



VISUAL LEARNING SYSTEMS

LIDAR Analyst for ArcGIS Reference Manual



Visual Learning Systems, Inc.

We put the information in GISsm

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Notice: The information in this document is subject to change without notice. Changes, technical inaccuracies, and typographical errors will be corrected in subsequent editions. Graphics are for reference only. Actual screens may differ when using LIDAR Analyst.

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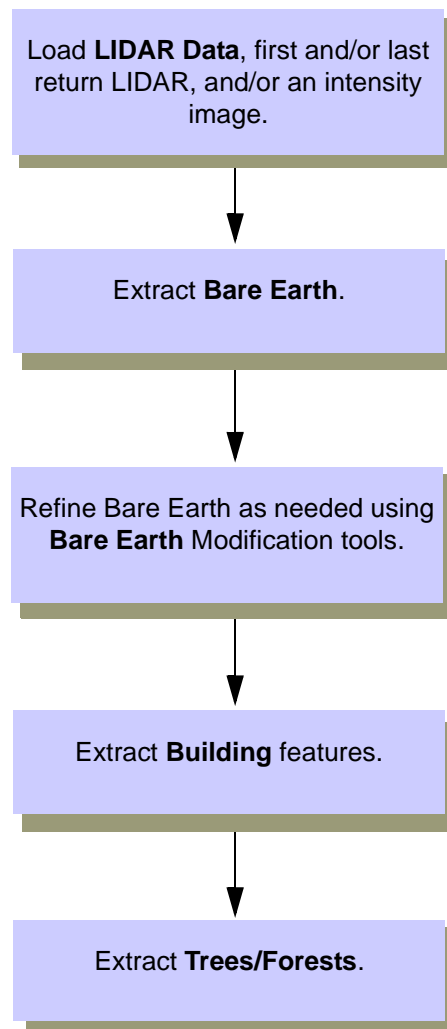
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INTRODUCTION

Visual Learning Systems, Inc.'s LIDAR Analyst allows you to quickly and easily extract features using your first and last return LIDAR images. LIDAR Analyst automates many of these processes to make extraction as simple as possible. Use LIDAR Analyst to automatically extract three types of data: Bare Earth, Buildings, and Trees/Forests.

LIDAR ANALYST WORK FLOW

LIDAR Analyst requires a specific work flow to acquire satisfactory results.



TIP: To save yourself time, we recommend working on a small sampling of your LIDAR images to find the best settings. Then use those settings to complete the extraction on the entire LIDAR data set.

INTRODUCTION TO LIDAR

LIDAR is an acronym for LIght Detection And Ranging. It is a newly developed technology for determining the shape of the ground surface plus natural and man-made features.

LIDAR technology offers accurate, expedient and cost-effective ways to capture wide-area elevation information to produce detailed Digital Elevation Models (DEMs).

LIDAR data sets contain vast amounts of elevation information. Buildings, trees, power lines, and many other visible features that may not be accessible in a GIS database. The data is digital and is directly processed to produce detailed bare earth DEMs at vertical accuracies of 0.15 meters to 1 meter. Resultant products include contour maps, slope/aspect, three-dimensional topographic images, virtual reality visualizations, and more.

LIDAR data can be integrated with other data sets, including orthophotos, multispectral, hyperspectral, and panchromatic imagery. LIDAR is combined with Geographic Information System (GIS) data and other surveying information to generate complex geomorphic-structure mapping products, building renderings, advanced three dimensional modeling, and many more high quality mapping products.

The two primary results derived from the raw LIDAR data include a first-return file and a last return data file.

- 1 The first-return file is a combination of all data classes received from the first-return of each laser pulse.
- 2 The last return file contains a combination of all data classes received from the last return of each laser pulse.

INSTALLING LIDAR ANALYST

Before you can get started using your LIDAR Analyst for extraction, you need to install and authorize your new software application. Follow the instructions below for completing that task.

- 1 Confirm that the following ESRI software is installed on your computer:
 - ArcMap
 - Spatial Analyst
- 2 Confirm that you have Administrative Privileges for the computer you are installing with LIDAR Analyst. If you do not, contact your System Administrator to install the product for you.

Or

Note: You must have Spatial Analyst to run LIDAR Analyst.

Request that you have read/write permissions for the installation directory. The default installation directory is C:\Program Files\VLS\LIDAR Analyst.

- 3 Run the install program that you downloaded from the Visual Learning Systems web site or from the LIDAR Analyst CD.

In some instances, the Windows Installer may want to reboot your PC to ensure that you have the latest version of Windows Installer.

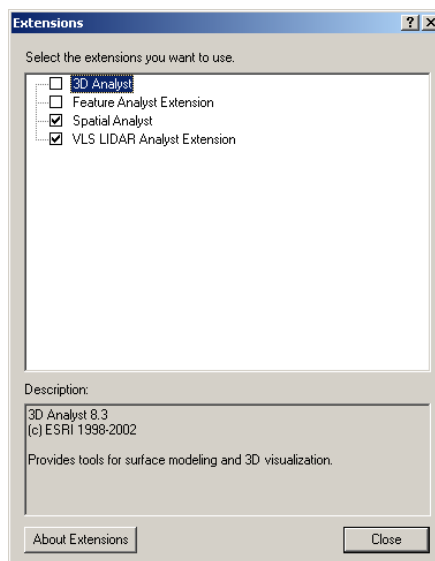
- 4 Follow the instructions provided on screen by the setup program.

Now that your software is installed, it's time to register your license and get authorization.

Activating LIDAR Analyst

Once you have installed the LIDAR Analyst, you must activate it as an extension of ArcMap.

- 1 Start **ArcMap**.
- 2 Choose **Tools** on the ArcMap menu bar and select **Extensions**.



The Extensions dialog box opens, allowing you to select the extension to activate.

- 3 Check the **VLS LIDAR Analyst** extension.
- 4 Confirm that **Spatial Analyst** is also activated and choose **Close**.

Remember: In order to run LIDAR Analyst you must have ESRI's Spatial Analyst Extension loaded.

LIDAR Analyst activates and the LIDAR Analyst toolbar opens.

Opening the LIDAR Analyst Toolbar

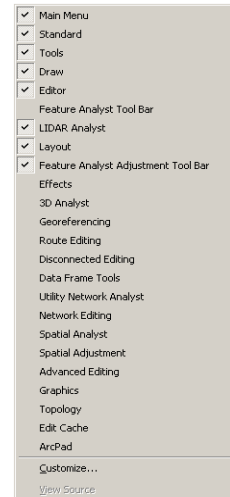
LIDAR Analyst has its own toolbar, allowing you to easily access the LIDAR Analyst features. If the toolbar does not activate automatically, you need to open it manually.

- 1 With the ArcMap open and LIDAR Analyst activated, right click on any toolbar.

The Toolbar popup menu appears.

- 2 Select **LIDAR Analyst** from the list of available toolbars on the popup menu.

The LIDAR Analyst toolbar opens in the application window. You can drag this toolbar anywhere in the work space or anchor it with other toolbars.



If the LIDAR Analyst toolbar does not appear on the list, choose Customize to open the Customize dialog box. Select the toolbar and choose Close to activate the toolbar.

The toolbar provides a menu plus quick tools. Click on LIDAR Analyst to open a drop menu of options for extracting each feature type. There are additional clean up tools available for working with bare earth layers. We'll discuss each tool as we walk through the extraction process.

AUTHORIZING LIDAR ANALYST

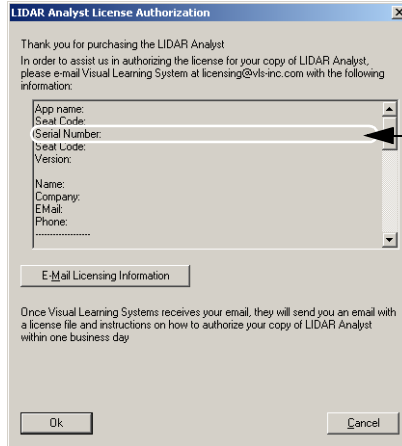
Note: If you are running LIDAR Analyst in Demo Mode, skip to "LIDAR Analyst Toolbar" on page 6. If you have an evaluation copy or have purchased LIDAR Analyst, you must complete this process to continue. You should have received a product key from VLS marketing.

- 1 Choose **LIDAR Analyst** on the LIDAR Analyst menu and select **Help Menu**.

- 2 Select **About** on the Help menu.

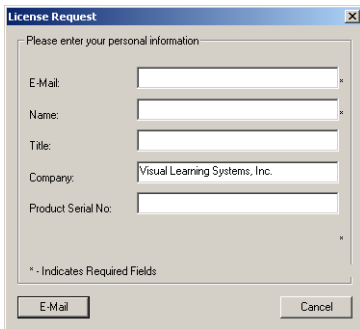
The LIDAR Analyst About dialog box opens.

- 3 Choose **Update** on the LIDAR Analyst About dialog box.



Serial Number field

The LIDAR Analyst License Authorization dialog box opens.



- 4 Place the cursor in the scrolled list box, next to the Serial Number heading.
- 5 Enter your **product serial number**. VLS provides this number. If you don't have one, contact our Sales Department at sales@vls-inc.com or (406)829-1384.
- 6 Choose **Submit License Request**.

The Submit License Request dialog box opens.

- 7 Enter your information in the fields provided. Some fields may auto-fill from your operating system.
- 8 Choose **E-mail**.

You return to the License Manager dialog box. A message box appears informing you that your email was sent successfully. Visual Learning Systems, Inc. will return a licensing file to you via email.

- 9 Save the license file you receive from VLS to your hard disk.
- 10 Return to the LIDAR Analyst About dialog box.



- 11 In the License Authorization box in the LIDAR Analyst About dialog box, choose the ellipses button.

The Set License Location dialog box opens.

- 12 Select the **Stand-alone option** and choose **Browse** to locate the file you saved to your hard drive.
- 13 Choose **OK**.

The system asks you to restart ArcMap.

- 14 Restart **ArcMap**.

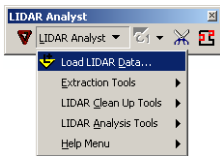
Now that you have authorized your LIDAR Analyst license you are ready to start working.

LIDAR ANALYST TOOLBAR

LIDAR Analyst provides you with a custom set of tools for working with your LIDAR models (DEMs) and intensity images in ArcGIS. In this section, we'll briefly describe each tool. Later, we'll show you how to use each tool during the extraction process.

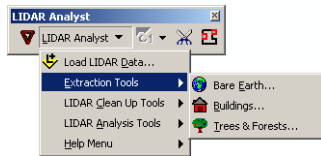
LIDAR Analyst Menu

The LIDAR Analyst menu provides you with five options for loading your LIDAR data, extracting data, cleaning up your result layers, and getting help.



LOAD LIDAR DATA

Choose this option to load your LIDAR DEMs and intensity images into a blank ArcMap project. LIDAR Analyst walks you through this process step-by-step. Follow the instructions on the dialog boxes to complete the loading.



EXTRACTION TOOLS

The Extraction Tools option opens to provide you with three additional extraction options for extracting specific data from your LIDAR DEMs.

Bare Earth

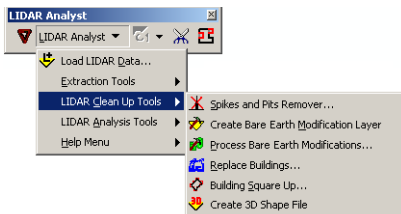
Choose Bare Earth to extract the bare earth data from your LIDAR data. The Bare Earth Extraction dialog box opens, allowing you to enter your bare earth extraction parameters. See page 14 for more information.

Buildings

Choose Buildings to extract buildings from your LIDAR data. The Buildings Extraction dialog box opens, allowing you to set your extraction parameters. See page 28 for more information.

Trees & Forests

Choose Trees & Forests to extract individual trees or forest stands from your LIDAR data. The Trees Extraction dialog box opens, allowing you to choose tree extraction or forest extraction and to set your extraction parameters. See page 32 for more information.



LIDAR CLEANUP TOOLS

The LIDAR Cleanup Tools menu provides five additional tools for cleaning up your result layers.

Spikes and Pits Remover

Choose Spikes and Pits Remover to remove anomalous pits and spikes from your bare earth results layer. The Spike and Pits Removal dialog box opens, allowing you to set the parameters for removing spikes and pits. See page 17 for more information.

Create Bare Earth Modification Layer

Choose Create Bare Earth Modification Layer to create a copy of your bare earth result layer. This allows you to manipulate the copy while keeping your original bare earth layer as a back up. See page 18 for more information.

Process Bare Earth Modifications

Choose Process Bare Earth Modifications to make changes to the modification layer you created with the previous option. Use the modification tools to mark up the newly created layer before running this process. See page 24 for more information.

Replace Buildings

Choose Replace Buildings to place the polygons from the building layer into your bare earth layer. This option provides for a cleaner layer and better views. See page 40 for more information.

Building Square Up

Choose Building Square Up to clean up your building result polygons. The Building Square Up dialog box opens, allowing you to enter your square up parameters. See page 40 for more information.

Create 3D Shape File

Choose Create 3D Shape File to generate a 3-dimensional view of your building layers. The Create 3D Shapes dialog box opens, allowing you to enter your parameters. In order to view 3D shapes, you must have ArcScene or ArcGlobe loaded on your computer. See page 41 for more information.

LIDAR ANALYST TOOLS

The LIDAR Analyst Tools option provides access to three process tools available in LIDAR Analyst.

Hillshade & Relief

Choose Hillshade & Relief to run the Hillshade process on the layer highlighted in the Table of Contents. See page 11 for more information.

Aspect

Choose Aspect to run the Compute Aspect tool. Aspect identifies the direction of the steepest downward pointing slope. See page 38 for more information.

Slope

Choose Slope to run the Compute Slope tool. Slope computes the maximum rate of change between a pixel and its neighbors. The value of slope ranges from 0 to 90 degrees. See page 38 for more information.

HELP MENU

The Help Menu options provides access to various extra LIDAR Analyst feature. This includes documentation and Online Help.

Launch Tutorial

Choose Launch Tutorial to open the LIDAR Analyst Tutorial manual which walks you through specific exercises to learn LIDAR Analyst.

Launch Reference Manual

Choose Launch Reference Manual to open the LIDAR Analyst Reference Manual. The reference manual explains all the features of the application with generalized instructions.

Help Menu

Choose Help Menu to open the LIDAR Analyst Online Help system. Like the reference manual, the online help system provides information on most features in the system with generalized instructions.

LIDAR Analyst About

Choose LIDAR Analyst About to open the LIDAR Analyst About dialog box. The About dialog box provides access to the LIDAR Analyst Licensing and Authorization options.

LIDAR Analyst Settings

Choose LIDAR Analyst Settings to open the Settings dialog box. This dialog box allows you to set parameters for your cache files.

LIDAR Analyst Toolbar

Along with the LIDAR Analyst menu, the LIDAR Analyst Toolbar includes several quick tools. These tools allow you to quickly get to the action you want to perform.

BARE EARTH MODIFICATION TOOL

Clicking on the Bare Earth Modification Tool opens the Bare Earth Modification toolbar. These tools become available when you create a bare earth modification layer.



Remove Bare Earth Tool

Use this tool to remove non-bare earth features that are not represented by the other modification tools.



Add Points to Bare Earth Tool

Use this tool to alter the bare earth layer to show greater detail in the slope or rise of the landscape. This tool allows you to fix areas where the original extraction pass overly smoothed the result layer. We recommend drawing small polygons to add points. This speeds up the modification extraction pass.



Remove Cars, Shrubs, and Other Low Height Objects Tool

Use this tool to remove cars, low vegetations, and other low height objects that were returned as bare earth.



Smoothing Tool

Use this tool to smooth ragged bare earth features.



Reassign Height Tool

Use this tool to reassign the height of objects or areas within the bare earth layer.



Raise/Lower Height Tool

Use this tool to raise or lower the height of an object or area within the bare earth layer.



Replace with Last Return DEM Tool

Use this tool to replace areas within the bare earth layer with areas from the original DEM.

CUT IMAGE TOOL



The Cut Image Tool allows you to cut all the your images down to only the portions that you want or need. See page 39 for more information.



POLYGON DELUXE RESHAPE TOOL

The Polygon Deluxe Reshape Tool allows you to quickly modify your result polygons. See page 47 for more information on using this tool.

GETTING STARTED

To get started you must open ArcMap. This document assumes that you have a working knowledge of your Arc application and are comfortable working in that environment. If not, see your ArcMap documentation.

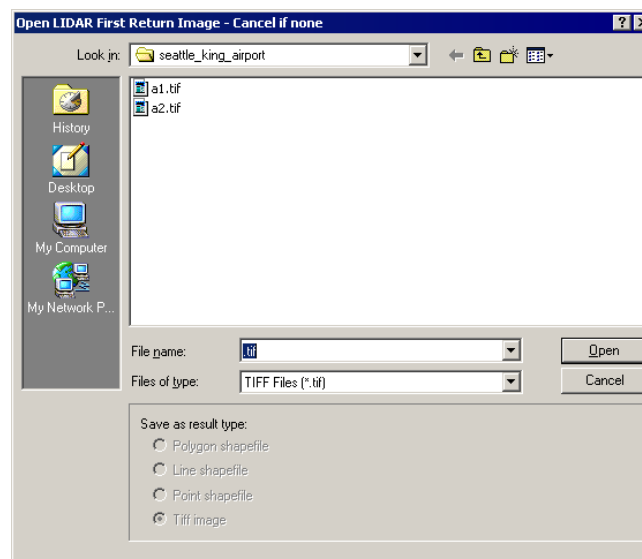
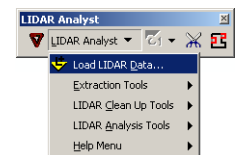
LOADING LIDAR DATA

The first step in your LIDAR feature extraction is loading the LIDAR data into your map document. LIDAR Analyst automates much of the loading process by walking you through hillshading for both first and last LIDAR returns.

Note: A floating-point number is a digital representation for a number in a certain subset of the rational numbers and is often used to approximate an arbitrary real number on a computer. In particular, it represents an integer or fixed-point number (the significand or, informally, the mantissa) multiplied by a base (usually 2 in computers) to some integer power (the exponent). When the base is 2, it is the binary analog of scientific notation (in base 10).

You can complete LIDAR extractions using only the last returns, however, LIDAR Analyst gives you the option to use both, if available. Using both returns delivers more accurate results. In order to run the application on both first and last returns at once, the spatial extents of each image must be the same. LIDAR Analyst only works with floating point data.

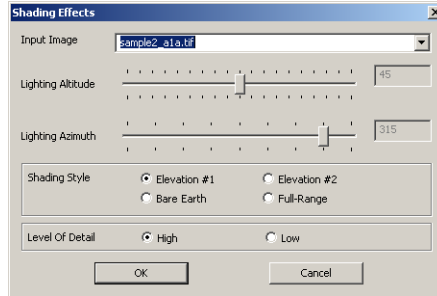
- 1 Start **ArcMap** and open a new blank project.
- 2 Choose **LIDAR Analyst** on the LIDAR Toolbar and select **Load LIDAR Data** on the drop menu.



The Open LIDAR First Return Image dialog box opens.

Notes: If you don't have a first return LIDAR Image or don't want to use one, choose Cancel. The system moves to the last return selection.

- 3 Select your first return LIDAR image from the list and choose **Open**.



The Shading Effects dialog box opens, allowing you to select hillshading options.

Applying Shading Effects

Note: If you don't want to add shading effects to the layer at this time, choose Cancel on the Shading Effects dialog box. The system takes you to the Last Return Selection dialog box.

- 1 In the Lighting Altitude field, accept the default or use the slider bar to enter a new value.

Altitude is the slope or angle of the illumination source above the horizon. The units are in degrees, from 0 (on the horizon) to 90 degrees (over-head). The default is 45 degrees.

- 2 In the Lighting Azimuth field, accept the default or use the slider bar to enter a new value.

Azimuth is the angular direction of the sun, measured from north in clockwise degrees from 0 to 360. An azimuth of 90 is east. The default is 225.

- 3 In the Shading Style box, select one of the following options.

OPTION	FUNCTION
Elevation #1	Uses 8 colors to develop an algorithmic color ramp to display the DEM.
Elevation #2	Uses 9 colors to develop an algorithmic color ramp to display the DEM.
Elevation 1 & 2 are best used to represent first and last return DEMs, respectively.	
Bare Earth	Uses 3 colors to represent bare earth. This option is best used to represent bare earth layers.
Full Range	Uses the full color spectrum. This option is used mainly for DEMs that have a large range of values.

Note: You may need to experiment with the various hillshading options to find the best view.

- 4 In the Level of Detail box, select **High** or **Low**. The default is High.
- 5 Choose **OK** to complete the process.

The LIDAR Analyst Save As dialog box opens, asking you to name the new feature layer that will appear in the Table of Contents. LIDAR Analyst suggests a name based on the name of the image and the process (in this case, Hillshading). You can accept the default or enter a new name.

- 6 Enter a **name and path** for the new layer and choose **Save**.

The first return layer appears in the Table of Contents and the Open LIDAR Last Return Image dialog box opens, asking you to identify your last return LIDAR image.

Selecting the Last Return Image

- 1 Select your **last return image** in the list box and choose **Open**.

The Shading Effects dialog box opens. This is the same dialog box that opened in the previous section. For detailed explanations of the Shading Effects options, see page 11.

- 2 In the Lighting Altitude field, accept the default or use the slider bar to enter a new value.
- 3 In the Lighting Azimuth field, accept the default or use the slider bar to enter a new value.
- 4 In the Shading Style box, select an option.
- 5 In the Level of Detail box, select **High** or **Low**. The default is High.
- 6 Choose **OK** to complete the process.

The LIDAR Analyst Save As dialog box opens, asking you to name the new feature layer that will appear in the Table of Contents.

- 7 Enter a **name and path** for the new layer and choose **Save**.

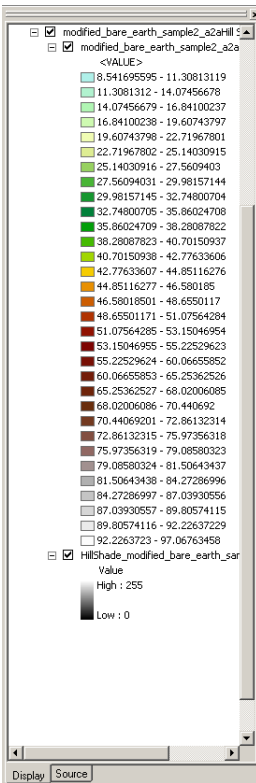
The last return layer appears in the Table of Contents and the Open LIDAR Intensity Image list box opens.

Selecting an Intensity Image

If you have an intensity image that you would like to include for LIDAR visualization, select it in this step. The intensity image loads as a black and white transparency. It is provided to assist you in viewing the scene, but provides no processing input.

- 1 In the Open LIDAR Intensity Image list box, select **your intensity image** from the list of available images.
- 2 Choose **Open**.

Note: If you don't have an intensity image or don't want to use one, choose Cancel. The list box closes and you return to the ArcMap workspace.



The LIDAR Analyst Save As dialog box opens, asking you to name the new layer.

- 3 Enter a **name and path** for the new layer and choose **Save**.

The Intensity Image appears in the Table of Contents along with your LIDAR returns.

LIDAR Analyst places the selected layers in the Table of Contents in the order you created them. If you applied hillshading effects to the loaded layers, each layer appears as a grouped layer with the original return plus the hillshading. The Table of Contents appears much like the image to the left. The hillshade layer underlays the return layer, showing the ground shading. This allows better visualization of the image objects, providing a pseudo 3D output.

With your LIDAR images loaded, you're now ready to start the extraction process. The first step is to extract the bare earth layer.

BARE EARTH EXTRACTION

The most important step in achieving optimal results with LIDAR Analyst relies on the integrity of the Bare Earth layer. A clean Bare Earth layer is essential for creating an accurate building and tree extraction because it is from this layer that LIDAR Analyst captures the points for buildings and trees and provides the basis for a coherent and clutter-free data set.

Bare Earth extraction removes ground clutter, such as trees, building, cars, and other above ground objects to get the digital elevation model (DEM) or bare earth to best represent the topography.

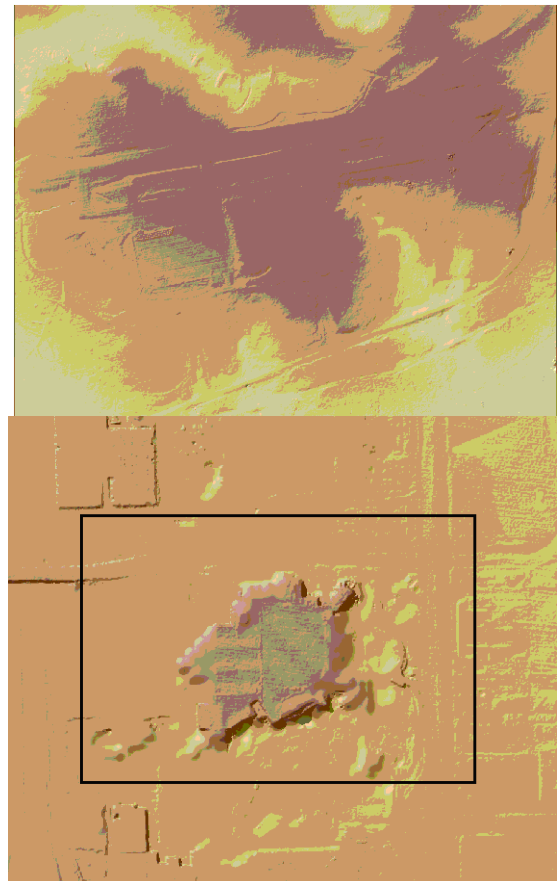
The Bare Earth Extraction tool has default settings designed to produce consistently good results on most datasets. The default settings incorporate additional steps such as applying hillshade, smoothing, cleaning of the last return DEM, and spike and pit removal to save processing time and generate clean results. All of these settings or modifications can be done independently after a bare earth extraction with no consequence to the initial results.

The Bare Earth Extraction dialog box provides two separate methods for completing the extraction. Which method to use is dependent on the type of data set you have. You can experiment with each setting and determine which is most suitable for your dataset. We recommend Method 2 if your imagery contains tall buildings or a high-density urban environment.

Once you complete your bare earth extraction it should appear to be relatively smooth and uniform with regards to topography and should have no cars or vegetation clearly visible. On the right is an example of a good bare earth extraction layer. Color shading indicates elevation changes.

Since there are no fool-proof criteria from which to rate a bare earth extraction, it is essential to examine the layer to look for raised features, such as trees, vegetation, cars, or buildings, that were returned as part of the bare earth. See example image below right.

If these features do appear in your bare earth layer, experi-



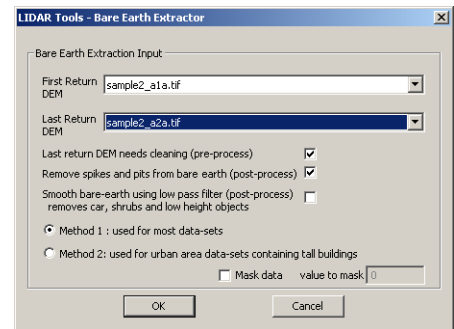
ment further with the bare earth extraction settings to acquire better results. Also, check the last return image for errors. Sometimes distortion from the original image can transfer to your bare earth extraction. This can be corrected later in the process.

LIDAR Analyst provides additional tools for modifying the bare earth layer after extraction. Use the extraction settings to get better initial results and use the modification tools to clean up any anomalies in those results. Follow the steps below to accomplish a basic bare earth extraction.

SETTING UP THE BARE EARTH EXTRACTION

- 1 Choose **LIDAR Analyst** on the LIDAR Analyst toolbar and select **Extraction Tools** on the drop menu.
- 2 On the Extraction Tools menu, select **Bare Earth**.

The Bare Earth Extractor dialog box opens, allowing you to enter your input information.



- 3 In the First Return DEM field, enter the **First Return LIDAR image**. Only images in the active data frame appear in the selection list. If you have no first return image, select None in this field.
- 4 In the Last Return DEM field, enter the **last return LIDAR image**. Again, only images in the active data frame appear in the list. Remember, you **MUST** have a last return image to complete a LIDAR extraction.
- 5 If desired, choose **Remove Spikes and Pits from Bare Earth**. You can run this as a separate operation later, if you want.

This option automatically runs the Spike and Pits Clean Up tool during the extraction process. The Spike and Pits Removal Tool removes anomalies caused by bad data. To view detailed information on the Spikes and Pits Clean Up Tool, see page 17.

- 6 If necessary, select **Mask Data**. Mask Data and Value to Mask field allow you to mask areas of the image using the spectral value.

Mask Data allows you to automatically cut out border areas around the image. This is especially helpful if a black band has been added to square up an awkward image.

- 7 Choose **OK**.

The LIDAR Analyst Save As dialog box opens, asking you to enter a name for the new layer that will be created from this process. LIDAR Analyst

Note: Bad data in LIDAR is normally caused when the laser returns after striking airborne objects such as birds and airplanes. Bad data can also occur due to the instruments being used for the capture and also during the interpolation of the DEM.

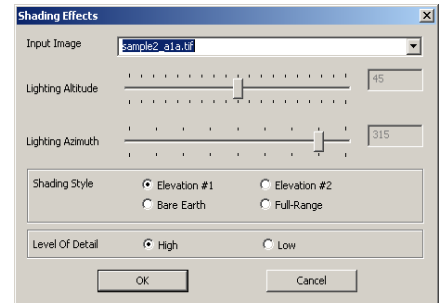
suggests a name based on the name of the image and the process (in this case, bare earth). You can accept the default or enter a name of your own.

- 8 Enter a **name and path** for the new layer and choose **Save**.

The LIDAR Analyst extraction process dialog box opens, displaying the progress of the extraction.

When the process is complete, the Shading Effects dialog box opens.

The Shading Effects dialog box allows you to enter shading effects to aid in visualizing the features in the bare earth layer. Shading Effects add shadows and texture to the output image.



Applying Shading Effects

This is the same Shading Effects dialog box that opened during the data loading process. For more information on the various options, see page 16.

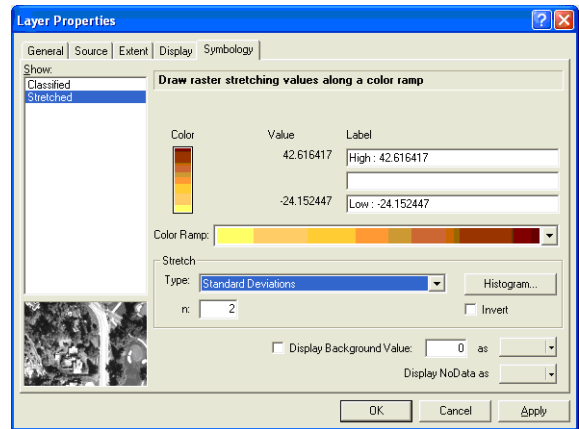
- 1 In the Input Image field, enter the **Bare Earth layer**. The bare earth layer should appear automatically. However, if not, select it in the field.
- 2 In the Lighting Altitude field, accept the default or use the slider bar to enter a new value.
- 3 In the Lighting Azimuth field, accept the default or use the slider bar to enter a new value.
- 4 In the Shading Style box, select an option. Since this is your bare earth layer, we recommend you select Bare Earth.
- 5 Select **High** or **Low** Level of Detail. The default is High.
- 6 Choose **OK** to complete the process.

LIDAR Analyst generates a bare earth hillshade layer and places it in the data frame with the base image(s) and the bare earth layer. The new layer is a grouped layer with the bare earth layer and the hillshade layers combined.

Optimizing the View

Once you have your results there are a few adjustments you can make to enhance the bare earth layer and the associated hillshade layer so features and details are more visible and potential errors more apparent.

- 1 Double click on the bare earth layer in the Table of Contents to open the Layer Properties dialog box.
- 2 Select the **Symbology** tab.
- 3 In the Color Ramp field, select a **more natural color** for the bare earth then select apply. Choose a brown/tan color scheme.



- 4 Next, select the **Display** tab and change the transparency percentage to 50%.
- 5 Choose **OK** to close the dialog box and apply the changes.

Your settings apply to the layer selected in the Table of Contents and displayed in the viewer. This should make the bare earth feature more visible.

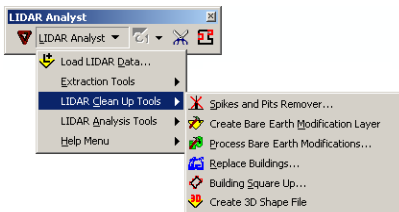
Cleaning Up Bare Earth Results

The next step in the LIDAR extraction is to clean up any anomalies or false positives in the bare earth layer. Once you have clean results, this layer will serve as a valuable tool in the remaining extractions.

LIDAR Analyst provides a series of clean up tools designed to quickly clean up your bare earth results. These tools can be found on the LIDAR Clean Up Tools menu.

- 1 Choose **LIDAR Analyst** on the toolbar.
- 2 Select **LIDAR Clean Up Tools** on the LIDAR Analyst menu.

The LIDAR Clean Up Menu opens, providing additional clean up tools for the bare earth layer.



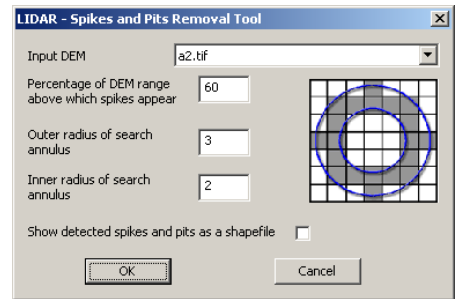
SPIKES AND PITS REMOVAL TOOL

The Spikes And Pits Removal Tool scans the input bare earth layer for sudden changes in height. If these changes are detected to be either a spike or a pit LIDAR Analyst removes them and replaces them with a value that represents the average height of the pixels' neighbors.

- 1 Choose **Spikes and Pits Removal Tool** on the menu.

The Spikes and Pits Removal Tool dialog box opens.

- 2 In the Input DEM field, enter the **Bare Earth layer**. Be sure to identify the color layer of the grouped bare earth layer.
- 3 In the Percentage of DEM range above which spikes appear field, enter the **maximum height of allowable spikes**. Anything over this height will be registered as a spike and altered.



This percentage represents the amount that a pixel's height has to differ from its neighbors to be classified as either a pit or a spike. The default value is 60.

- 4 In the Outer radius of search annulus field, enter the **number of pixels** making up the Outer radius of the annulus. All pixels that fall outside this radius, will be ignored in the calculation. See the diagram on the right side of the dialog box to visualize the Spikes and Pits Removal values.
- 5 In the Inner radius of search annulus field, enter the **number of pixels** making up the Inner radius of the annulus. All pixels that fall between the inner radius and outer radius, will be used in the calculation. Any pixels that fall inside the inner radius, will also be ignored in the calculation.
- 6 Choose **OK** to start the clean up process.

The LIDAR Analyst Save As dialog box opens, asking you to name the resulting layer.

- 7 Enter a **name and path** for the layer and choose **Save**.

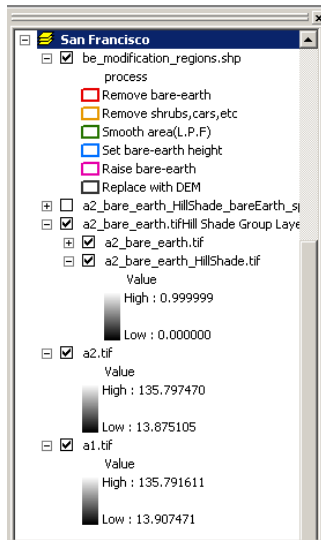
LIDAR Analyst returns the results of the clean up layer to the Table of Contents. The new bare earth layer appears in the ArcMap work space.

The next step in cleaning up the bare earth layer is to manually identify false positive objects in the bare earth layer. To facilitate this process, you need to create a modification layer.

CREATING A BARE EARTH MODIFICATION LAYER

Creating a bare earth modification layer allows you to run clutter removal on the bare earth layer you created in previous section while keeping a backup layer. You must identify each incorrect object in your result layer. Once the editing process is complete, the new, modified bare earth layer will overlay the original bare earth extraction and should be used as the input layer for building and tree extractions.

When you generate the modification layer, LIDAR Analyst automatically starts an editing session for you and the Modification tools activate.



Note: If you come back to your modification layer after closing the project or ending an editing session, you will need to restart the editing session to activate the Modification tools. Choose Editor on the ArcMap toolbar and select Start Editing from the drop menu.

- 1 On the LIDAR Clean Up Menu, choose **Create Bare Earth Modification Layer**.

The LIDAR Analyst Save As dialog box opens, allowing you to name the new layer.

- 2 Enter a **name and path** for the modification layer and choose **Save**.

LIDAR Analyst generates the modification layer and places it in the active data frame. Notice that the modification layer contains a list of objects that may be modified in the bare earth layer. These same items are represented by tools on the modification toolbar.

USING THE REMOVE BARE EARTH TOOL

Use this tool to remove non-bare earth features that are not specifically represented by the other modification tools. This might include parking lots that appear as bare earth.

- 1 Choose the **Modification tool** on the Bare Earth Modification toolbar.
- 2 Create polygons identifying objects that are not bare earth. Objects in this group appear with red lines.

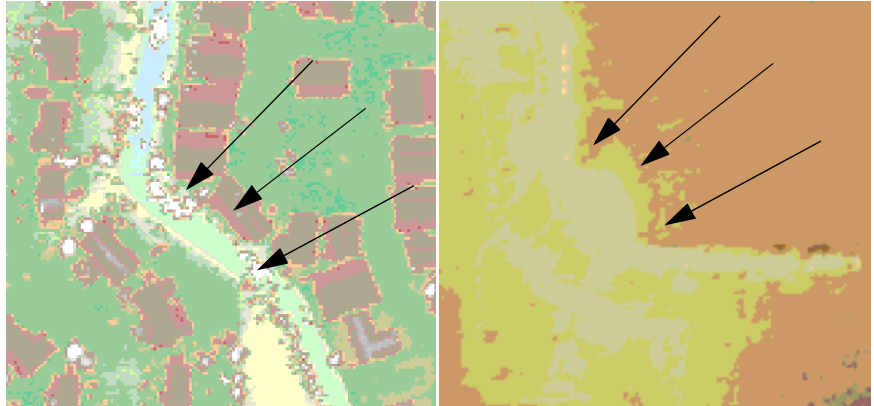


When you run the Process Bare Earth Modification feature the results should be similar to the above.

- 3 Once you have identified all non-bare earth objects, choose **Editor** on the ArcMap toolbar and select **Save Edits**.

USING THE ADD POINTS TO BARE EARTH TOOL

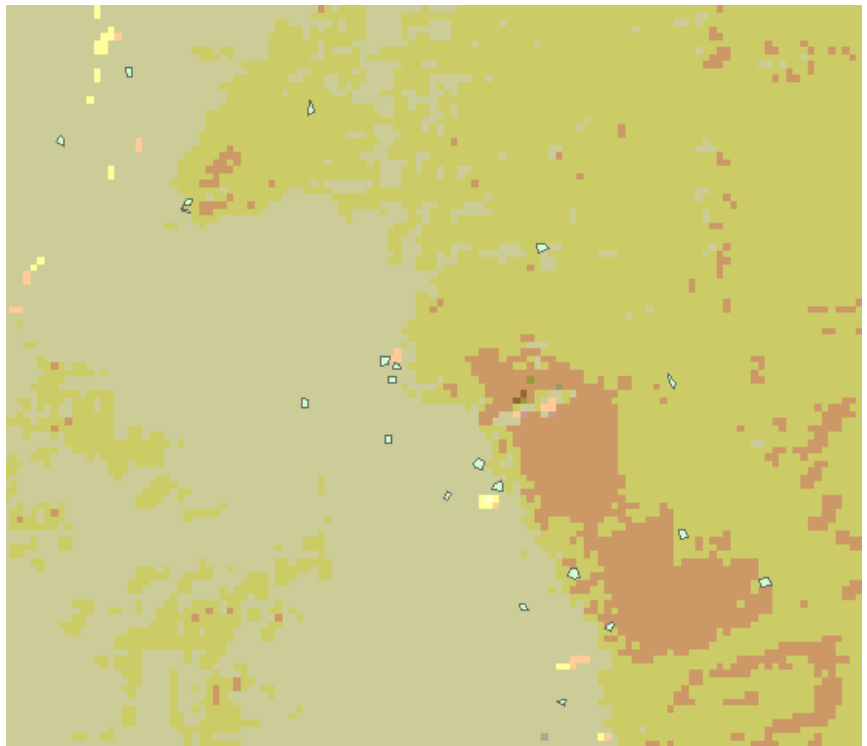
Use this tool to improve the slope on the bare earth layer where a cut bank or cliff feature is not accurately represented. It is important to examine the last return image to see if there are any buildings or other features that would cause the extraction pass to miss the edge of the drainage.



The arrows show where the buildings and vegetation have interfered with the LIDAR return results.



- 1 Choose the **Add Points to Bare Earth layer tool** on the Modification toolbar.
- 2 Create small polygons to correct the bare earth layer. Polygons in this group appear black. See image below.

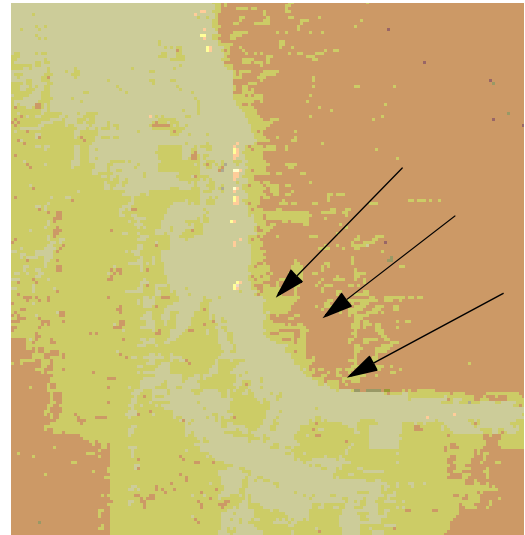


Tip: It is important not to draw polygons too close to buildings because the change in relief will cause a conflict between actual ground points and the new points.

Try to place points around the perimeter of the area being modified and in low points that are clearly visible to create an accurate representation the terrain.

- 3 Choose **Editor** on the ArcMap toolbar and select **Save Edits**.

Once you run the Process Bare Earth Modifications feature the results should look similar to this example. The bare earth is more uniform as it approaches the slope.



If the results are not satisfactory, compare the modification layer with the original bare earth layer and DEM to determine if additional points need to be added or if some of the points were too close to the buildings. This process may take several attempts to achieve optimal results and provide a better basis for your building and tree extractions.

Remember: If you exit while working on your modification layer, you will need to restart the editing session to activate the Modification tools. Choose Editor on the ArcMap toolbar and select Start Editing from the drop menu.

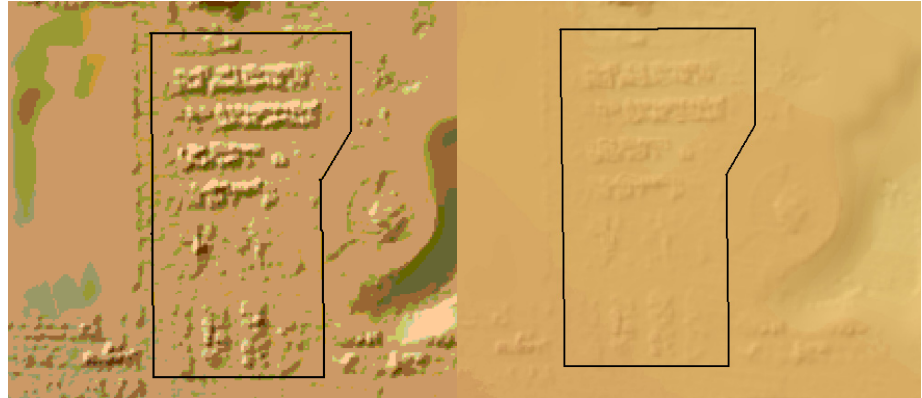


USING THE REMOVE CARS, SHRUBS, AND OTHER LOW HEIGHT OBJECTS TOOL

Use this tool to remove cars, low vegetation, and other low height objects that were returned as bare earth. This tool is useful for removing specific features rather than smoothing an entire area. However, smoothing can be a better option if the shrubs or vehicles are large and variable in size. The example illustrated here is a parking lot with several cars. The Hillshade Layer has been turned on to improve visibility.

- 1 Choose the **Remove Cars, Shrubs, and other Low Height Objects Tool** on the Modification toolbar.
- 2 Create polygons identifying cars, shrubs, and other low height objects. Polygons in this group appear with orange lines. In this example, draw a polygon around the entire parking lot to identify the items to remove.
- 3 Choose **Editor** on the ArcMap toolbar and select **Save Edits**.

Tip: Try using Remove Cars, Shrubs, etc., and Smoothing simultaneously to improve your results.



LIDAR Analyst smooths out the objects that were incorrectly identified as bare earth. Remember, hillshading was turned on for better visibility.

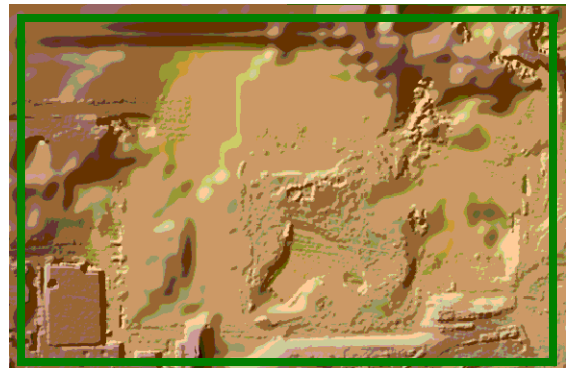
USING THE SMOOTHING TOOL

Use this tool to smooth ragged bare earth features. Smoothing is different from removing bare earth because it simply cleans up features that are part of the bare earth rather than removing unwanted or raised features.



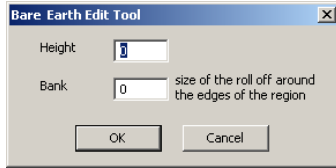
- 1 Choose the **Smoothing tool** on the Modification toolbar.
- 2 Draw polygons around bare earth areas that need to be smoothed. Lines in the this group appear green. See images on next page.
- 3 Once you have finished identifying areas to be smoothed, choose **Editor** on the ArcMap toolbar and select **Save Edits**.

When you run the Process Bare Earth Modification feature, the system returns results similar to the lower image shown above.



USING THE REASSIGN HEIGHT TOOL

Use this tool to reassign the height of objects or areas within the bare earth layer. This tool is especially useful if water features such as ponds and lakes created a depression in the bare earth results. One way to



identify inconsistencies is to compare the last return DEM with the original bare earth layer.

- 1 Choose the **Reassign Height** tool on the Modification toolbar.
- 2 Draw a polygon around an incorrect area and double-click the close the polygon. Polygons in this group appear with blue lines.

When you close the polygon, the Bare Earth Edit Tool dialog box opens.

- 3 In the Height field, enter the **height**, in map units, you want to adjust the area within the polygon.

In order to determine the height to set for the feature, use the Identify tool in ArcMap to sample different points around the area. Make note of the average height and then begin the modification procedure.

- 4 In the Bank field, enter the **size of the roll off around the edges** of the identified region. This entry indicates the amount of slope in the feature edge. The lower the number, the sharper the incline.
- 5 Choose **OK** to close the dialog box.
- 6 Once you have finished reassigning height, choose **Editor** on the ArcMap toolbar and select **Save Edits**.

When you run the Process Bare Earth Modification process, the system adjusts the height of the area included in the polygon.

USING THE RAISE/LOWER HEIGHT TOOL

Use this tool to raise or lower the height of an object or area within the bare earth layer. This works the same as the Reassign Height tool, allowing you to adjust the elevation of the area up or down.



- 1 Choose the **Raise/Lower Height** tool on the Modification toolbar.
- 2 Draw a polygon around the area you want to raise or lower and double-click to close the polygon.

When you close the polygon the Bare Earth Edit Tool dialog box opens, allowing you to set the height values. This is the same dialog box that opens with the Reassign Height tool.

- 3 In the Height field, enter the **height**, in map units, you want to adjust the area within the polygon. Polygons in this group appear with purple lines. You can enter a positive or negative number in this field.
- 4 In the Bank field, enter the **size of the roll off around the edges** of the identified region. This entry indicates the amount of slope in the feature edge. The lower the number, the sharper the incline.
- 5 Choose **OK** to close the dialog box.

- 6 Once you have finished raising/lowering the height of objects, choose **Editor** on the ArcMap toolbar and select **Save Edits**.

USING THE REPLACE WITH LAST RETURN DEM TOOL

Use this tool to replace areas within the bare earth layer with areas from the original DEM. This tool is useful mostly for visual purposes when you want to have certain features such as buildings and airplanes visible in the bare earth layer. Replacing with DEM simply allows features from the last return DEM to be visible on the bare earth layer.



- 1 Choose the **Replace with Last Return DEM tool** on the Modification toolbar.
- 2 Draw polygons around areas in the bare earth layer that you want to replace with areas in the DEM.
- 3 Once you have finished identifying areas, choose **Editor** on the ArcMap toolbar and select **Save Edits**.

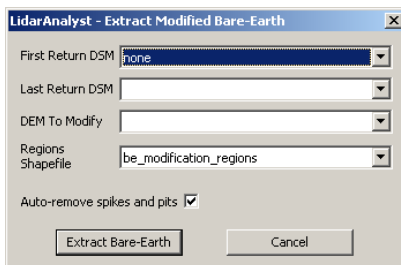
Completing the Modification Process

- 1 Once you finish identifying areas to modify, choose **LIDAR Clean Up Menu** on the LIDAR Analyst toolbar.
- 2 Select **Process Bare Earth Modification**.

A message box appears, asking you if you want to end your editing session and save the edits.

- 3 Choose **Yes**.

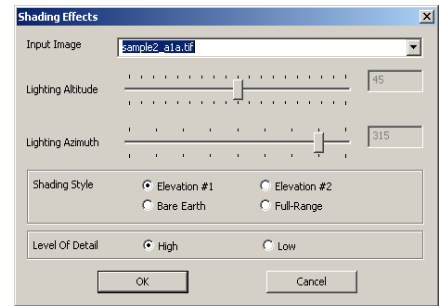
The Extract Modified Bare Earth dialog box opens.



- 4 In the First Return DEM field, enter the **first return LIDAR image**.
- 5 In the Last Return DEM field, enter the **last return LIDAR image**.
- 6 In the DEM to Modify field, enter the **name of the original bare earth layer**.
- 7 Confirm that the modification layer appears in the Regions Shapefile field.
- 8 If necessary, select the **Auto Remove Spikes and Pits** option.
- 9 Choose **Extract Bare Earth**.

The LIDAR Analyst processing dialog box opens, displaying the progress of the extraction process. When the process completes, the Shading Effects dialog box opens.

The Shading Effects dialog box allows you to enter shading effects to aid in visualizing the features in the bare earth layer. Shading Effects add shadows and texture to the output image. See page 16 for instructions on setting shading effects.



10 Enter your **shading effect settings** and choose **OK**.

LIDAR Analyst returns the modified hillshade layer to the active data layer. The changes you indicated using the modification tools appear in the new layer. Compare the modification layer with the Last Return LIDAR image to confirm that you have gotten the best results.

With your bare earth layer cleaned up, you're now ready to run the LIDAR Building extraction.

Tips for Bare Earth Extractions

There are a few tricks you might try when working with your bare earth extraction.

EXPERIMENT WITH PARAMETER SETTINGS

Use these different combinations of settings to determine which produces the best results.

- Use Method 1 with first and second return images
- Use Method 2 with first and second return images
- Use Method 1 with only the second return image
- Use Method 2 with only the second return

IF USING LARGE DATASETS

Since bare-earth extraction on large images can take a long time to process, it may be worthwhile to first cut a 1000 x 1000 pixel section of the image to experiment with the different settings before processing the whole image.

IF DATA IS OF INTEGER TYPE

Integer DEM's need to be scaled to work with LIDAR Analyst.

Procedure for converting into floating point type:

- MIN = min value occurring in input DEM
- MAX = max value occurring input DEM

- Scale the input DEM so that all the values lie between 0 - 1 using the formula: $\text{New value of DEM} = (\text{Old value of DEM} - \text{MIN}) / (\text{MAX} - \text{MIN})$
- Now multiply this new DEM by a constant 'C' so that the height of the buildings is at least 2.5 meters above the surrounding ground level.

IF DEM CONTAINS NULL VALUE:

If the DEM contains values that represent NoData, use the mask value option. To do this, use the “identify” tool in ArcMap or just use the low value number in the table of contents as the mask value. This will speed up the bare-earth extraction, as well as make it more robust.

COMBINE BARE EARTH MODIFICATION TOOLS

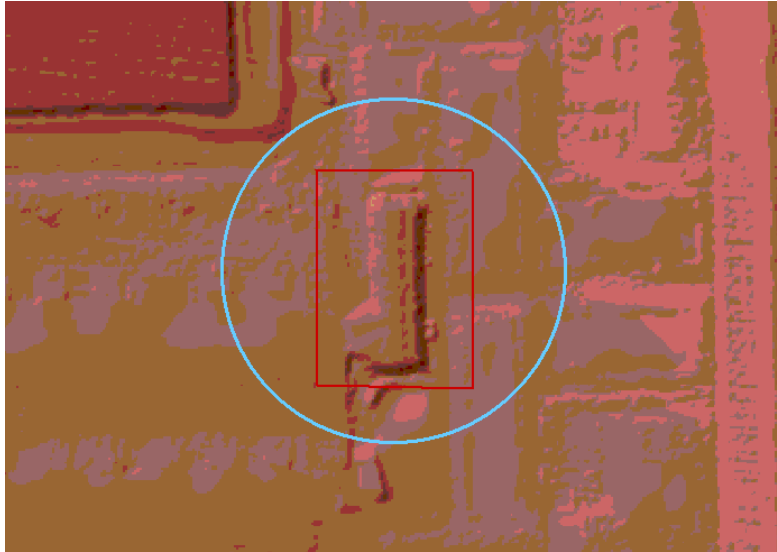
In the image below, some above ground objects were extracted as part of the bare-earth. To remove them use the steps shown below.



- 1 On the LIDAR Analyst tool bar, select the **Clean Up Tools** and then select **Create Bare-Earth Modification Layer**.

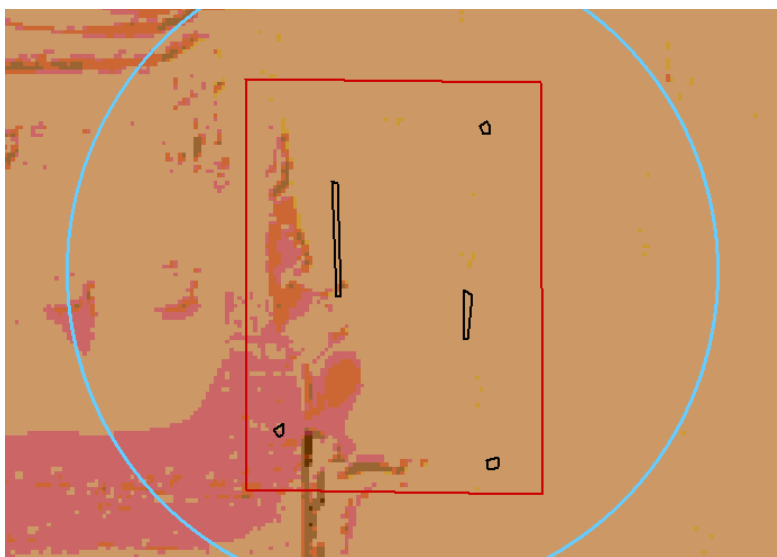
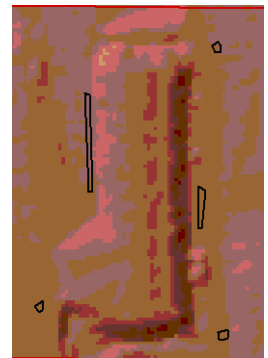
A vector file appears, allowing you to save your edit operations separately.

- 2 Mark the incorrect area using the remove bare-earth tool as closely as possible.



NOTE: Marking a large region for removal can lead to over-simplification of the bare-earth. To avoid this, add points that are on the ground for reference.

- 3 To add points use the **Add points to bare-earth tool** and draw small polygons on the around the feature that are on the ground. (These regions should be as small as possible because the bare-earth extractor uses all the pixels within the marked region for the extraction).
- 4 Run the bare-earth modification process. Choose **LIDAR Analyst Clean up tools** and select **Process Bare-Earth Modifications**.
- 5 Select the appropriate files and choose **Update bare-earth**.



The results should be similar to those in the image above.

BUILDING EXTRACTION

Once you have extracted your bare earth features, use the LIDAR Analyst to extract buildings. The building extraction tool includes default settings that are suitable for most data sets and typically produce excellent results. If the default settings do not produce satisfactory results, then there are a number of different parameter settings you can experiment with.

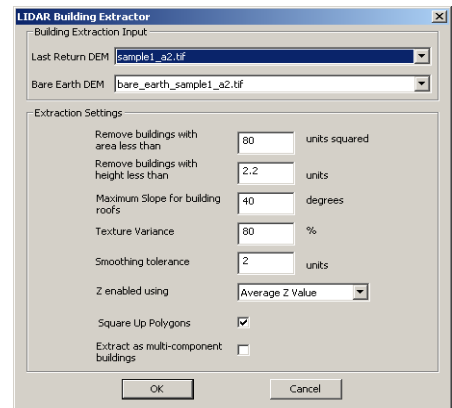
LIDAR Analyst automatically calculates an average elevation for each building rooftop, however, it is sometimes beneficial to have a 3-dimensional view of your buildings. The building extraction options allow you to set a Z-value for the polygon vertices, applying elevation values from the input DEM.

SETTING UP THE BUILDING EXTRACTION

- 1 Choose **LIDAR Analyst** on the LIDAR Analyst toolbar.
- 2 Select **Extraction Tools** on the drop menu.
- 3 Select **Buildings** on the Extraction tools menu.

The Buildings Extractor dialog box opens.

- 4 In the Last Return DEM field, enter the **last return LIDAR image**.
- 5 In the Bare Earth field, enter the **bare earth layer**. Be sure to select the Bare Earth layer and NOT the hillshade layer.



- 6 In the Extraction Settings box, set the following parameters:

OPTION	FUNCTION
Remove Buildings with area less than ___ sq. meters	Enter the minimum building size to extract in map units. Default setting is 80, indicating that the system will remove buildings less 80 square meters in size.
Remove Buildings with height less than ___ meters	Enter the minimum building height to extract in map units. The default setting is 2.2 meters, indicating that the system removes buildings lower than 2.2 meters in height.

* A high building slope value will return more of the building footprint, but the system may also pickup objects close to the building.

A lower building slope value will return less of the building footprint, but the system is less likely to pickup items adjacent to the building.

<p>Maximum Slope for building roofs ___ degrees*</p>	<p>Enter the maximum building roof slope to extract in degrees. The default is 40 degrees.</p> <p>The maximum slope for building roof values specifies the cut off for roof area. Above this maximum the slope is classified as a building edge. Once identified as a potential building region, further processing occurs to complete the building extraction.</p>
<p>Texture Variance</p>	<p>Use this option to allow LIDAR Analyst to use texture to differentiate between trees and buildings. The default is 80%.</p> <ul style="list-style-type: none"> • The higher the texture variance, the larger the number of buildings extracted, but also the more trees might be returned. • The lower the texture variance, fewer buildings will be extracted, but also the fewer trees will return.
<p>Smoothing Tolerance</p>	<p>Enter the number of pixels to move a vertex to smooth the line. The Smoothing default is 2.</p>
<p>Z Enabled using To view the outcome of these settings use the features in ESRI's Spatial Analyst.</p>	<p>Apply 3D visualization by choosing a Z-Value from the drop list. Options include:</p> <ul style="list-style-type: none"> • No Z-Value—Select this option if you do not want to apply z-values to your building polygons. • Actual Z-Values—Attaches actual z-values to each vertex. This may result in lopsided polygons, if the elevation varies greatly from vertex to vertex. • Average Z-Values—Takes the average of the pixel z-values underlying the polygon and attaches that value to each vertex. • Max Z-Value—Takes the maximum of the pixel z-values underlying the polygon and attaches that value to each vertex. • Standard Deviation—Takes the standard deviation z-value to each pixel underlying the polygon and attaches it to each vertex.
<p>Square Up Polygons</p>	<p>Check this option to apply LIDAR Analyst's Square Up Shapes algorithm to square the building polygons in the result layer automatically. This feature can also be run as a separate post processing function. The default is checked.</p>

Extract as multi-component buildings	Check this option to split roof tops into multiple sections, for example, a pitched roof would have two polygons separated by the roof's ridge line. A multi-level flat roof would appear as separate polygons for each level. The default is unchecked.
--------------------------------------	--

- 7 Choose **OK** to close the dialog box.

The LIDAR Analyst Save As dialog box opens, asking you to enter a name and path for the new layer that will be created from this action. LIDAR Analyst suggests a name based on the name of the LIDAR image and the action.

- 8 Enter a **name and path** for the new layer and choose **Save**.

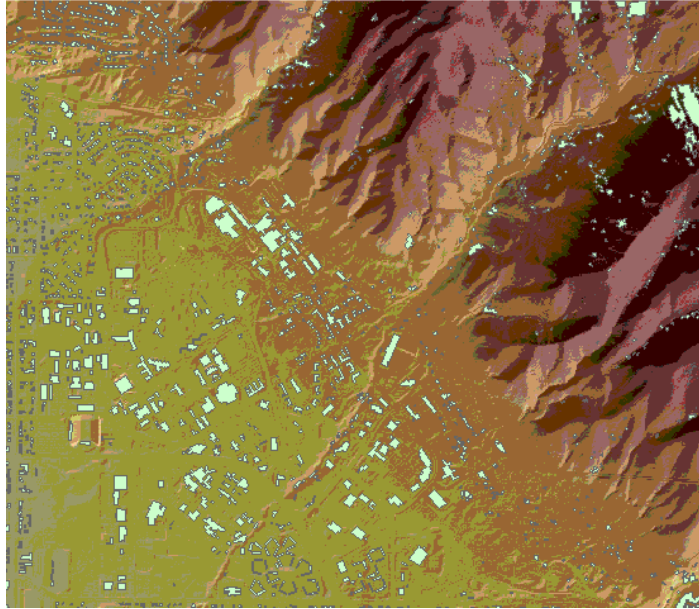
LIDAR Analyst returns the building extraction layer to the active data frame.

Once the building extraction is complete, check the results to see if any buildings were missed and if the building shapes closely match those in the last return DEM. Also look for misplaced buildings in areas where there is a significant change in elevation. Sometimes LIDAR Analyst can mistake elevation gain for building rooftops when using the default settings.

The following examples show an acceptable building extraction of downtown Seattle and an unacceptable extraction of Salt Lake City where variations in terrain created phantom buildings in the mountains and on ridge lines.



Seattle Building Extraction.



Salt Lake City Building Extraction.

Building Extraction Tips

- If the building extractions are unacceptable try setting all the parameters except *Maximum Slope for building roofs* to 0. Based on the results obtained, set the parameters to appropriate values and extract the buildings again. If this doesn't improve the results, try increasing the maximum slope.
- Use the DEM to view building results to find missed buildings and false positives.
- Set *Remove Buildings with area less than 80 sq. meters* to **20** and *Maximum Slope* to **60**.
- If buildings are squared up excessively, try reducing the *Smoothing Tolerance* parameter.
- If there is too much clutter, try resetting the *Slope* to **45** and the *Texture* to **65**.
- Building Extraction can be affected by large buildings, high gradient, and dense forest canopy. Bare-Earth Modification tools can be used to resolve most of these situations.
- If there are too few buildings then increase the slope by increments of **5**.
- If there are too many buildings then increase the texture by increments of **5**.
- When experimenting with the parameter settings, use the attribute table to check the number of results for each pass.

TREE EXTRACTION

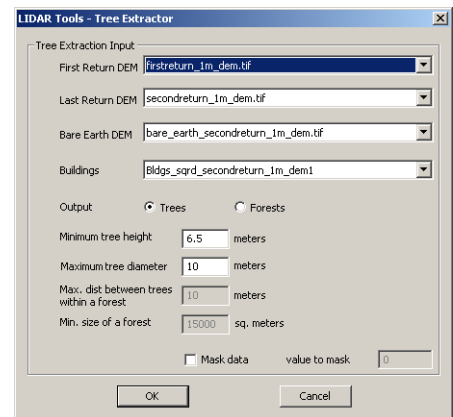
Now that you have extracted bare earth and buildings from your LIDAR image(s), the next step is extracting the trees or forests to complete the LIDAR extraction process.

SETTING UP THE TREE EXTRACTION

1 Choose **LIDAR Analyst** on the toolbar.

2 Select **Extraction Tool** on the menu and then select **Trees & Forests**.

The Tree Extractor dialog box opens.



3 In the First Return field, enter your **first return LIDAR image**. Remember, if you aren't using a first return image, enter None in this field.

4 In the Last Return field, enter your **last return LIDAR image**.

5 In the Bare Earth field, enter the **bare earth layer**.

6 In the Buildings field, enter the **buildings layer** generated in the previous exercise.

7 Choose one of the following output options:

- Trees - returns a point vector file showing individual trees.
- Forests - returns a polygon vector file showing trees grouped together in forests or stands.

8 In the Minimum Tree Height field, enter the **minimum tree height to extract**. LIDAR Analyst ignores any tree or vegetation below this height.

9 In the Maximum Tree Diameter field, enter the **maximum diameter of the trees** to extract. This feature allows you to ignore trees larger in diameter.

10 In the Max. dist between trees within a forest field, enter the **maximum distance** for LIDAR Analyst to calculate between the trees. This option is only available if you select the Forest output option.

Note: Selecting these two layers masks them in the tree extraction. LIDAR Analyst ignores them and concentrates on finding features not contained in either.

- 11 Min. size of a forest, enter the **minimum stand size** that LIDAR Analyst should extraction. This option is only available if you select the Forest output option.
- 12 If necessary, select **Mask Data**. Mask Data and Value to Mask fields allow you to mask areas of the image using their spectral value.

Mask Data allows you to automatically cut out border areas around the image. This is especially helpful if a black band has been added to square up an awkward image.

- 13 Choose **OK**.

The LIDAR Analyst Save As dialog box opens, asking you to enter a name for the new layer that will be created from this process. LIDAR Analyst suggests a name based on the name of the image and the process.

- 14 Enter a **name and path** for the new layer and choose **Save**.

The LIDAR Analyst extraction process dialog box opens, displaying the progress of the extraction. When the extraction completes, LIDAR Analyst places the new layer in the active data frame.

Tips for Tree and Forest Extractions

TREE EXTRACTION

- To extract more trees, experiment with increasing or decreasing the tree diameter setting and the tree height setting depending on the data set.
 - Smaller tree diameter works better in an urban forest setting.
 - Larger tree diameter works better in actual forested areas.
- Try setting both filter values at 0 and then slowly increasing them to get more or less trees.

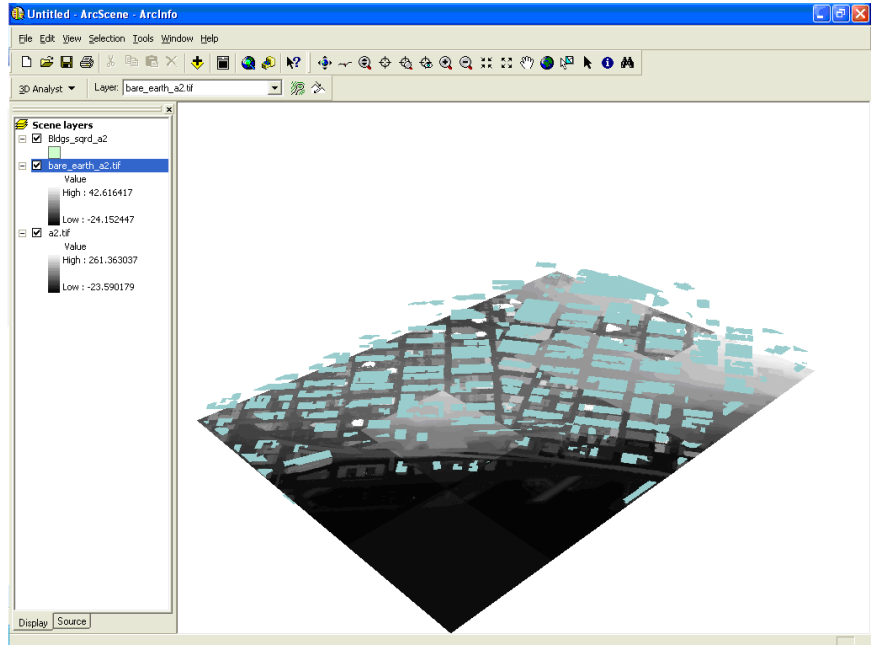
FOREST EXTRACTION

- Apply the same techniques above for extracting trees to optimize forest results.
- Try adjusting the minimum size of a forest by using the *Measure Distance tool* in ArcMap to determine the approximate size of the forest area.
- Again, try setting filter values to 0 and then slowly adjusting each to achieve the desired results.

USING ARCSCE

Once you have acquired your LIDAR results you may want to view those results using ESRI's ArcScene.

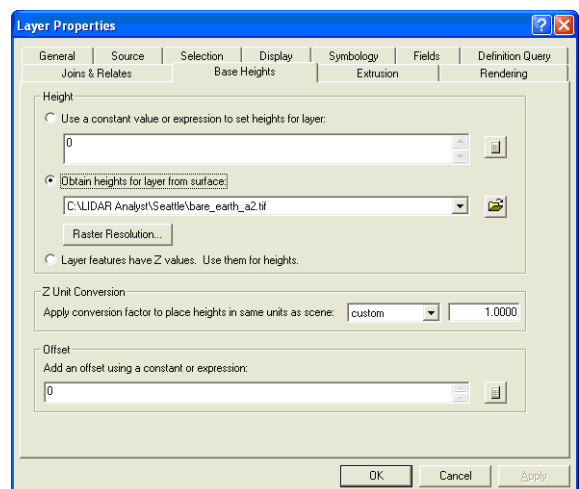
- 1 Open **ArcScene**.
- 2 Add the buildings, bare earth, and second return DEM to the view.



Your imagery should look similar to the example above.

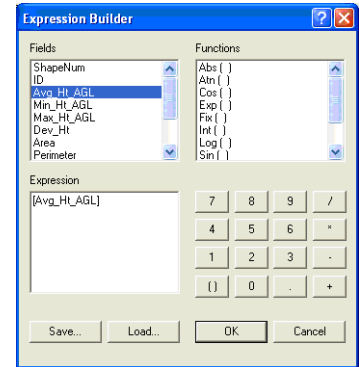
SETTING BUILDING OPTIONS

- 1 Double-click on the building layer.
The Layer Property dialog box opens.
- 2 Select the **base height tab**.
- 3 Select **Obtain heights for layer from surface**.
- 4 Select the **bare earth layer** in the drop down field.



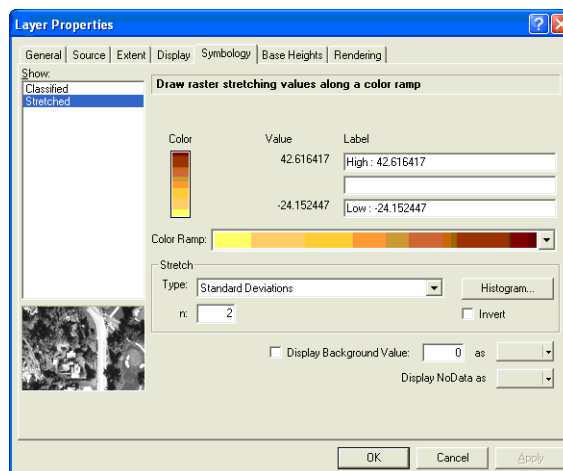


- 5 Select the **Extrusion** tab and check the **Extrude features in layer** box.
- 6 Click on the calculator on the right side of the expression list box to open the Expression Builder dialog box.
- 7 In the Field scrolled list box, select **Avg_Ht_AGL**.
- 8 Choose **OK** to close the Expression Builder.
- 9 Select the **Symbology** tab.
- 10 In the Show list box, select **Categories**.
- 11 Select **Unique Values** under Categories and then make sure that **ID** is selected in the Value Field.
- 12 Next, choose **Add All Values** and then choose **Apply**.
- 13 Choose **OK** to close the dialog box.

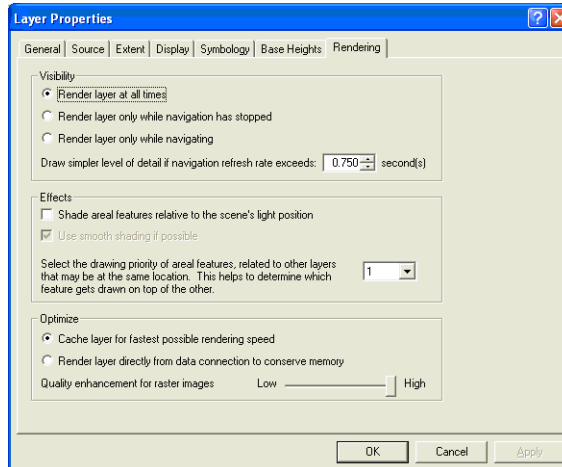


SETTING BARE EARTH OPTIONS

- 1 Double-click on the bare earth layer to open the Layer Property dialog box.
- 2 Select **Symbology**.
- 3 Change the color ramp to the color scheme shown below and select **OK**.



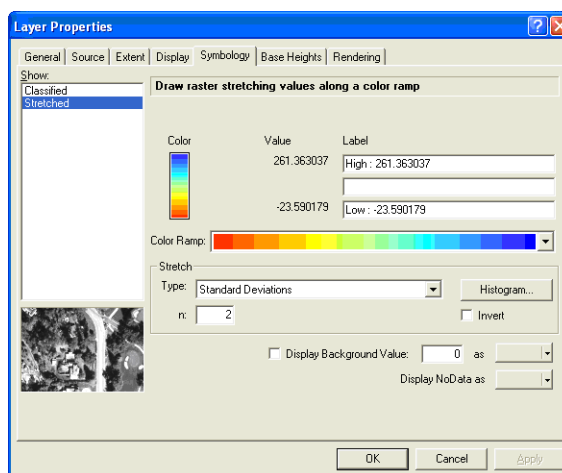
- 4 Next, select the **Rendering** tab and use the illustration below as a guideline for setting your parameters.



- 5 Choose **OK** to close the dialog box.

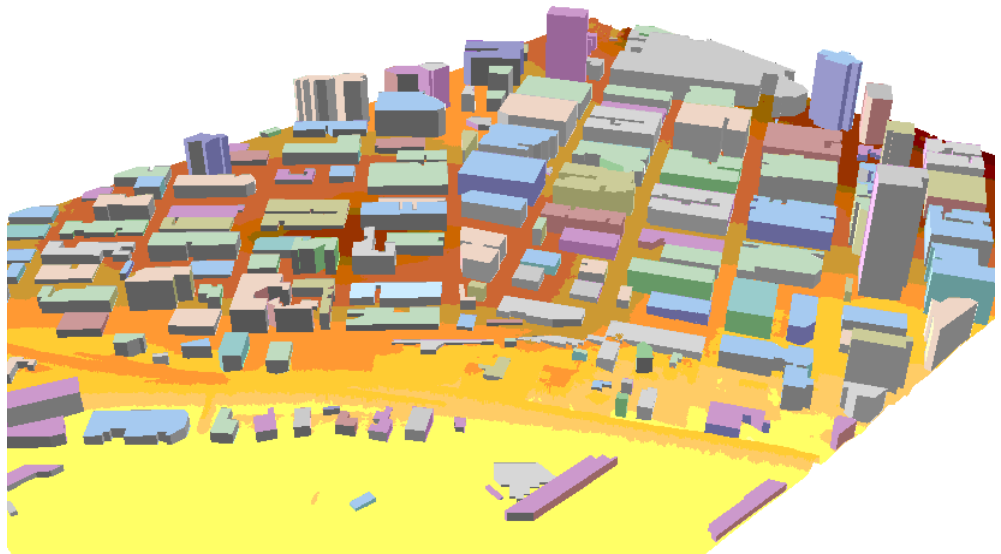
SETTING SECOND RETURN LAYER OPTIONS

- 1 Double-click on the **Second Return DEM** to open the Layer Properties dialog box.
- 2 On the Rendering tab, enter **10** in the Effects box.
- 3 In the Optimize box, set the Quality enhancement for raster images to **High**.
- 4 Select **Apply**.
- 5 Select the **Symbology** tab and adjust the color ramp to match the example below.



- 6 Select the **Base Heights** tab and check the **Obtain heights for layer from surface** option.
- 7 Enter **Second Return DEM** in the Obtain Height field.
- 8 Choose **OK** to close the dialog box.

Results should be similar to the example below. (Make sure second return is turned off.)



ADDITIONAL TOOLS

LIDAR Analyst toolbar includes the several additional tools, allowing you to modify or clean up your result layers.

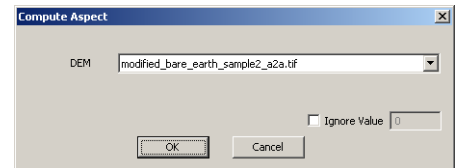
COMPUTE ASPECT

The Compute Aspect tool can be found on the LIDAR Analysis Tools menu. Aspect identifies the direction of the steepest downward pointing slope.

When used with LIDAR data, it shows the direction of a slope. The values range from 0 degrees (north) to 360 degrees (north) and 180 degrees representing south.

- 1 Choose **LIDAR Analyst** on the toolbar.
- 2 Select **LIDAR Analysis Tools** and then select **Aspect**.

The Compute Aspect dialog box opens.



- 3 In the DEM field, enter the DEM layer you want to run the calculations on.
- 4 If you want to exclude a value, check the Ignore Value option and enter a value in the field. This is the same as a masking value.
- 5 Choose **OK** to close the dialog box.

The Save As dialog box opens, asking you to name the new layer.

- 6 Enter a **name and path** and choose **Save**.

The process message box appears, displaying the progress of the extraction. When the process is complete the new layer appears in the Table of Contents.

COMPUTE SLOPE

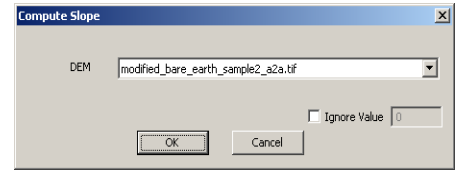
The Compute Slope tool can be found on the LIDAR Analysis Tools menu. Slope computes the maximum rate of change between a pixel and its neighbors. The value of slope ranges from 0 to 90 degrees.

When used with LIDAR data, it shows the gradient of the terrain. The lower the value of slope, the flatter the terrain and higher values of slope denote steeper terrains.

- 1 Choose **LIDAR Analyst** on the toolbar.
- 2 Select **LIDAR Analysis Tools** and then select **Slope**.

The Compute Slope dialog box opens.

- In the DEM field, enter the DEM layer you want to run the calculations on.
- If you want to exclude a value, check the Ignore Value option and enter a value in the field. This is the same as a masking value.
- Choose **OK** to close the dialog box.



The Save As dialog box opens, asking you to name the new layer.

- Enter a **name and path** and choose **Save**.

The process message box appears, displaying the progress of the extraction. When the process is complete the new layer appears in the Table of Contents.

CUT IMAGES

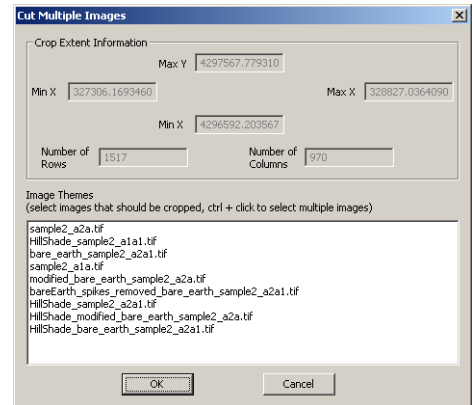
This tool allows you to cut your images. This is helpful when you are working with multiple images and you need to ensure that you are extracting from the same regions. Cut Image crops the images, getting rid of the portion outside the polygon you draw.



- Choose the **Cut Image tool** on the toolbar.
- Draw a rectangle around the area in the image(s) you want to keep for your feature extraction.

When you release the left mouse button, after drawing your rectangle, the Cut Multiple Images dialog box opens. The fields at the top of the dialog box display the extents that you drew in Step 2.

- In the list box, select the **images you want to cut**.



Tip: To select consecutive images, hold down the Shift key and click on the first and last image you want. To select random images, hold down the CTRL key and click on each image you want.

- Choose **OK**.

The LIDAR Analyst Save As dialog box opens for each image selected in the list box.

- Enter a **name and path** for each new image file and choose **Save**.

The new cropped image(s) appears in the Table of Contents in the active data frame with the original images.

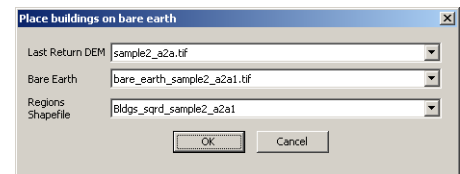
REPLACING BUILDINGS

Once you have extracted your buildings, you can use the DEM Clean up tools to replace the buildings into the bare earth layer. This makes for a cleaner result layer and better views.

- 1 Choose **LIDAR Analyst** on the toolbar and select **DEM Clean Up Menu** on the drop menu.

- 2 Select **Replace Buildings** on the Clean Up Menu.

The Replace Buildings dialog box opens, allowing you to select your last return, bare earth, and building layers.



- 3 In the Last Return DEM field, enter **your last return layer**.
- 4 In the Bare Earth field, enter **your bare earth layer**. Again, you want to select the color layer in the bare earth bare earth layer.
- 5 In the Regions Shapefile field, enter **your building layer**.
- 6 Choose **OK**.

The LIDAR Analyst Save As dialog box opens, asking you to name the new layer created from this action.

- 7 Enter **a name and path** in the File Name field and choose **Save**.

The process starts and the Shading Effects dialog box opens.

- 8 Verify that your new layer file name appears in the Input Image field.
- 9 Apply the shading effects parameters you want and choose **OK**. See page 16 for more information on setting shading effects parameters.

The Save As dialog box opens, asking you to enter a new filename.

- 10 Enter **the filename and path** and choose **Save**.

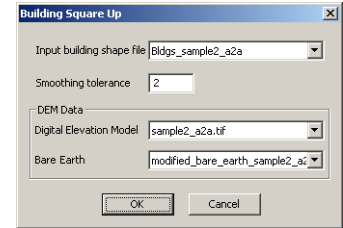
The process completes and the new layer appears in the Table of Contents.

SQUARE UP SHAPES

The Square Up Shapes tool allows you to straighten up the edges of polygons by squaring up the corners. This is helpful when you're extracting buildings or other essentially square objects.

- 1 Highlight the result layer in the Table of Contents and select **Square Up Shapes** on the LIDAR Clean Up tools menu.

The Square Up Shapes dialog box opens.



- 2 In the Input Building Shape File field, enter your building layer.
- 3 In the Smoothing Tolerance field, enter number of pixels to cull in order to square up the building polygons.
- 4 In the Digital Elevation Model field, enter **your DEM layer**.
- 5 In the Bare -earth field, enter **your bare earth layer**.

Note: Several of the fields in this dialog box will auto-fill. Simply confirm that the correct data appears.

- 6 Choose **OK**.

The Save As dialog box opens.

- 7 Enter **a name and path** for the new shape file and choose **Save**.

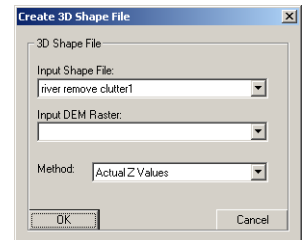
The system smooths the edges of the polygon shapes and displays the new layer in the Table of Contents.

CREATE 3D SHAPE FILES

LIDAR Analyst allows you to use elevation data to convert your result polygons to 3D shapes. This function allows you to get a clearer vision of what your actual features look like.

- 1 Highlight a building result layer in the Table of Contents and select **Create 3D Shape File** from the LIDAR Tools menu.

The 3D Tool dialog box opens. The Input Shape File field displays the shape file selected in the Table of Contents.



- 2 In the Input DEM Raster field, select the **elevation file** to use in assigning z-values.
- 3 In the Method field, select the method you want the system to use in calculating the 3D shapes:

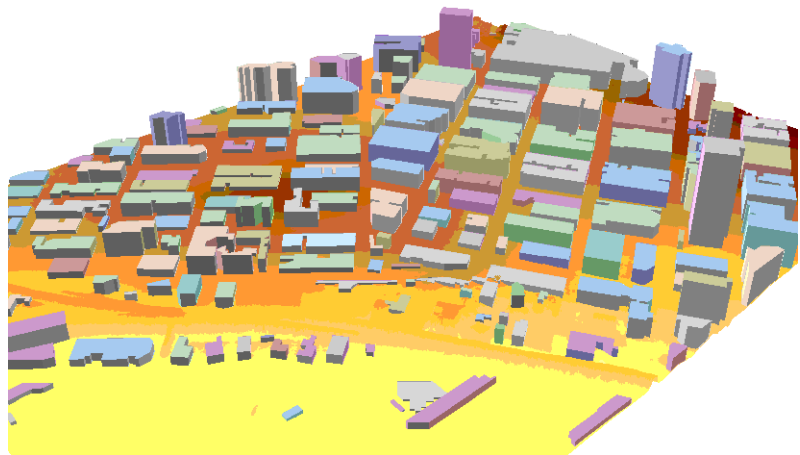
OPTION	FUNCTION
Actual Z-Values	Attaches actual z-values to each vertex. This may result in lopsided polygons, if the elevation varies greatly.

OPTION	FUNCTION
Average Z-Values	Takes the average of the pixel z-values underlying the polygon and attaches that value to each vertex.
Max Z-Value	Takes the maximum of the pixel z-values underlying the polygon and attaches that value to each vertex.
Standard Deviation Z-Value	Takes the standard deviation z-value to each pixel underlying the polygon and attaches it to each vertex.

- 4 Choose **OK** on the dialog box.

The LIDAR Analyst Save Feature As dialog box opens.

- 5 Enter a **name and path** for the new shape file and choose **Save**.



The new layer appears in the active data frame in the Table of Contents. If you were adding 3D shapes to a building extraction, your results might look like the image above.

LINE RESHAPE DELUXE TOOL

The Line Reshape Deluxe tool allows you to quickly and easily edit or clean up line features.

Selecting a Layer for Editing

- 1 Choose **Editor** on the ArcMap toolbar and select **Start Editing**.

Note: if you accidentally select a polygon shape file in the Target field, the Deluxe Line Reshape tool will not function.

- 2 In the Target field, select the **line shape file** you want to edit.

Setting Snapping Parameters

In order to use the Deluxe Line tool, you have to use the snapping functions. Snapping does exactly that; it snaps the tool to the closest vertex. When the tool is hovering over an existing vertex, the cursor appears to have a blue halo. Click and the system places the new vertex directly over the existing vertex. This makes it easy to exactly match the features.

- 1 Choose **Editor** on the ArcMap Editing toolbar and select **Snapping** on the menu.
- 2 In the top half of the Snapping Environment box, select **Vertex** and **End** for the appropriate layer. You must select both of these options for the tool to work correctly.
- 3 In the bottom half of the Snapping Environment box, select **Edit Sketch vertices** and **Edit Sketch edges**. You must also select both of these options for the tool to work correctly.

Now, you are ready to use the Deluxe Line Tool.

Using the Deluxe Line Tool

There are three methods for using the tool. Use the tool alone to draw line features, hold down the Shift key and use the tool to split lines, or hold down the CTRL key and use the tool to cut line features.

- Choose the **Deluxe Line tool** on the LIDAR Analyst toolbar.

In the tables that follow, we'll show you how to use the Deluxe Line Reshape tool.

DELUXE LINE TOOL WITH NO CONTROL KEY

ACTION/RESULT	
Creating a new line feature	
	<p>You can use the Deluxe Line Tool to draw a new line feature anywhere on the workspace. Simply, click and drag a stretchy line. Single click where you want to place a vertex and double-click to end the line.</p>
Extending a line feature	
	<p>To extend a line features, snap the cursor to the existing vertex (A) and click. Draw a line to the next vertex and double-click. The system automatically draws a new line, extending the existing line feature.</p>
Connecting line features	
	<p>To merge two line features, snap the cursor to the first existing vertex (A) and click. Next, snap the cursor to the second existing vertex (B), and double-click. The system adds a segment, connecting the two line features.</p>
Realigning a line feature	
	<p>To realign a line feature, snap the cursor to the first existing vertex (A) and click. Draw the stretchy line to the second vertex (B), and double-click. The system realigns the line feature with the line you drew.</p>

DELUXE LINE TOOL WITH SHIFT KEY

In this table, we'll show you how to use the Shift key with the Deluxe Line tool to split or link line features.

ACTION/RESULT	
Adding a segment to an existing line feature	
<p>The diagram illustrates the process of adding a segment to an existing line feature. The top part shows a black line with a red dashed line extending from its right end. The bottom part shows the result: a three-way intersection where the original black line is now joined to a new segment, and the intersection point is connected to three other segments colored orange, blue, and green.</p>	<p>To add a segment to a line feature, hold down the Shift key and click at the starting point of the new segment. This can be on an existing vertex or setting a new vertex. Draw the stretch line to the next point and double-click. The system creates a three-way intersection with the new line and the existing line feature.</p>
Connecting separate line features	
<p>The diagram illustrates the process of connecting separate line features. The top part shows two separate black line features. A red dashed line is drawn between vertex A on the first feature and vertex B on the second feature. The bottom part shows the result: a three-way intersection where the two original line features are now joined by a new segment, and the intersection point is connected to three other segments colored orange, blue, and green.</p>	<p>To connect separate line features, hold down the Shift key, snap the cursor to the first vertex (A), and click. Draw the stretch line to the next vertex (B), and double-click to end the line. The system draws a new segment between the existing line features, creating a three-way intersection between the line features.</p>

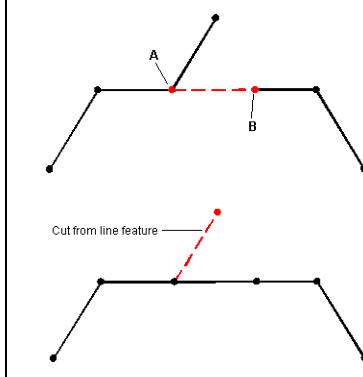
Another example of connection separate line features	
	<p>Holding down the Shift key, snap the cursor to the first vertex, and click. Draw the stretchy line to the next vertex, and double-click. The system creates a new connecting segment between the line features.</p>

DELUXE LINE TOOL WITH THE CTRL KEY

In this table, we'll show how to use the control key with the Deluxe Line tool to cut line features.

ACTION/RESULT	
Realigning a line feature	
	<p>The CTRL key used with the Deluxe Line tool provides you with another way to realign line features. Hold down the CTRL key, snap the cursor to the first vertex (A), and click. Continue holding down the CTRL key and draw the stretchy line to the next point. Double-click to set a new vertex (B) and end the new segment. The system creates a new segment and removes the end of the old segment.</p>
Connecting line features and cutting unnecessary segments	
	<p>The CTRL key used with the Deluxe Line tool provides you with another way to connect line features. Hold down the CTRL key; snap the cursor to the first vertex (A), and click. Continue holding down the CTRL key, snap the cursor to the next vertex (B), and double-click to end the segment. The system creates a new segment linking the line features and removes the loose ends of the old line features.</p>

Another example of connecting line features and cutting unnecessary segments



Hold down the CTRL key, snap the cursor to the first vertex (A), and click. Continue holding down the CTRL key, snap the cursor to the next vertex (B), and double-click to end the line. The system connects the existing line features with a new segment. The extra segment disappears from the line feature.

POLYGON RESHAPE DELUXE

Feature Analyst provides a deluxe Polygon Reshape tool that allows you to quickly and easily edit or clean up polygon features.

Selecting a Layer for Editing

- 1 Choose **Editor** on the ArcGIS toolbar and select **Start Editing**.
- 2 In the Target field, select the **polygon shape file** you want to edit.

Using the Deluxe Polygon Tool

There are three methods for using the tool. Use the tool alone to draw polygon features, hold down the Shift key and use the tool to extend features, or hold down the CTRL key and use the tool to fill holes in polygon features.

- Choose the **Deluxe Polygon tool** on the Feature Analyst toolbar.

In the tables that follow we will show you how to use the Deluxe Polygon Reshape tool.

Note: If you accidentally select a line shape file in the Target field, the Polygon Reshape tool will not function.

DELUXE POLYGON TOOL WITH NO CONTROL KEY

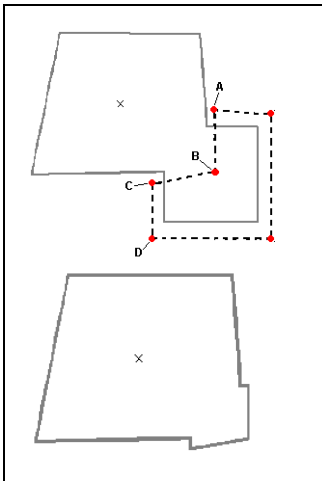
In this table, we'll show how to the Deluxe Polygon tool with no control keys to draw new polygon features or extend existing features.

ACTION/RESULT	
Extending a polygon feature	
	<p>To extend a polygon feature, click to set the first vertex of your extension. Draw the stretchy line and click to set the next vertex. Continue to place vertex until you have drawn the shape you want. Double-click to close the polygon. The system redraws the lines of the existing polygon to include the area OUTSIDE the boundary of the existing polygon feature.</p>
Merging polygon features	
	<p>For Feature Analyst to merge the polygons, the shape you draw must overlap the edges of both features you want to merge. To merge polygon features, click to set the first vertex (A). Draw the stretchy line and click to set the next vertex. Continue placing vertices until you have drawn the shape you want. Double-click to place the last vertex (D). The system merges the polygons</p>

DELUXE POLYGON TOOL WITH SHIFT KEY

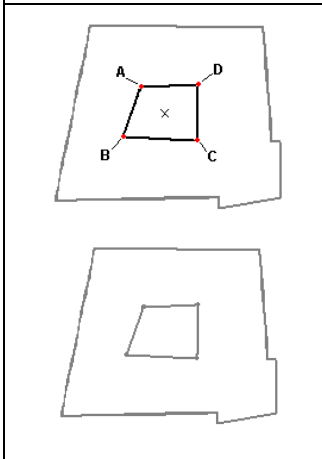
In this table, we'll show you how to use the Shift key with the Deluxe Polygon tool to trim polygon features.

ACTION/RESULT
Trimming Polygon Features



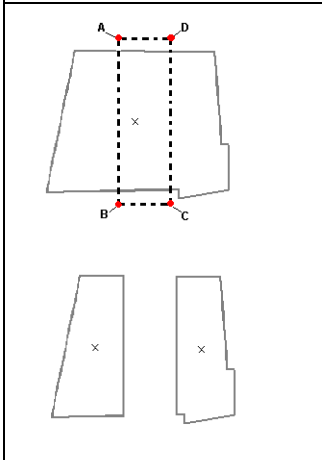
To trim an existing polygon feature, hold down the Shift key and click to place the first vertex (A). Continue holding down the Shift key and continue to place remaining vertices (B, C, D, & E). Double-click to place the last vertex (F) and close the polygon. The system cuts the area inside the polygon you drew and closes the existing feature.

Cutting holes in polygons



To cut a hole in an existing polygon, hold down the Shift key and click to place the first vertex (A). Continue holding down the Shift key and continue placing remaining vertices (B & C). Double-click to place the last vertex (D) and close the polygon. The system cuts a hole in the existing polygon.

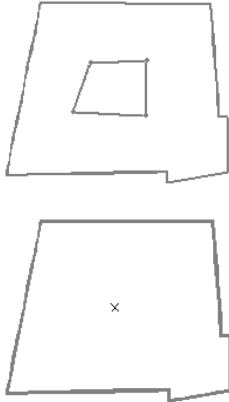
Cutting a polygon into multiple polygons



Holding down the Shift key, click to place the first vertex (A). Continue holding down the Shift key and place the remaining vertices (B, C & D). Double-click on D to close the polygon. The system cuts the existing polygon, creating two polygons with the remaining vertices.

DELUXE POLYGON TOOL WITH THE CTRL KEY

In this table, we'll show how to use the CTRL key with the Deluxe Polygon tool to fill holes in polygon features. If you have holes in your polygons, the CTRL + Deluxe Polygon tool allows you to close the holes with one click.

ACTION/RESULT	
Closing holes in Polygons	
	<p>To close holes in polygons, simply hold down the CTRL key click inside the polygon in which you want to close holes. The system closes all holes in the selected polygon with one click.</p>

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