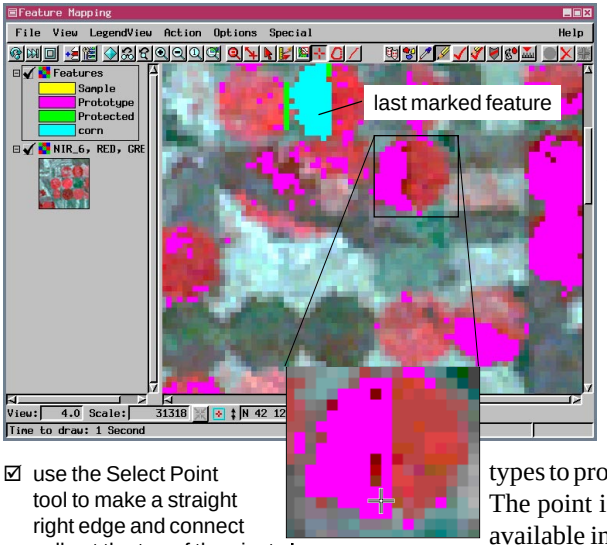


Drawing Prototypes and Features

STEPS

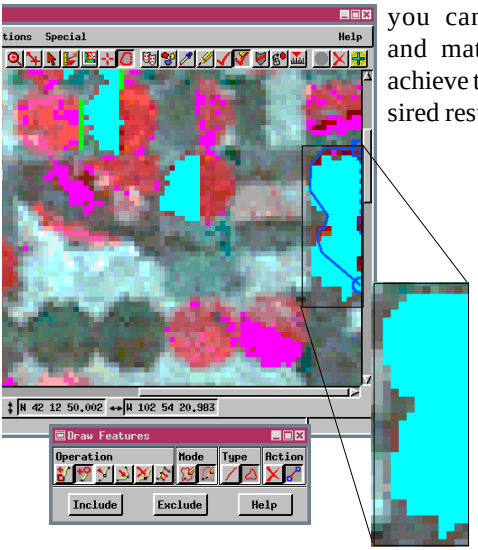
- ☑ scroll if necessary to locate the next set of pivots shown
- ☑ click on the Draw Prototypes icon 

The sample points added to mark the second feature were sufficient to almost completely identify additional pivots planted with corn. Some nearby features can be easily filled in by drawing a few additional prototype cells.



The sample range remains unchanged when you draw either prototypes or marked features, so generally you would repeat the adding sample points / classification cycle to see if the entire feature could be classified as a prototype. Sometimes adding more samples and classifying again introduces too many prototypes to proceed with that strategy. The point is, there are many tools available in Feature Mapping, and you can mix and match to achieve the desired results.

- ☑ use the Select Point tool to make a straight right edge and connect cells at the top of the pivot
- ☑ turn on Hole Filling if it is not already on
- ☑ click on the Mark Features icon 
- ☑ click on the newly modified prototype feature and on the two connected pivots at the right edge of the image
- ☑ click on the Draw Marked Features icon (tool changes to Select Area) 
- ☑ draw a polygon that includes the dark red cells not yet marked around the two pivots at the edge
- ☑ right-click or click on the Include button



Finish Marking Irrigated Corn

At this point you need to use a combination of the techniques already learned to identify and mark the rest of the corn pivots, which are identified for you in the vector map of all the pivots in this MSS scene below. I would recommend starting with the pivots closest to those already marked to define more sample cells and classify iteratively until some prototype fields are well defined. Use the drawing tools to exclude some cells from the prototypes if necessary, then mark these features. You can also draw marked features using either the point or polygon tool. You may need to remove sample points at the extremes of the range and clear prototypes if a classification step produces results that overrun adjacent fields. I recommend adding only a few sample cells between classification steps so that it is not difficult to identify and remove offending sample points. You can also introduce more protected areas if need be.

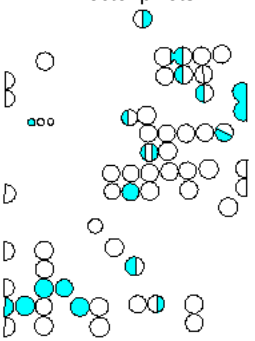
Once you have features (or categories) saved as a raster, you canget measurements of individual features using the GeoToolbox. Simply position the Point tool on a feature, right click and choose the Raster Solid Trace region tool from the menu, select the features raster in the Region Generation window and click OK. The Measurement panel in the GeoToolbox provides feature measurements, extents, and the centroid location with the region tool selected.

STEPS

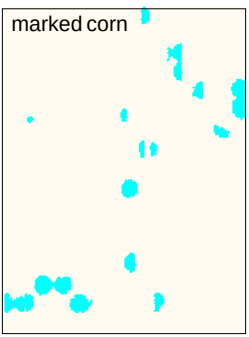
- ☑ click on Define Samples and expand the sample set for corn
- ☑ click on Classify
- ☑ repeat the first two steps as necessary
- ☑ remove extreme sample points and clear prototypes if the classification results are too messy
- ☑ click on the Draw Prototypes icon and add to or subtract from the prototypes generated as necessary
- ☑ click on the Mark Features icon and mark corn fields
- ☑ click on the Draw Marked Features icon and edit marked features as necessary
- ☑ save your features raster object (File / Features / Save)
- ☑ click on the GeoToolbox, choose the Point tool, left-click on a feature, then right-click and choose Raster Solid-Trace
- ☑ click on [Raster], select your saved features, and click [OK]

MSS scene

vector pivots



marked corn



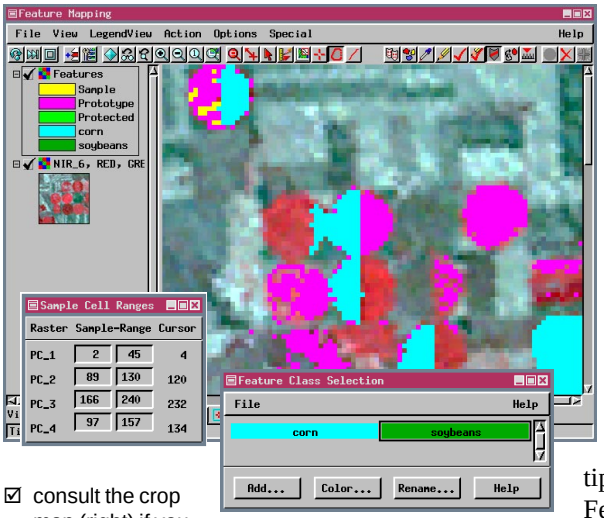
More than One Feature Class

STEPS

- ☑ select Clear Samples and Prototypes then Unprotect All from the Special menu
- ☑ repeat steps 2–4 on page 18, except this time define samples in the left half of the pivot 
- ☑ click on the Classify icon; add more samples as needed 
- ☑ repeat the steps on page 8 to add a feature class and name it soybeans

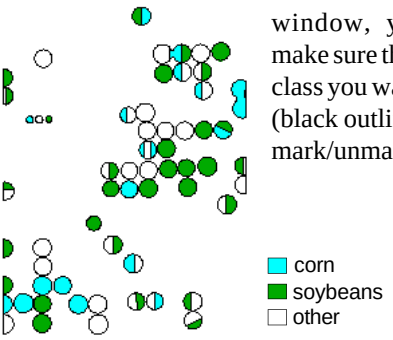
Before you begin to work on identifying another feature class, you need to clear both the samples and prototypes. Or, if you exited after completing the last page, just open the features raster (File / Features / Open); there are no sample points, prototypes, or protected areas to clear. You also need to establish a new feature class sometime before you mark the first new feature.

When there is overlap in cell values for different feature classes, as there is in this example, you'll find it gets progressively easier with each subsequent class to identify prototypes and mark classes because cells from the first feature type marked are no longer under consideration. Now that the corn is marked, you'll find it is easier to identify and cleanly mark the soybeans. When defining samples, previously marked features are displayed in their assigned color so you know they are ineligible for sample point selection.



When you have multiple feature classes in the Feature Class Selection window, you need to make sure that the feature class you want is selected (black outline) when you mark/unmark a feature.

- ☑ consult the crop map (right) if you aren't clear on which pivots and partial pivots in the view are soybeans, add more soybean sample points as necessary or draw features
- ☑ mark the soybean pivots 
- ☑ save your marked features and style object

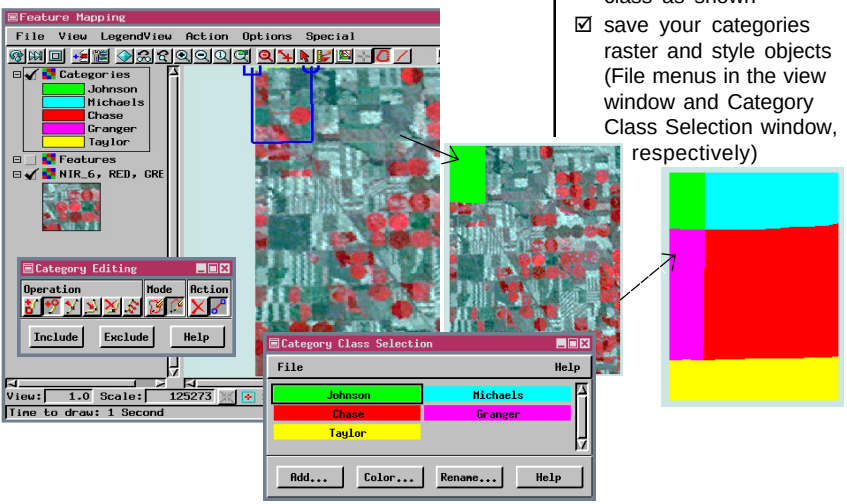


Creating Categories

Categories are used to group features in the report generated by the Feature Mapping process. Thus, you can look at the number and area of features of specific types by land ownership or any other attribute you choose. There are two components to any category: the ground area to which the category refers and the category's style, which includes its name and assigned color. We will create hypothetical land ownership categories to use in generating a report that includes the acres of corn and soybeans planted for each land owner in the area.

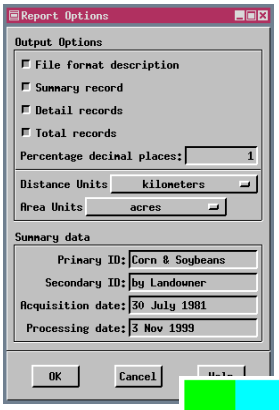
The mechanics for creating categories are much the same as for drawing marked features. Once an area is assigned to one category class, it cannot be included in a second class. Thus, you need to be careful only when drawing the first category class boundaries; adjacent categories will share this boundary regardless of how they are drawn. It is actually a good idea to draw later categories so their boundaries overlap previously assigned areas so there are no unintentional gaps between categories. Categories are only shown in the Feature Mapping window when Categories is the action selected on the toolbar.

- ☑ click on the Categories icon 
- ☑ repeat the steps on page 8 for adding feature classes five times to create five category classes
- ☑ click on the first class name you are going to draw
- ☑ draw internal edges of the boundary polygon carefully and extend outer edges beyond edge of raster
- ☑ click on [Include]
- ☑ click on the name of the next class
- ☑ carefully draw the edges that don't bound the first category or the edge of the raster; draw other edges so that they extend into the first category or beyond the edge of the reference image
- ☑ repeat the last two steps until all areas have been assigned to a category class as shown
- ☑ save your categories raster and style objects (File menus in the view window and Category Class Selection window, respectively)

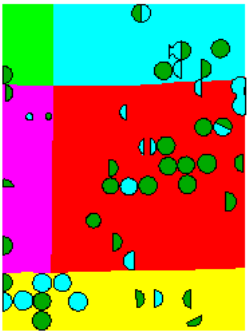


Generating a Report with Categories

☑ follow Steps 2 through 6 on page 14 to generate and view a Feature Mapping Report



Categories are reflected in the Feature Mapping report in three different ways. A general summary about each category is included (Record Type CS). This information includes the category name, the total area covered by the category, the number of cells in the category, and the percentage of the total area that belongs to the category. Each feature is also broken down by category (Record Type FB). If an individual feature is entirely within one category, this information will be the same as the feature summary record (Record Type FS). Feature totals for each category are also provided (Record Type CT). In this example, there may be three feature total records for each category: corn, soybeans, and unclassified.



Marked corn and soybean features overlaid on categories raster.

	category class	area (acres)	number of cells	percentage of area
CS	Johnson	1850.66	2307	5.2
CS	Michaels	6809.01	8488	19.2
CS	Chase	16117.66	20092	45.5
CS	Granger	4178.62	5209	11.8
CS	Taylor	6472.09	8068	18.3

	feature class (FS) or category class (FB)	feature number	centroid line & column		area (acres)	boundary length	cells in area & boundary		feature class (if FB)
Feature entirely on Johnson land	FS soybeans	7	3	51	68.99	7.01	86	123	
	FB Johnson	7	3	51	68.99	7.01	86	123	soybeans
Feature that crosses Michaels and Chase boundary	FS corn	8	175	68	215.79	19.67	269	345	
	FB Michaels	8	175	68	4.01	0.46	5	8	corn
	FB Chase	8	175	68	211.78	19.22	264	337	corn

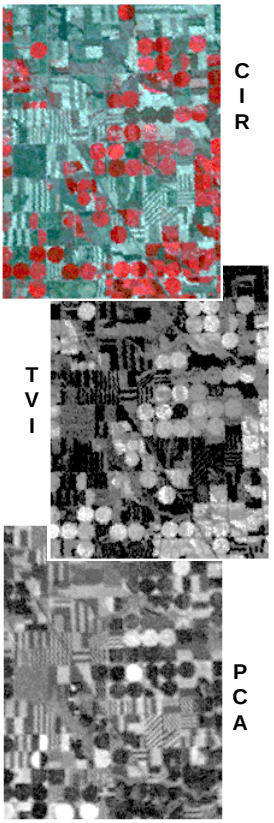
	category class	feature class	number of features	area (acres)	boundary length	average area	avg. bound. length	percent of area	cells in area & boundary	
CT	Johnson	Unclassified	1	1781.67	0.00	1781.67	0.00	96.3	2221	0
CT	Johnson	soybeans	1	68.99	7.01	68.99	7.01	3.7	86	123
CT	Michaels	Unclassified	1	6241.86	0.00	6241.86	0.00	91.7	7781	0
CT	Michaels	corn	4	206.16	21.95	51.54	5.49	3.0	257	385
CT	Michaels	soybeans	4	360.99	36.21	90.25	9.05	5.3	450	635
CT	Chase	Unclassified	1	14299.89	0.00	14299.89	0.00	88.7	17826	0
CT	Chase	corn	8	622.50	61.81	77.81	7.73	3.9	776	1084
CT	Chase	soybeans	9	1195.27	119.29	132.81	13.25	7.4	1490	2092
CT	Granger	Unclassified	1	4002.94	0.00	4002.94	0.00	95.8	4990	0
CT	Granger	corn	1	15.24	1.94	15.24	1.94	0.4	19	34
CT	Granger	soybeans	4	160.44	17.79	40.11	4.45	3.8	200	312
CT	Taylor	Unclassified	1	5369.88	0.00	5369.88	0.00	83.0	6694	0
CT	Taylor	corn	4	620.09	58.91	155.02	14.73	9.6	773	1033
CT	Taylor	soybeans	5	482.12	47.33	96.42	9.47	7.4	601	830

Afterword

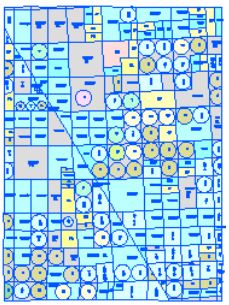
You have created two simple feature maps and used most of the tools available. Using Feature Mapping with your own imagery may require more than two classes. The steps are the same regardless of the number of classes you want to map. Just remember, the class you are marking or unmarking needs to be selected in the Feature Class Selection window. If you mark a feature as belonging to the wrong class, you can simply unmark it and remark it with the correct class selected unless it happens to merge with a previously marked feature. If you accidently mark soybeans, for example, as corn and it adjoins an already marked corn field, you have a single, larger corn feature. Because you cannot unmark part of a feature, correcting this error will likely involve redrawing the corn feature after unmarking then reclassifying and marking the soybeans.

One simple idea not introduced is the decision rule settings (Options menu) for classification. The default Rule setting uses a simple boxcar classifier that establishes the area of n-dimensional space (where n is the number of rasters selected for analysis) where prototypes are identified by the range of sample values. Quantitative data is required for such an approach to provide meaningful results. Individual grayscale bands or 16- or 24-bit composite color are appropriate data for the default Rule setting (Range); *8-bit composite color is not*. If 8-bit composite color is all you have available for analysis, you need to use the Exact decision rule. Prototypes identified by the Exact decision rule are only those cells that match the set of cell values defined by one of the sample points.

An important concept that was only mentioned in passing in this booklet is the simplicity of creating vector polygons from your features rasters. You just select the features raster and run the Auto-Boundaries process and you have vector polygons with the correct feature class assigned.



Run Auto-Boundaries to generate vector objects from feature maps (Process / Convert / Raster-to-Vector / Auto-Boundaries).



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