

provide easy access to common editing commands. The Sketch Properties is used to examine vertices of sketches. And finally, the Attributes button launches an editing menu for the feature attributes. In the next few sections, we will examine in more detail how these editing menu elements work.

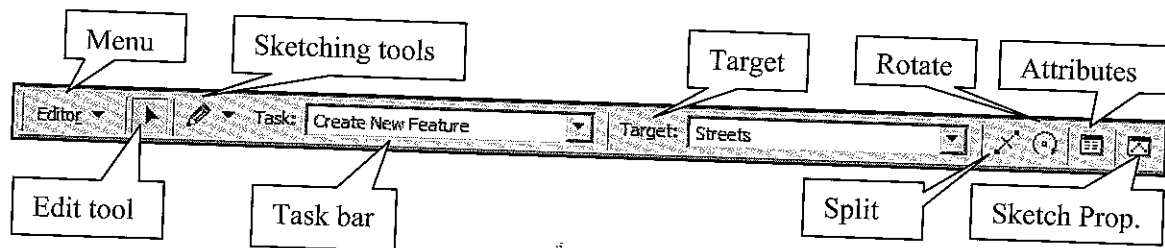


Fig. 11.1. The Editor toolbar contains many editing options and functions in one neat package.

General information about editing

What can you edit?

ArcGIS offers different levels of editing capability, according to whether you've purchased ArcView, ArcEditor, or ArcInfo. ArcView can edit shapefiles and personal geodatabases only. ArcEditor or ArcInfo can also edit databases, coverages, geometric networks, and feature topology. All of these levels are accessed through the same ArcMap interface.

ArcMap can edit several layers at once, as long as they are all in the same folder or geodatabase. This capability makes it easier to view and edit related layers simultaneously or to copy features from one layer to another.

TIP: Coverages cannot be edited in ArcMap. Use the ArcEdit program in Workstation ArcInfo instead, or convert the coverages to shapefiles or geodatabases for editing.

Editing and coordinate systems

ArcMap can display and edit layers containing different coordinate systems. As long as the coordinate systems are correctly defined for each layer, the edits will automatically be converted to the coordinate system of the layer being edited. Consider editing a shapefile of roads stored in a geographic coordinate system (GCS) while displaying the roads with a digital orthophotoquad (DOQ) in Universal Transverse Mercator (UTM) projection. As the roads are edited, the coordinates will automatically be converted into decimal degrees before they are saved into the roads shapefile.

Performance and reliability

Although ArcMap has many useful capabilities, such as editing across coordinate systems, and editing multiple files simultaneously, one must be somewhat cautious in taking advantage of these benefits. Editing coordinate features can be a complicated process, and software does not always work perfectly under arduous conditions. If an editing scenario is demanding extensive system resources by having many files open, or by doing many projection transformations during an edit session, the system performance and reliability may suffer adversely. Moreover, because spatial data files are complex constructions of multiple files, the price of an editing glitch may be

the integrity of the data. An ill-timed system glitch might not only lose recent changes, but might also corrupt the entire data set. Thus, you are encouraged to use the following procedures while editing:

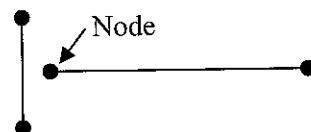
- **Always have a backup copy of the file being edited**, stored elsewhere on the disk or on a different medium. This precaution is especially important when working on data sets that would be expensive or impossible to replace should something go wrong.
- Shapefiles are the simplest and most robust type of data file to edit and the hardest to corrupt. When feasible, create and enter data as shapefiles first, and then, if necessary, convert them to geodatabases or coverages later. However, geodatabases offer special capabilities for editing; if these are being used, then using shapefiles is not an option.
- Keep the number of open files in an ArcMap editing session to a minimum. A prolonged editing session should be conducted in its own map document and include only the layers that are actually needed.
- Avoid editing across different coordinate systems whenever possible. On-the-fly projection takes additional system resources and can degrade editing performance. Projecting vectors is preferable to projecting rasters, however, because raster projection is more time-consuming.
- Save edits frequently in case of a system glitch. Every 20 to 30 minutes usually works well. ArcMap does NOT automatically save edits at regular time intervals, like some programs do.

Snapping features

When creating line features that connect to each other, such as roads, one must take care that the features connect properly. In other words, the features must have topological integrity. Two tools can be used to ensure topological integrity: snapping and integration. Snapping makes sure that features are topologically correct as they are added. Integration can correct errors after the fact, but requires an ArcEditor or ArcInfo license.

Lines which fail to connect are called **dangles**. Although you may not be able to see the gap between the lines when displaying the map, the gap will exist unless the endpoints of each line (nodes) have exactly the same coordinate values (Fig. 11.2). Even though the map may look correct, certain functions, such as tracing networks or locating intersections, will not work properly. It is impossible to intersect lines properly by simple digitizing.

The snapping option ensures that the nodes of lines and the vertices of polygons match. When snapping is turned on, it affects features which are being added or modified. If you place the cursor within a specified distance of an existing node or vertex, then the new feature is automatically snapped to the



A dangle—the two lines fail to connect.



Correct topology—the horizontal line intersects the vertical one, creating three lines.

Fig. 11.2. Topological relationships between lines

existing one—that is, the coordinates are matched at that one point (Fig. 11.3). When you have snapping turned on, you will notice the cursor jumps to an existing vertex whenever you move the mouse within the snap distance, and remains there until you move away.

The snap distance can be changed to suit your preference. However, caution must be used to specify a realistic distance. If the snap distance is too small, then you will have difficulty making features snap. If it is too large, then you may find yourself constantly snapping to objects when it isn't needed. The distance may be set in pixels, in which case it remains constant as you zoom into and out of the map. Alternatively it may be set in map units in order to prevent overzealous snapping when zoomed out to small scales.

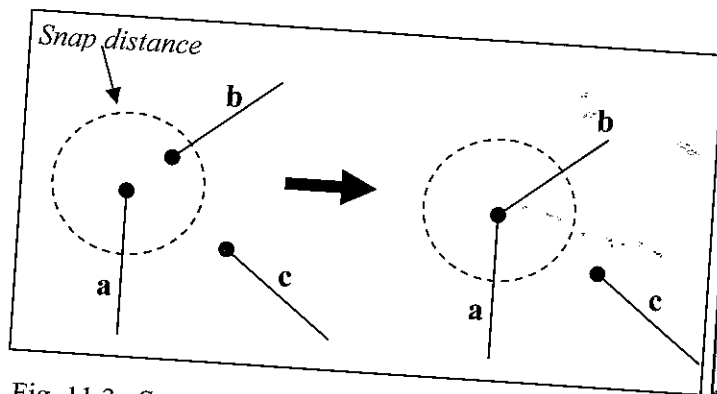


Fig. 11.3. Snapping. Line “b” snaps to “a” because it falls inside the snap distance. Line “c” remains unconnected.

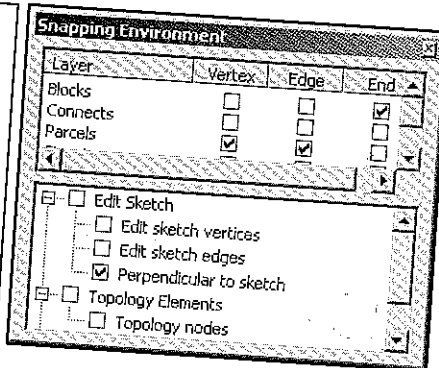


Fig. 11.4. Setting the snapping environment

Three types of snapping can be set independently for each layer (Fig. 11.4). When snapping is turned on for a layer, it affects the features being added to every other layer, not just itself.

End snapping is the most restrictive: it only allows a new line to be snapped to the endpoints of an existing line. End snapping ensures that new streams connect to the ends of existing streams.

Vertex snapping allows the endpoints of the new line to be snapped to any vertex in an existing line. It can ensure that adjacent polygons connect only at existing corners.

Edge snapping constrains the feature being added to meet the edge of an existing feature. In this case, the vertex being added could be placed anywhere along an existing feature. Edge snapping can ensure that a street ends exactly on another street, even if the new street falls in between two vertices of the existing one.

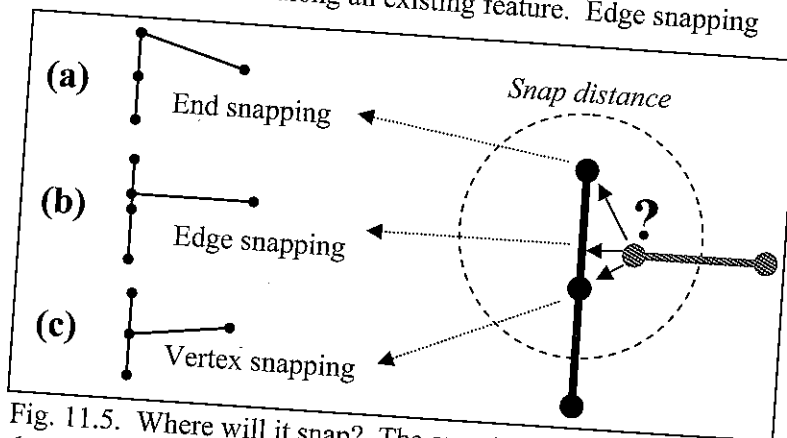


Fig. 11.5. Where will it snap? The snap type dictates where the new horizontal line will end.

Figure 11.5 illustrates how the snapping effect changes depending on which type of snap has been set. The vertical line already exists in the layer, and the horizontal line is being added. The dashed circle shows the snap distance. If

end snapping is turned on, then the new line will snap to the endpoint of the existing line (Fig. 11.5a). If the edge snap is turned on, then the line can be snapped anywhere between the end and the vertex (Fig. 11.5b). If vertex snapping is set, then the new line will connect to the closest vertex or end (Fig. 11.5c).

If more than one kind of snapping is turned on, then the most inclusive one takes precedence. To ensure snapping only to ends, therefore, both edge and vertex snapping must be turned off.

Creating adjacent polygons

Two adjacent polygons should always share the same boundary. In shapefiles and geodatabases, the boundary gets stored twice, once for each of the polygons. However, the vertices should exactly match in both features. If this condition holds, the polygons are said to share a coincident boundary (Fig. 11.6). If they fail to match, gaps or overlaps are generated, which constitute topological errors and may cause problems during display or analysis.

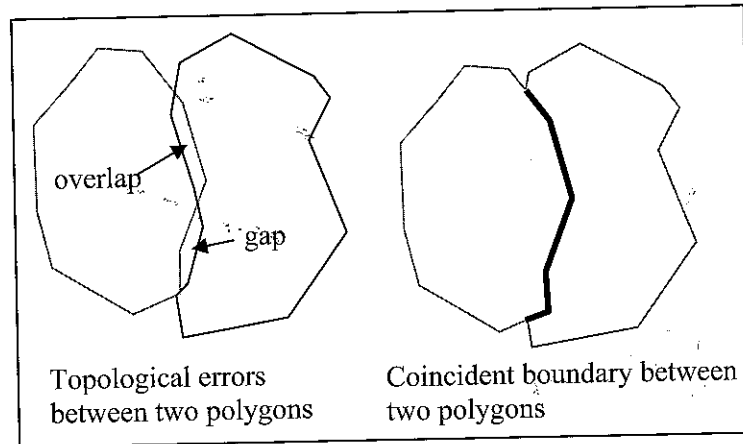


Fig. 11.6. Topological relationships between polygons

Although snapping can help create coincident boundaries between polygons, it grows annoying to digitize every boundary twice. The Editor toolbar has a special method for adding adjacent polygons. The Create New Feature task is used to enter a complete polygon with no neighbors. To add an adjacent polygon, you would set the task to AutoComplete Polygon, and digitize only the new part of the polygon. The editor then ensures that the polygon is finished and shares the same boundary as the first polygon (Fig. 11.7).

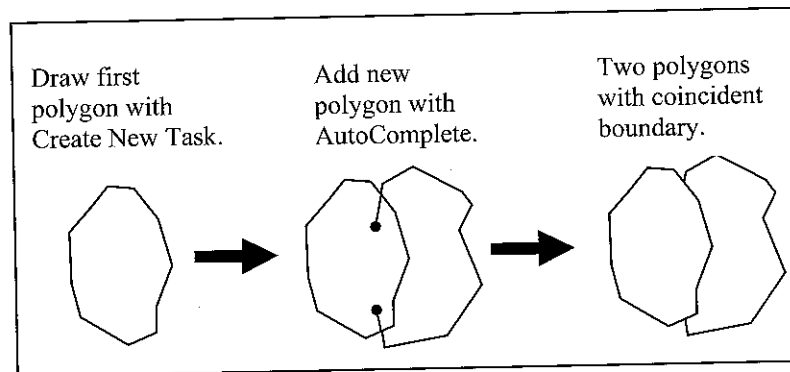


Fig. 11.7. Creating a coincident boundary between two adjacent polygons with the AutoComplete task

Editing features

Editing must be performed within an existing data layer or table. Feature classes must be first created in ArcCatalog before any features can be added to them. New empty layers cannot be created within ArcMap.

An editing session must be initiated before any changes to a file can be made. This requirement protects the user from accidentally making changes to a file without realizing it. Also, because ArcMap can only edit within one directory or one geodatabase at a time, opening the session establishes the folder or geodatabase being edited.

The Editor toolbar controls which layer is being edited. On the toolbar, a drop-down box specifies the **target layer**. Any feature created will be placed in this layer. The type of target layer also dictates the types of edits which can be made. You can create a new feature in any kind of layer (point, line, or polygon), but the AutoComplete Polygon task would be dimmed if the target layer contains points or lines.

Basic editing uses three components of the Editor toolbar: the Edit tool, the Sketch tool, and the Task bar (Fig. 11.8). The Task bar specifies which editing action is taking place, such as creating a new feature, or reshaping an existing feature. The Sketch tool provides the input to the task, such as sketching the vertices of the new feature. The Edit tool can specify which features will be affected by the task.

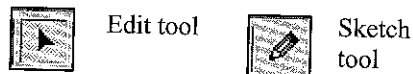
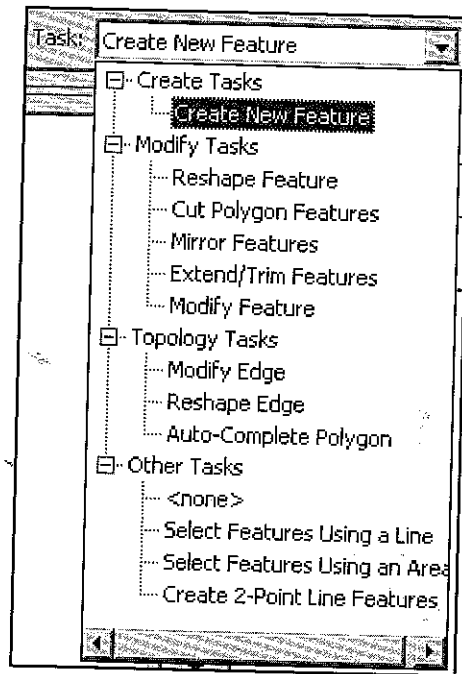


Fig. 11.8. The Edit tool, Sketch tool, and Task bar work together.

For example, to create a new feature you first select the Create New Feature task, and then enter the shape of the feature using the Sketch tool. To modify a feature (change the shape defined by its vertices), you must first specify the Modify Feature task, then select the feature using the Edit tool, and then move the vertices with the Sketch tool.

At any point during a sketch, you can bring up context menus to help you locate the next vertex with specific characteristics (Fig. 11.9), such as making the next segment have a specific length, or a specific bearing, or making it perpendicular or parallel to an existing line, or deleting part or all of a sketch. The context menus provide a variety of ways to enter features.

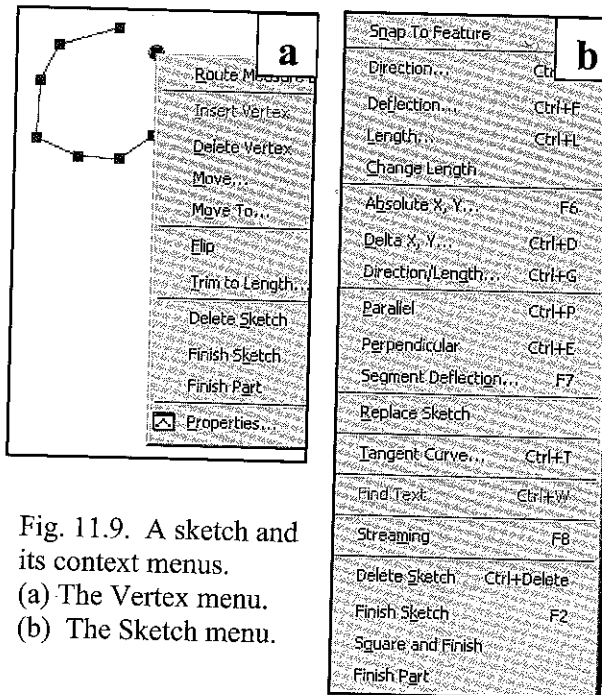


Fig. 11.9. A sketch and its context menus.
 (a) The Vertex menu.
 (b) The Sketch menu.

Two context menus are available. The **Vertex menu** appears when you right-click a vertex or segment of the sketch (Fig. 11.9a). This menu can add, delete, or move vertices. It can also flip

and trim the sketch. The **Sketch menu** appears when you right-click any location off the sketch (Fig. 11.9b). This long menu provides detailed functions for specifying exact angles, lengths, distances, and more. Both menus allow the user to delete or finish the sketch.

About the sketching tools

The sketching tools create a preliminary shape of a feature, analogous to an artist sketching a figure lightly in pencil prior to inking in the final lines of the picture. This sketch is not actually added to the target layer until it is “finished.” In Figure 11.9a, the Sketch tool (looks like a pencil) has been used with the Create New Feature task to enter the vertices of the polygon. When it is complete, the user right-clicks the sketch to show the Sketch menu and chooses Finish Sketch. The sketch then becomes a feature.

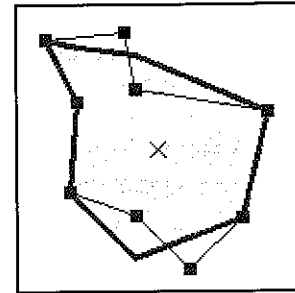


Fig. 11.10. Modifying a feature

Sketches also appear when reshaping or modifying an existing feature. Figure 11.10 shows an original feature as a shaded polygon, and the lines and square vertices show a sketch which will become the new shape. Reshaping permits the user to change vertex locations, insert new vertices, or delete old ones. The sketch converts to a feature when the user finishes making changes.

The Sketch tool is one of nine different sketching tools used to enter vertices for sketches, which can be chosen by clicking the black drop-down arrow next to the current sketching tool (Fig. 11.11). Each sketching tool has its own way to enter vertices for a sketch. The functions of the other tools are explained in Chapter 12.

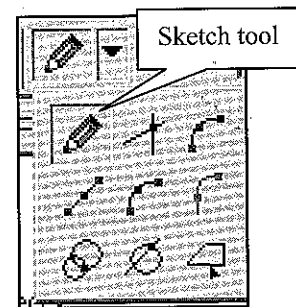


Fig. 11.11. Nine sketching tools

Editing attributes

Editing features often include editing their attributes. The user can modify attributes in two ways. In the first way edits are typed directly into an attribute table, as discussed in Chapter 5. The second method uses the Attribute Editor to display and edit the values of many features at once.

The Attribute Editor is accessed through a button on the Editor toolbar (Fig. 11.12). The left side of the editor shows the selected records; if no features or records are selected, then both areas will be blank. The right side of the editor shows the attributes of the feature highlighted on the left. In Figure 11.12, for example, the attributes are shown for the first road, St Charles St. Clicking another feature displays its attributes instead.

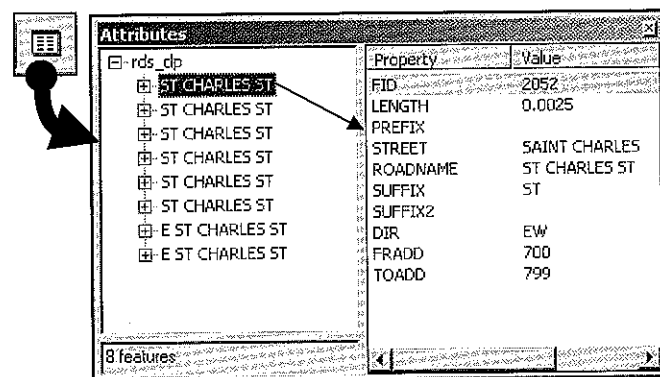


Fig. 11.12. The Attribute Editor lets you view and edit many records at once.

To edit the attributes of a single feature, you simply highlight it on the left and type the changes into the fields

Chapter 12. More Editing Techniques

Mastering the Concepts

Objectives

- Modifying shapes of existing features
- Advanced techniques for editing lines and polygons
- Combining features with merge, union, intersect, and clip
- Buffering features to create lines and polygons
- Editing shared lines and polygon boundaries

Concepts

Chapter 11 presented some basic and advanced techniques for creating new features in a data layer. In this chapter we examine additional ways to form and modify features. First we will examine the functions of the different types of sketching tools, look at ways to modify and reshape features, combine features together, and create new features by buffering old ones. Finally, we will discover how to easily edit features which share a common boundary.

Using different sketching tools

So far we've used mainly the Sketch tool to enter vertices of features. However, several different sketching tools can be used to create specialized vertices with specific characteristics. If the black arrow on the current sketching tool is clicked, the menu expands to show many different tools (Fig. 12.1). More tools have been added with later releases of ArcMap.

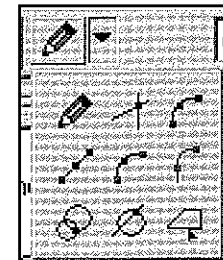


Fig. 12.1. The nine sketching tools

The **Distance-Distance** tool finds locations that fall a specified distance from two points. Imagine that the owner of a house left a note that the septic tank lies 50 feet from the NE corner of the house, and 32 feet from the NE corner of the tool shed. The tool could use this information to pinpoint the two possible locations of the tank when it becomes necessary to dig it up for repairs (Fig. 12.2a).

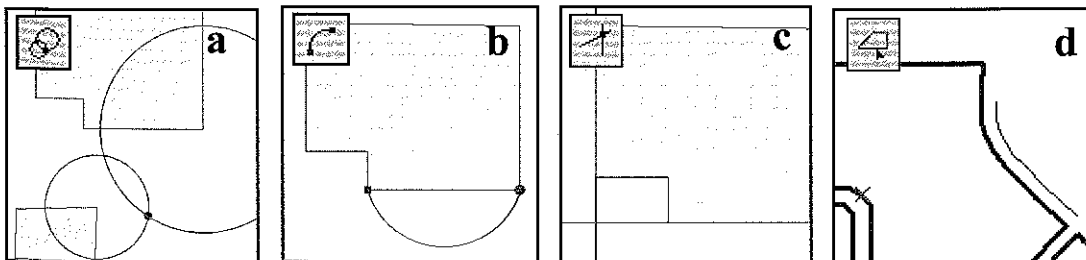


Fig. 12.2. Using some of the sketching tools. (a) Distance-Distance tool. (b) Curve tool. (c) Intersection tool. (d) Trace tool.

The **Arc tool** creates true parametric arcs of set radius. The user enters the start point, the point which the curve passes through, and the endpoint, as shown by the patio in Figure 12.2b.

The **Intersection tool** finds the intersection point of two lines, such as the location where the two sides of a parcel would intersect if the cutout did not exist (Fig. 12.2c).

The **Trace tool** creates new features which follow along existing features, either directly on top of them or with a specified offset. For example, the second side of a street could be created from the first side, with the exact width in between (Fig. 12.2d).

Additional sketching tools perform other specialized functions. The **Midpoint tool** will enter a new point midway between two points entered by the user. The **Endpoint Arc** tool enters a different kind of curve than the Arc tool. The user enters the two endpoints of the arc and then types in the radius of the arc. The **Tangent** tool adds a new sketch segment that is tangent to the previously sketched segment. The **Direction-Distance** tool allows the user to create a new vertex using a bearing direction from a known point plus a distance from another point.

Changing existing features

Once a polygon or line has been created, it can be changed by eliminating unwanted vertices, adding vertices, or moving existing vertices. Other modifications include flipping lines, trimming them, extending them, and performing a variety of other editing functions.

Modifying features

The Task bar contains an option for modifying existing features by adding or deleting vertices, or moving the existing vertices. The Modify Feature task causes the sketch of the feature to appear. When the edits are complete, the feature is updated to the current form of the sketch. Figure 12.3 shows how an original circular polygon is modified to a keyhole shape by moving vertices in the sketch.

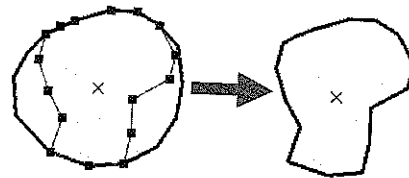


Fig. 12.3. Modifying a feature

Reshaping features

The reshaping task reenters a feature or a portion of a feature, using a new sketch to define the revised shape. The sketch must start and finish on the original feature, so it is helpful to have vertex or edge snapping on. When the sketch is finished, the original feature is modified to follow the sketch. Figure 12.4 shows the process of reshaping parts of lines and polygons.

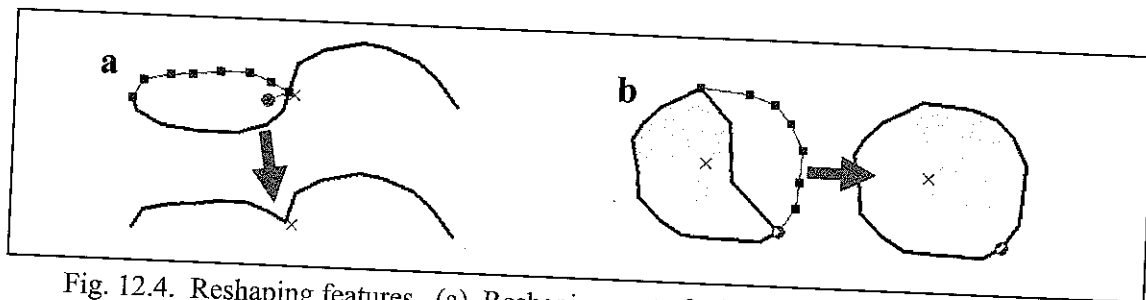


Fig. 12.4. Reshaping features. (a) Reshaping part of a line. (b) Reshaping a polygon.

Flipping lines

As we found in the chapter on geocoding, lines can have a direction. Lines begin at the “from” node and end at the “to” node. Normally the direction of a line generates little concern, and either direction works just as well. In some instances, however, the direction matters. In geocoding, it matters because it defines which way the addresses increase along the street. A streams layer used for network analysis uses the line direction to encode the flow of water. A similar situation would hold for constructing a network of water pipes or sewers, in which the direction of flow must be constrained and recorded.

The direction of lines may be determined by drawing them with arrow-ended symbols. Once drawn, you can see the direction of flow and flip the direction if required (Fig. 12.5).

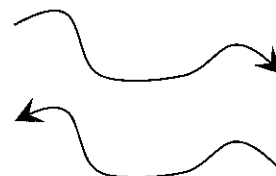


Fig. 12.5. A flipped line

Combining features

Chapter 8 introduced overlay techniques such as intersection, union, and merging. In the Geoprocessing Wizard, these functions are applied to entire shapefiles or feature classes. These functions are also available during editing and can be applied to individual features on an interactive basis. The functions perform similar operations: intersect still finds the area common to both inputs, and union includes all areas from both inputs. However, the attributes are treated differently. Instead of combining all the attribute fields from both inputs, the output feature simply has the same attribute fields as the target layer.

When using these combinations, the user should be sensitive to how any attributes of the features are handled. In cases of a merge, union, or intersect, the resulting features will be given the attributes of one of the original features. In a geodatabase, the attributes of the feature selected FIRST will be copied to the output feature. For shapefiles and coverages, the feature with the lowest feature-id will be copied. If the feature attributes matter, then the user must pay attention to which attributes are being copied and must correct any attributes that were not copied as desired.

Merge

A merge takes one or more features and combines them into a single feature (Fig. 12.6). If the two features are adjacent, then the boundaries between them are removed. If the two features are separate, then a multipart feature will be created. This function might be used frequently to update a parcels map when an owner has purchased two adjacent parcels and combined them into one.

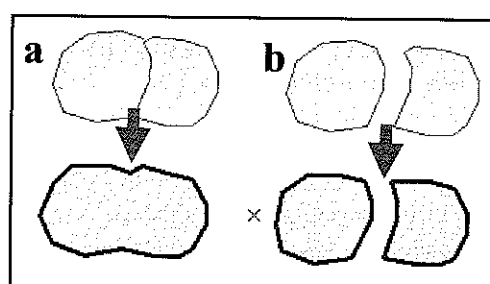


Fig. 12.6. (a) Merging adjacent polygons to create a new feature. (b) Merging separate polygons to form a multipart feature.

Union

A union performs the same operation as a merge, except that the original two features remain unchanged and a new feature is created in addition.

Intersection

An intersection creates a new feature from an area common to both original features (Fig. 12.7). A new feature is created and the original ones are maintained. If two features are selected and an intersection is performed, the resulting new polygon will consist only of the areas shared by the original polygons. The new feature is created in addition to the original features, which are not changed or deleted. This function might be used to identify repeat infestations of pine bark beetle attacks. Two features representing infestations in two different years could be intersected to reveal the area attacked twice.

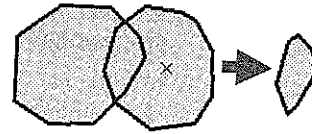


Fig. 12.7. Intersection of two polygons to create a third polygon

Clip

A clip behaves in a cookie cutter fashion. If one feature lies over another, the underlying feature will be cut along the boundaries of the overlying feature (Fig. 12.8a). Two options may be specified: preserving the area common to both features (Fig. 12.8b), or discarding the area common to both features and retaining what is outside the clip polygon (Fig. 12.8c). In either case the feature used for clipping is retained unchanged, and the feature underneath is modified. As shown in Figure 12.8c, clipping is one way to create a "donut" polygon. Clipping is useful anytime a polygon must have internal boundaries, such as a residential area with a park in the middle.

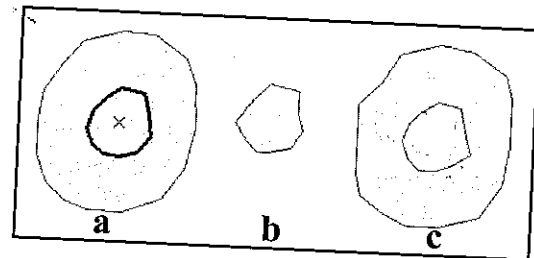


Fig. 12.8. Clipping. (a) Ready to clip the outer polygon with the selected polygon. (b) Option to preserve the common area. (c) Option to discard the common area.

Buffering features

A buffer delineates the area within a specified distance of a feature and can be created from points, lines, or polygons (Fig. 12.9a-c). The output buffers may be lines or polygons, as determined by the feature type of the target layer. The buffer distance must be specified in map units. In the case of buffering polygons, a negative distance may be used to reduce the size of the feature (Fig. 12.9d). Buffers are useful for tasks such as identifying setbacks from parcels, finding drug-free zones around schools, or creating road widths from a set of centerlines.

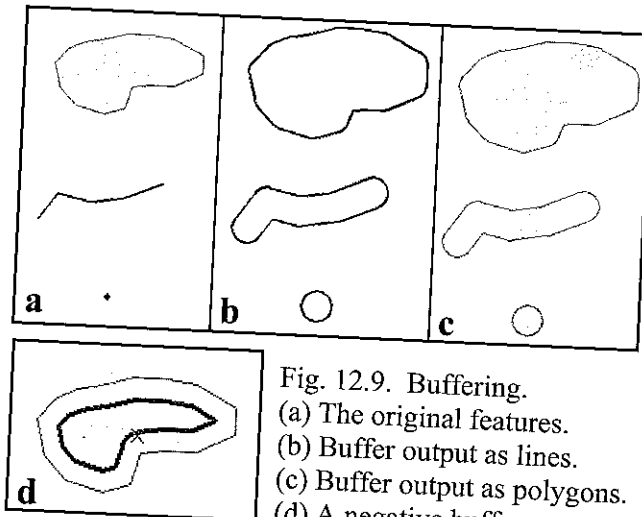


Fig. 12.9. Buffering. (a) The original features. (b) Buffer output as lines. (c) Buffer output as polygons. (d) A negative buffer.

Topology and shared features

Shared features have boundaries or nodes in common with each other. When editing them, it proves very convenient to be able to edit the shared boundary or node, rather than editing each individual piece separately. ArcMap has a special tool which allows editing of shared features.

Consider the problem of changing a boundary between two polygons. Editing the first polygon leaves a gap between the two, so that the edit must be repeated on the second polygon. Snapping can help ensure that the boundaries match, but it quickly becomes tedious to edit every boundary twice. The Topology Edit tool provides a better way.

Topology refers to spatial relationships between features. Shapefiles contain only simple features and are incapable of storing topological information. Coverages store topology as an integral part of the data structures for lines, polygons, and multifeatures. Geodatabases can store several types of topology, including network topology and planar topology. Only feature classes inside a feature dataset can participate in a topological association. Chapter 14 demonstrates some uses of a network topology.

Planar topology is used to specify the spatial relationships allowed in and between feature classes. A topology in a geodatabase is composed of rules. For example, the Must Not Overlap rule stipulates that within a single layer one polygon cannot extend onto another, even a little bit. This situation would clearly be an error in the case of parcels, for the same bit of land cannot belong to two different parcels. Other rules specify relationships between layers, such as the rule Must Cover Each Other. This rule describes the relationship between counties and states, in which every bit of the state area must belong to a county, and no part of a county should lie outside the state. In other words, the rule helps enforce that shared boundaries of features between layers are identical, with no gaps or overlaps between them.

Figure 12.10 shows typical topological errors occurring between different layers. The boundary of the Pine Ridge Indian reservation (stippled area) should match the boundary between Shannon and Bennett counties, but it does not. Neither does it properly match the South Dakota–Nebraska boundary. Such errors can cause problems during analysis, such as the generation of sliver polygons during an intersection or union, as described in Chapter 8.

Creating planar topology makes it easier to locate and eliminate boundary errors by using special Topology tools while editing. This approach is especially helpful when errors are too small to see at normal viewing scales—in Figure 12.10 the county boundaries appear to match the state boundaries, but might not actually do so. Such errors typically occur as a result of combining data sets from different sources, or from files created by people who do not understand or use snapping very well. Users interested in topology should read the appropriate sections in *Editing with ArcMap*, one of the digital books that come with ArcGIS.

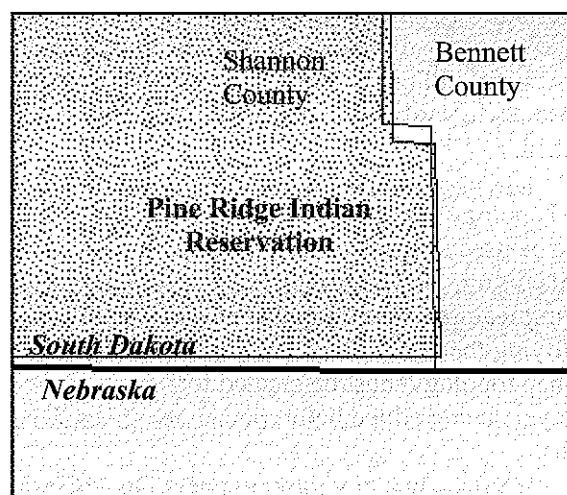


Fig. 12.10. Topological errors between layers

Building planar topology for a feature dataset and using it during editing requires an ArcEditor or ArcInfo license. However, users with ArcView licenses, or who are editing shapefiles rather than feature datasets, can use a function called **map topology** to edit features with shared edges or vertices. Map topology creates temporary relationships between features so that they can be edited together. Its purpose is to preserve existing coincident boundaries, however, not to fix problems like the ones shown in Figure 12.10.

The user creates map topology during editing by selecting which feature classes will participate in it. The map topology is created on-the-fly for the set of features currently in the data view. In a topological association, the endpoints of lines are called nodes and lines or polygon boundaries are called edges. The user selects the node or edge to be edited using the Topology Edit tool, and then selects one of the topology tasks from the Task bar.

The Topology Edit tool is similar to the normal Edit tool, except that its purpose is to select shared boundaries in preparation for editing. When using the Topology Edit tool to select a feature, or part of a feature, all other features sharing that boundary are also affected by the edits.

Figure 12.11 shows the use of the Topology Edit tool and the Reshape Edge task to change the boundary between two polygons. First, the shared boundary is selected using the Topology Edit tool. The selection color of the Topology Edit tool is purple, to distinguish the selection from those made with the Edit tool. The Sketch tool is then used to draw the new boundary between the polygons. When the sketch is finished, the new boundary replaces the old one, and the change is applied to both polygons.

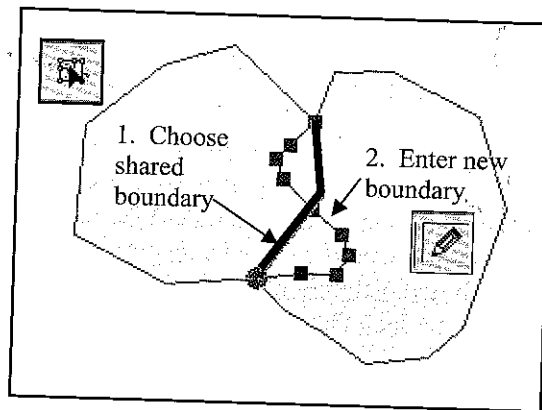


Fig. 12.11. Reshaping a polygon boundary with the Topology Edit tool and the Sketch tool

The Topology Edit tool is also convenient when working with connected line features, such as roads. If one road node is moved, the roads attached to the node move also to maintain their connection. In Figure 12.12, the road node was selected with the Topology Edit tool and then moved downward. The attached vertices of the other lines are also moved when the sketch is finished.

The Topology Edit tool can in many cases be used in place of the Edit tool when editing. It can be applied to moving features, reshaping them, modifying them, and so on. However, the map topology must be created for the layers being edited before it can be used.

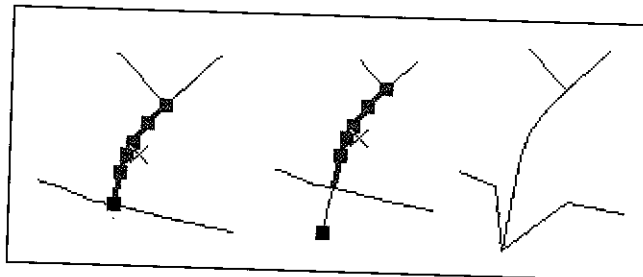


Fig. 12.12. When editing shared nodes, the node is moved, and the attached roads follow.

Summary

- The sketching tools provide nine different ways to create vertices.
- Modifying and reshaping are two ways to change existing features.
- Features may be combined to create new ones using merge, union, intersect, and clip. Care must be taken to ensure that attributes are correctly copied during these transactions.
- New polygons or lines may be created by buffering existing points, lines, or polygons.
- Planar topology establishes rules about the spatial relationships within and between layers, and can be used to help locate and eliminate errors. Building and editing with planar topology requires an ArcEditor or ArcInfo license.
- Temporary topologic relationships, called map topology, may be used when editing with an ArcView license, allowing features which share vertices or boundaries to be edited simultaneously with the Topology Edit tool.

Chapter Review Questions

You may need to consult the Skills Reference section to answer some of these questions.

1. What is the difference between modifying a feature and reshaping a feature?
2. What is the difference between a union and a merge?
3. What determines the direction of a newly created line?
4. What are two ways to create donut polygons?
5. Examine the drawing. In (a), the polygons were created one after the other using Create New Feature. In (b), the first was created as a donut and then filled using the Trace tool. They look identical, but they are not. What is the difference? (**Hint:** What is the area of the outer polygon in each case?)
6. How do you establish whether the output feature of a buffer command is a line or a polygon?
7. What are the two types of output features possible when you divide a line?
8. Which sketching tool is used when filling a hole in a polygon?
9. If you trim a line and the wrong end gets deleted, how do you fix it?
10. Explain the differences between map topology and planar topology in a geodatabase.

