Assessing Clearcutting Activities

—by Glen Jordan

Instructor notes

This lesson will show your students how they can leverage GIS forest analysis know-how, including reclassifying and characterizing, to assess clearcut harvesting from economic, ecological, and aesthetic perspectives. It's assumed that students have at least intermediate ArcGIS® skills and are knowledgeable of forestry terminology and data.

In the *Lesson background* and *Methods background* sections that follow, you'll find details on clearcut harvesting, as well as reclassifying and characterizing. You can use this material when introducing your students to the lesson before they tackle the lab exercises. The material in these two background sections will not expose your students to new ArcGIS functionality. In fact, the examples provided should be quite familiar. The purpose of this background material is to establish the conceptual context for the lesson. The *Geoprocessing background* material, on the other hand, may well introduce new ArcGIS functionality.

The lesson's three lab exercises are detailed in the *Lab exercises* section that follows. Labs are structured to engage students with the background material in realistic fashion. If this is your students' first lesson in the Forestry series, you can also use the examples in the background material to introduce the Woodlot inventory.

Lesson background

Harvesting of forest timber for manufacture of lumber, pulp, paper, chemicals, fuel, and a variety of other products is big business in many countries of the world. Harvesting methods vary greatly, but clearcutting is prevalent. More information can be found at the **Wikipedia** website.

Clearcutting involves felling, delimbing, and removing all trees from a site by mechanical or other means. The result is obvious—a once forested area, sometimes upwards of 100 hectares (ha), stripped of all trees. For some individuals, clearcutting is a practice that should be outlawed; for others, it's a necessary evil, and for still others, an acceptable practice. Who's right?

It depends, since there is both right and wrong in clearcutting.

Because clearcuts are so common and obvious, their size is something that can cause an immediate negative reaction. From a human aesthetic perspective, of course, small is beautiful. However, from an economic perspective, large is beautiful, as it's much more costly to operate across several small clearcuts as opposed to one large one. Likewise, from an ecological perspective, small is not necessarily good either. It spells fragmentation of conditions and is not desirable; rather, a mixture of sizes from small through large is important for ecological well-being in a forest.

Desirability of any activity, forestry or otherwise, depends on the effects it produces. Clearcutting can be bad or good, depending on the outcome and your value perspective—economic, ecological, or aesthetic.

It's important that your students know the differences between *economic*, *ecological,* and *aesthetic* clearcutting effects before attempting to assess clearcuts using GIS.

Economic

Harvesting trees is a huge business in many countries, often contributing billions of dollars annually to the economy. The 1:5,000 aerial photo below is typical of what you might see flying at low altitude over many of the forested regions in the northern hemisphere. Some recent clearcuts, outlined in red, and older clearcuts with regeneration appearing are evident.

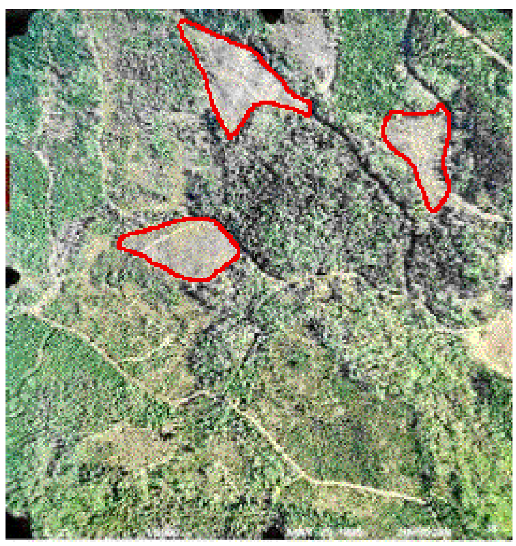


Figure 1. A 1:5,000 Air Photo Showing Recent Clearcuts Outlined in Red

From an economic perspective, clearcutting usually makes good sense.

For one thing, on many sites, it's more productive to remove all trees as opposed to selected ones, as would be the case in a partial cut.

For another, many tree species thrive in even-aged communities following a clearcut, since over the millennia they've adapted to disturbances, like fire, that remove all (or most) trees from an area at one time. These species will not regenerate effectively in the shade of an existing stand of trees.

As well, trees that regenerate following a clearcut are young, fast growing, and very productive, unlike the old trees removed. That means they are accumulating cubic meters of wood and storing carbon faster than the old trees they replace.

And last, clearcuts can be planted with seedlings that produce faster-growing and superior-quality trees in conditions where the species selection and density (seedlings per hectare) can be optimized.

The stand data stored in GIS forest inventories allows foresters to assess the clearcutting economies of stands and schedule their harvests accordingly.

Ecological

Over the past 30 years, many governments have placed constraints on clearcutting activities in public forests. At issue is clearcut size. Constraints typically restrict initial clearcut sizes to some minimum and, further, forbid enlarging the opening for several years. The latter allows regenerating trees to reach a size, typically 2 meters (m) in height, sufficient to provide cover for animals and is termed harvest "adjacency delay," or simply "green up."

The 15,000 ha forest in northwestern North America mapped below illustrates the effects of opening size constraints applied over several decades. The forest is now composed of mostly small stands, whereas originally larger stands, a legacy of wildfires and other natural disturbances, would have dominated. This transformation of large stands into smaller stands occurred gradually, as the large originals were harvested piecemeal with small clearcut openings.

Figure 2. A Fragmented Pacific Northwest Forest

Harvest opening size constraints are intended to limit ecological, as well as visual, or aesthetic, impacts. Undoubtedly, they do limit visual impact, but forest ecologists warn of a negative ecological consequence.

Again, look at the forest mapped above. Today, it's fragmented into many small stands. The largest is less than 200 ha. In this forest, animals once served by large old-growth stands are likely much reduced in number and replaced by those adapted to smaller stands.

With GIS, foresters can assess harvest opening size distributions over time and avoid fragmenting their forests by adjusting clearcut sizes.

Aesthetic

The image below was taken from a roadside looking over a recent clearcut in northeastern North America. It's not a pretty sight. For this reason, it's not uncommon to leave a strip of standing trees about 30 m wide where clearcuts would otherwise abut well-traveled roads.

Figure 3. A Clearcut in the US Atlantic Northeast

In mountainous regions, hiding clearcuts is more challenging. There, attempts are sometimes made to avoid clearcuts where they'd be visible from any point along roads or navigable rivers.

Hiding clearcuts from public view has no ecological value. Mostly, its value is aesthetic, although it may have some economic value where forest-oriented tourism is promoted.

In any case, GIS helps foresters control and monitor harvest visibility as they schedule clearcuts in forests over time.

All in all, the clearcuts issue is not so clear cut.

Methods background

As with forest analysis generally, assessing economic, ecological, and aesthetic clearcutting outcomes involves characterizing a forest in some fashion. What's not so obvious is that, more often than not, effectively doing so requires some reclassifying of forest features.

Your students need to know about *characterizing* and *reclassifying* in forest analysis and applicable GIS techniques.

Characterizing forests

There are three ways to characterize forests: single numbers, numerical distributions, and geographical distributions (maps).

In a forest's timber volume, for example, you can calculate a single number—its total volume, or so-called growing stock, as an amount expressed in cubic meters. On the other hand, you could characterize the forest's volume in more detail with a numerical distribution, for example, the distribution of volume by broad stand type. Finally, you could characterize the geographic distribution of the forest's volume with a map, for example, a map of stand volume by volume classes.

Single Numbers

These are by far the easiest to calculate, limited only by the array of attributes stored in the forest inventory. Here's an example:

Explore

Explore

To characterize a forest by its growing stock amount—a single number—you would simply sum individual stand volumes.

In ArcMap, add the *cover* feature class.

Using Definition Query, limit cover to just the 533 stands (AGE <> -99).

Open the attributes table and calculate statistics on the *Total Volume* field.

You'll see that the Woodlot's total growing stock is 91,273.3 m^3, with an average stand volume yield of 171.2 m^3/ha.

A single number, like a forest's growing stock, is quantitative. A single number, however, lacks detail. The growing stock amount tells you nothing about how the timber volume is distributed. Perhaps most of it occurs in low-yield stands? Perhaps most occurs in hardwood stands? Perhaps most occurs in habitat conservation areas? You don't know. If knowing these things is important, then calculating the single number isn't enough, and you need a *numerical distribution*.

Numerical Distributions

Calculating a numerical distribution, such as growing stock by broad stand type, would require that the inventory have some sort of stand type attribute, as well as stand volume amounts, or that you first group stands into a number of classes by species composition or some other inventory attribute.

Explore

The Woodlot inventory doesn't have a stand type attribute, but it does include a cover type attribute (TYPE field in cover). You can use it as a proxy in calculating a numerical distribution of growing stock.

With ArcMap started and the cover feature class added, open the Summary Statistics tool in ArcToolbox.

In the dialog box, set Input table as cover, Output table as the default, Statistic Field as TV, Statistic Type as SUM, and Case field as TYPE.

With this summary table, you can see how the Woodlot's growing stock (m^3) is distributed across six different cover types. Not surprisingly, most is concentrated in the untreated forested areas.

But here too, some questions remain unanswered. Where are these cover types located? Where are the forested areas, the planted softwood, and so forth? Where do the larger, or smaller, amounts of volume occur? Maps, of course, provide insight into these sorts of questions.

Maps

Mapping a forest's growing stock distribution would also require that you first group stands into classes, in this case, volume classes. As illustrated below, you might organize the classes, from least volume to most, by grouping stands according to their volume content in cubic meters: 0–100, 100–400, 400–800, 800–1,800, 1,800–4,300.

Explore

With ArcMap started and the *cover* feature class added, map the *Total Volume* field with a graduated color scheme across five manually defined volume classes, as follows:

Symbol	Range	Label
	0.000000 - 100.000000	100
	100.000001 - 400.000000	400
	400.000001 - 800.000000	800
	800.000001 - 1800.000000	1800
	1800.000001 - 4300.000000	4300

This produces a map that provides a picture of the spatial distribution of growing stock, making it easy to see where concentrations are located.

Bear in mind, however, that maps are not quantitative, even though they may present quantitative data, like growing stock in this example. In this case, the map certainly gives you an idea where low- through high-volume stands are located, but you can't tell exactly how much of each there is.

Remember, a picture may be worth a thousand words, but numbers speak louder than pictures.

Reclassifying forests

Analyzing and characterizing forests, whether by map, numerical distribution, or single number, often involve first *reclassifying* their features aspatially or spatially. For example, an existing stand age attribute would allow you to repackage a forest's stands into broad seral stages—regenerating, immature, mature, and old. Or, stands could be repackaged spatially by removing boundaries between those sharing some attribute value—crown closure, for example.

Reclassifying is used to exclude certain data values, replace old values with new, assign preference or priority, or simplify.

How does GIS help?

Reclassifying is always a two-stage process of first selecting features based on their thematic or locational attributes, then assigning them new attribute values that *label* (nominal), *rank* (ordinal), or *quantify* (ratio).

Thematic attribute filtering selects forest features solely on the basis of attribute values. Locational attribute filtering, on the other hand, selects features on the basis of their size, shape, and geographic position relative to other features (i.e., spatial relationships, including nearness, containment, and overlap).

So, how do you use *thematic* and *locational* attributes of features to *label*, *rank*, and *quantify*?

Reclassify—Labeling

Any existing nominal, ordinal, or ratio attribute(s) may be used, but the new attribute is always nominal.

Explore

Explore

Reclassify all Woodlot cover type features as either wet or dry land. Wet land would be those polygons with a *TYPE* value of BG, PD, or DU. All others would be dry land. In this reclassification, you'll use the thematic attributes of features.

In ArcMap, add the *cover* feature class as a layer.

Add a new text field (length 3) in *cover* called "LandClass."

Using Select By Attributes, select water features with TYPE = 'BG' or TYPE = 'DU' or TYPE = 'PD'.

Using Field Calculator, assign LandClass = "Wet".

Switch the selection and calculate LandClass = "Dry".

Clear the selection.

At this point, you could summarize the *LandClass* field into a single number, a numerical distribution, or a map.

Reclassify—Ranking

Reclassifying features by ranking (ordinal) may use any existing nominal, ordinal, or ratio attribute(s), but the new attribute is always ordinal.

Explore

Explore

Reclassify Woodlot stands (AGE<> -99) according to the road class that they are near or intersected by: 1—Within 15 meters of a main road, 2—Intersected by a secondary road, and 3—Inaccessible. Here, you'll use locational attributes to complete the reclassification.

In ArcMap, add the *cover* feature class as a layer.

Add a short integer field, "AccessClass."

Using Definition Query, limit the *Cover Types* layer to just stands (AGE <> -99).

Using Select By Location, select all stands that are within 15 m of main road centerlines (*clines* feature class).

Calculate *AccessClass* = 1.

Using Select By Location again, select all stands that are intersected by one or more secondary roads (*roads* feature class) and calculate *AccessClass* = 2.

Using Select By Attributes, select for *AccessClass* Is Null and calculate *AccessClass* = 3.

Clear the selection.

If you summarized the *AccessClass* field by the TV field, you could get an idea of how stand volume amounts are distributed across (1) most accessible, (2) adequately accessible, and (3) inaccessible stands.

Reclassify—Quantifying

Reclassifying features by quantifying (ratio) may use any existing nominal, ordinal, or ratio attribute(s), but the new attribute is always ratio, calculated using ratio attribute values.

Explore

Reclassify each Woodlot stand (AGE <> -99) according to its percentage of spruce and balsam fir pulpwood.

In ArcMap, add the *cover* feature class as a layer.

Join the *volumes* table to the *cover* attributes table via the *STAND_ID* and *Stand#* fields, respectively.

Using Definition Query, limit *cover* to stands that have volume yield present (VH > 0). (This prevents division by zero later.)

Add a float field, "SpBF_Pulp."

Using Field Calculator, calculate SpBF_Pulp = ([S_P] + [BF_P]) / VH * 100.

How would you now show the numerical or geographic distribution of this new attribute?

Those are some reclassifying possibilities and how you can use them to characterize a forest with a single number, numerical distribution, or map.

But there's more. You can reclassify spatially.

As you've seen in a previous example, reclassifying features spatially involves their repackaging on the basis of spatial relationships (locational attributes). But reclassifying spatially may also involve the redrawing of features on the basis of their attributes. Here the possibilities include *dissolving* boundaries between features, *buffering* features to fixed or variable widths, and *overlaying* features.

Spatially—Dissolve

Creating new, larger features by combining adjacent polygon or line features that share a common attribute(s) is common practice in forest analysis. One example follows:

Explore

Reclassify Woodlot cover types spatially by merging stands (AGE <> -99) that share common crown closure values.

In ArcMap, add the *cover* feature class as a layer.

Using Definition Query, limit c*over* to just stands (AGE <> -99).

In ArcToolbox, use the Dissolve tool to remove boundaries where adjacent stands share common *CC* values without creating multipart features. Name the output "CC_Patches."

If you examine *CC_Patches*, it's apparent that many adjacent stands share a common crown closure in the Woodlot. As a result, you see many larger polygons when you redraw stands from this crown closure perspective.

Spatially—Buffer

Buffering redraws polygon or line features by expanding their boundaries to fixed or variable distances.

Explore

In ArcMap, define riparian zones of 50 m around Woodlot streams.

Add the *streams* feature class as a layer.

In ArcToolbox, use the Buffer tool to buffer *streams* features to a fixed distance of 50 m. Set Dissolve Type to *ALL*. Name the output "Riparian."

If you examine *Riparian*, it's apparent that buffering has created polygons by expanding the boundaries of streams by 50 m on either side.

Spatially—Overlay

In addition to dissolving and buffering, forest features may be reclassified spatially using two classic map overlay procedures—intersect and union.

An overlay uses overlaps (intersections) between features in two or more maps to create new features with the combined attributes of their parent features. While an intersect overlay retains only the area common to the inputs, a union retains the combined area of the inputs.

The following examples illustrate how intersect overlay is used to reclassify spatially:

Explore

In the Woodlot, on what soil types do you find the highest-yield (volume) conditions? You'll need to first label Woodlot stands by their soil type.

In ArcMap, add the *cover* feature class and the *s4551* and *s4552* shapefiles, located in the *Shapes* folder, as layers.

Using the Merge tool in ArcToolbox, merge the two soil types layers in a single feature class "soils."

Using Definition Query, limit *cover* to high-yield stands with VH >= 180.

Using the Intersect tool, overlay *cover* and *soils*. Make sure the result is directed to a geodatabase; otherwise, feature areas will be incorrect.

This forms new polygons where stands are intersected by soils polygons. These new stand polygons are classified by soil type.

Open the result attributes table and sort the SOILS field in ascending order.

It should be apparent that a majority of the Woodlot's high-yield conditions occur on HT (Harcourt) or RE (Reece) soil types. How much area is there in each case, though?

In the open attributes table, manually select HT records or use Select By Attributes with SOILS = 'HT'.

Right-click *Shape_Area* and select Statistics. That will indicate 19 ha.

Repeat the process for RE records. You will find 15 ha.

But overlay is not limited to polygon-on-polygon overlays. Polygon-on-line is also a possibility. That allows you to spatially reclassify linear features.

Explore

Explore

Forest road density (amount/hectare) becomes an ecological concern where densities are high. What's the situation in the Woodlot? Do you have particularly problematic management compartments? In this case, you'll need to label roads by management compartment.

In ArcMap, add the *compart*, *clines*, and *roads* feature classes as layers.

Using the Merge tool in ArcToolbox, merge the *clines* and *roads* layers to create a single road network.

Using the Intersect tool, overlay *compart* and the road network. Make sure the result is directed to a geodatabase; otherwise, feature lengths will be incorrect.

Open the result attributes table.

It should be apparent that road features have been cut into new segments where intersected by compartment boundaries and have their enclosing compartment number attached (*Compart_ID* field).

This information allows you to examine the length of roads in each compartment.

For example, using Select By Attributes, select all road segments in management compartment 4 (*Compart_ID* = 4).

Right-click *Shape_Length* and select Statistics. That will indicate a total length of roads of 8.7 kilometers.

If you divide that by the compartment's area (*Shape_Area* in the *Management Compartments* layer), you'll find that road density is 0.05 km/ha, or 5 km/100 ha. That doesn't seem like a lot.

Geoprocessing background

This lesson involves geoprocessing procedures that your students may need some instruction in before proceeding with the lab exercises. These include delineating watersheds and calculating viewsheds.

Delineating watersheds

A watershed is an area of land, ranging from small to large, that drains to a common location—a small stream, a pond or lake, a river, or even an ocean. Watershed boundaries are defined by high points of land called divides. The Continental Divide is one such boundary, separating areas on the North American continent where water flows east from those where it flows west. Most often, however, you deal with watersheds for much smaller areas.

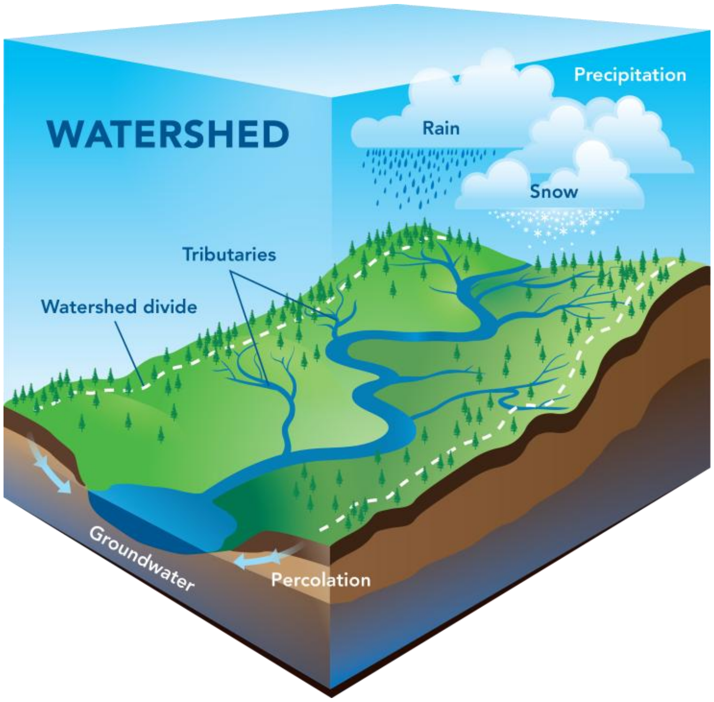


Figure 4. Elements of a Watershed

Regardless, it should be apparent that topographic relief in a geographic area is the main factor in determining watershed boundaries and the flow of water within.

Delineating watersheds, however, is a fairly complex, multistep process that uses a digital elevation model (DEM) to eliminate topographic sinks, calculate flow accumulation and direction, identify stream locations, and delineate watershed boundaries.

Fortunately, Esri has developed a Watershed Delineation tool that automates the watershed delineation process. This tool can be downloaded at Esri's support **website**.

When run, the tool prompts for a number of inputs and outputs as indicated in the following figure:

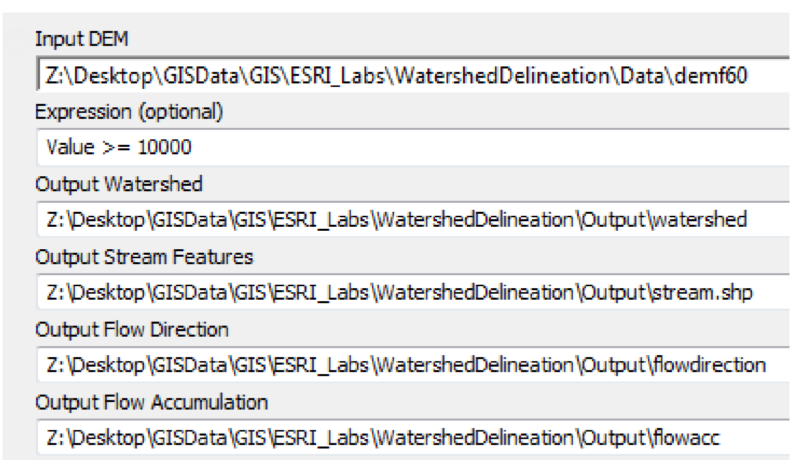


Figure 5. Water Delineation Tool Parameters

The only parameter that's a bit mysterious is `Expression`. It specifies the number of cells that represents a threshold value for identifying streams. A cell will only be considered a stream if the number of cells flowing into it reaches the threshold. Depending on the DEM cell size, the threshold can be equated with an area value.

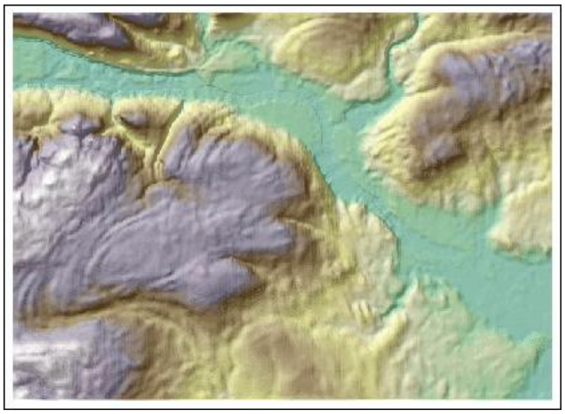
Explore

Explore

In ArcMap, add the *DEM_IDW* raster.

Symbolize the *DEM_IDW* raster using the *Elevation #2* color scheme with a transparency setting of 45%.

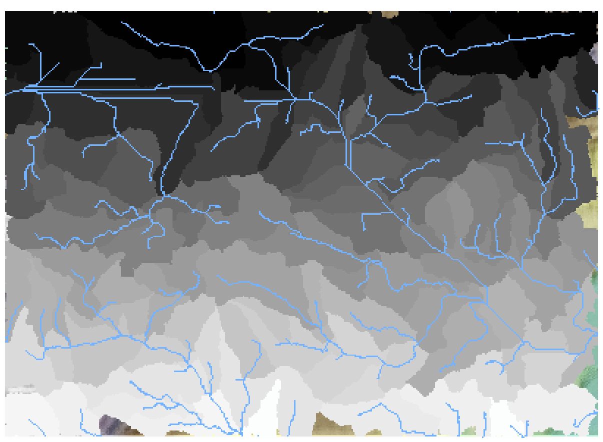
Add the *HillShade* raster and reposition it beneath *DEM_IDW*.



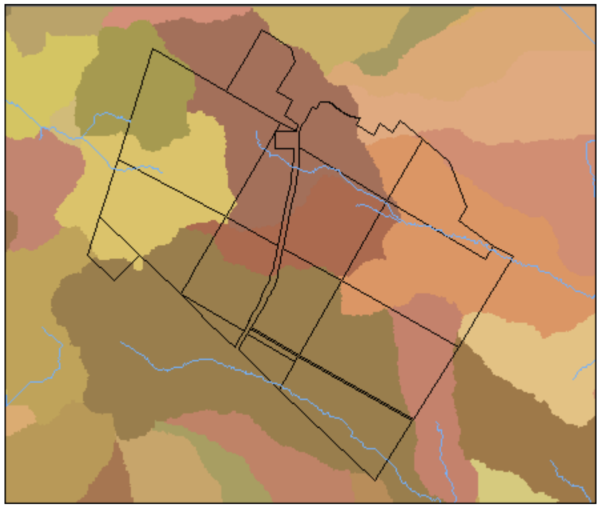
While in many locations, it's obvious where water flow will concentrate, it would be very challenging to draw out a complete network of streams and associated watershed divides. The Watershed Delineation tool makes easy work of that.

Run the *Watershed Delineation* tool with parameters set as above in figure 5 but with *DEM_IDW* as the *Input DEM* value.

If you close *flowdirection* and *flowacc*, you can see that 187 watersheds have been delineated, one for each stream segment identified.



Add the Woodlot's management compartments feature class (*compart*), fill its polygons with a hollow fill, zoom to the layer, then symbolize watersheds with `Discrete Color`.



That maps the Woodlot's three principal streams and their associated watersheds.

Calculating viewsheds

A viewshed is the area visible from one or more observer locations in a geographic area, considering observer height, elevation relief, and vegetation height or other structures that might obscure lines of sight. The observer locations may be point or line features.

Explore

Explore

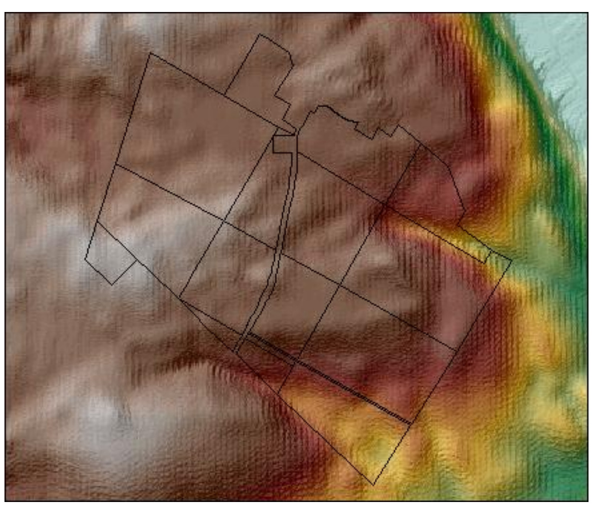
In ArcMap, add the *DEM_IDW* raster.

Symbolize the *DEM_IDW* raster using the *Elevation #1* color scheme with a transparency setting of 45%.

Add the *HillShade* raster and reposition it beneath *DEM_IDW*.

Add the Woodlot management compartments feature class (*compart*) and fill its polygons with a hollow fill, then zoom to the layer.

It would appear that the Woodlot is not an area, for the most part, with large elevation differences.

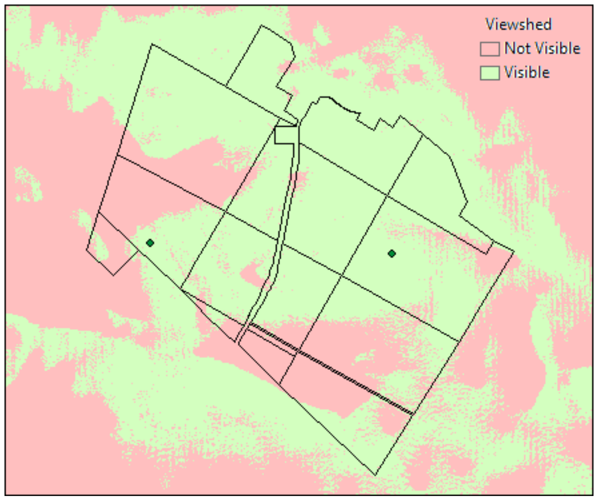


Add the *towers* feature class.

If you open the *Old Fire Towers* attributes table, you'll find two towers listed, each with recorded heights of 20 m (OFFSETA).

How much of the Woodlot and surrounding area could have been seen from one or the other, or both, of these old towers?

Using the *Viewshed* tool (*Spatial Analyst Tools > Surface*), compute the towers' viewshed, with *DEM_IDW* as `Input Raster`, and *Old Fire Towers* as `Input Observer Features`.



That indicates that there were some visibility gaps (pink) when surveying the Woodlot and surrounding area from these two towers.

Open the viewshed attributes table.

OBJECTID *	Value	Count
1	0	212783
2	1	839403
3	2	928522

This gives you the breakdown of not visible (0) and visible by one (1) or both (2) towers. Since the rasters have 10 m by 10 m cells, divide *Count* by 100 to convert to hectares.

Lab exercises

The lesson comprises three lab exercises: *Compiling Harvest Opening Sizes*, *Calculating Visible Clearcut Amounts*, and *Measuring Watershed Effects*. The three illustrate how forest-wide ecological and aesthetic effects of clearcuts can be measured.

In the first exercise, students compile and map clearcut opening sizes as an indicator of economic, ecological, and aesthetic effect. In the second exercise, they calculate clearcut exposure and visibility as indicators of aesthetic impact. In the final exercise, students delineate watersheds and assess the ecological influence of clearcutting activity.

While the lab exercises present instructive ways of assessing clearcutting in a forest, they also engage students in a range of forest analysis techniques that involve reclassifying forest features in a variety of ways as a basis for characterizing using single numbers, numerical distributions, and maps. The following table summarizes:

	Compiling Harvest Opening Sizes	*Calculating Visible Clearcut Amounts*	*Measuring Watershed Effects*
Clearcutting			
Economic	√		
Ecological	√		√
Aesthetic	√	√	√
Reclassify			
Label	√	√	
Rank			
Quantify		√	√
Spatial	Overlay; buffer	Dissolve; viewshed; raster overlay	Watershed; overlay; buffer; raster overlay
Characterize			
Number	√	√	√
Numerical distribution	√	√	√
Geographic distribution	√	√	√

If your students will be completing multiple exercises in this lesson, it's probably wise for you to suggest that they start each lab exercise with a "fresh" copy of the Woodlot geodatabase; otherwise, their geodatabases will become quite cluttered. As an alternative, you could suggest to your students that for each exercise they use a scratch workspace different from the Woodlot geodatabase.

The following provide overviews of each lab exercise, including general procedure, concluding observations, suggested review questions, and assignments for your students.

Compiling Harvest Opening Sizes

What are harvest opening sizes like in the Woodlot, where clearcut harvesting activity has been widespread and not bound by government opening size regulations? What does it tell you about economic, ecological, or aesthetic effects?

General procedure

1. Identify clearcuts as those stands with low-volume yield (30 m^3/ha or less) and young age (10 years or younger).

2. Merge adjacent clearcut stands into larger harvest openings.

3. Reclassify opening sizes into 10 ha classes.

4 Compute a harvest opening size distribution.

5 Map harvest openings by size class.

Concluding observations

- The Woodlot, or any forest, can be characterized using single numbers, distributions (table and charts), and maps.
- Tables and charts are ideal for presenting the aspatial distribution of some forest attributes, while maps provide the spatial distribution. A single number tells you neither.
- A numeric forest attribute may be summarized in some fashion—totaled or averaged, for example—for the unique values of another attribute.
- Forest features may be reclassified spatially by using the Dissolve tool to merge adjacent polygons that share a common attribute(s), such as merging adjacent clearcut stands, as in this exercise.
- By default, the Dissolve tool produces multipart features. Generally, this is not what you want.
- The Round function in Field Calculator is very handy for assigning a range of continuous data to fixed interval classes using the expression Class = round (value / interval + 0.49) * interval.
- Be careful when performing integer (whole number) arithmetic in a VBScript or Python expression—truncation will occur.
- VBScript does not do Nulls; you will need to use Python instead.
- There are 10,000 m^2 (100 x 100 m) in one hectare.

Suggested student deliverables

- Summary table, chart, and map of harvest openings by 10 ha size classes
- Answers to the questions posed in the exercise
  - What would happen if you didn't disable multipart features when merging?
  - Why can't you simply recalculate existing *Shape_Area* values to hectares?
- A summary of the exercise, indicating where and how related reclassify and characterize concepts and analysis techniques are exposed (This could take the form of a check-off table that maps the exercise's coverage.)
- A written assessment of clearcutting in the Woodlot from economic, ecological, and aesthetic perspectives
- Using techniques similar to those encountered in the exercise, compilation of a harvest opening size distribution for a different forest

Model

A model, *Harvest Openings*, located in the *Clearcutting* toolbox inside the *Models* folder implements this exercise. Running the model while varying clearcut identification criteria may be instructive for students. Adapting the model to run with inventory data from another forest is another possibility.

Calculating Visible Clearcut Amounts

What is the clearcut exposure and visibility situation in the Woodlot, where extensive clearcut harvesting has occurred over the past number of years and where people travel its main and nearby public roads daily? What does it tell you about aesthetic impact?

General procedure

1 Select clearcuts in the Woodlot as those stands harvested within the last five years.

2 Get an initial assessment of their visibility by determining how many are adjacent to main roads.

3 A more detailed assessment, however, requires determining what boundary lengths clearcuts share with main roads and calculating a frequency distribution. That involves using a polygon neighbors analysis.

4 A final assessment looks at visibility of clearcuts beyond those immediately adjacent to main roads. This involves a viewshed analysis using the Spatial Analyst extension whereby main and public road centerlines are the viewers and elevation plus stand heights forms the viewing surface. Clearcuts are then classified as visible or not using a map algebra overlay of the viewshed.

Concluding observations

- identifying and labeling boundaries shared by main roads or clearcuts, as in this exercise, is an example of reclassifying by locational attributes.
- Line features, as well as polygons, may be reclassified spatially (i.e., aggregated) using the Dissolve tool.
- Each cell in a viewshed raster indicates the number of observers that can see the cell (0, 1, 2, etc.).
- Spatial Analyst provides an array of tools for working with rasters, including Viewshed and Raster Calculator, as used in this exercise.
- Caution: When using linear features as observers in the Viewshed tool, the line vertices are used as observers; there may not be many of those for straight features.
- Single numbers, numerical distributions, and maps are all ways of characterizing a forest.

Suggested student deliverables

- A frequency distribution of boundary lengths shared by clearcuts and main roads
- A tally and map of clearcut visibility
- Answer to the question posed in the exercise
    - How do you tell ArcGIS that it's okay to replace existing files when error messages appear?
- A summary of the exercise indicating where and how related reclassify and characterize concepts and analysis techniques are exposed (This could take the form of a check-off table that maps the exercise's coverage.)
- A written assessment of clearcutting in the Woodlot from an aesthetic perspective

- Using techniques similar to those encountered in the exercise, calculation of clearcut exposure and visibility statistics for a different forest

Model

A model, *Clearcut Visibility*, located in the *Clearcutting* toolbox implements this exercise. Running the model while varying clearcut selection criteria or changing the classes of roads used in viewshed construction may be instructive for students.

You might even want to redigitize some of the public road features in *proads*, adding considerably more vertices. What effect does that have on the results?

Measuring Watershed Effects

How many watersheds exist in the Woodlot? How much area in each watershed has been recently clearcut? Is there a potential problem with any of the watersheds?

How about roads in the Woodlot? How many kilometers of main and secondary roads are there in Woodlot watersheds? How many stream crossings exist?

General procedure

1 Select clearcuts as those stands harvested within the last five years.

2 Delineate a Woodlot stream network and associated watersheds using the Esri Watershed Delineation tool.

3 Using map algebra, overlay clearcuts on watersheds and compute clearcut amounts by watershed.

4 Compute kilometers of road per hectare for each watershed using an intersect overlay of watersheds on roads.

5 Another intersect overlay locates road and stream crossings, and they in turn are overlaid with watersheds to determine their frequency by watershed.

Concluding observations

- Watersheds are delineated using a DEM. They delineate an area where all rainfall flows downhill, creating a network of streams where it concentrates.
- Esri's Watershed Delineation model makes it easy to delineate watersheds.
- Overlay is not restricted to polygon features but may also involve point and line features.
- You can also overlay rasters as you did using the map algebra Over function.
- Merging categories in a raster, analogous to dissolving boundaries between adjacent polygon features in a feature class, may be done using the Reclassify tool.
- A raster can be converted to a feature class and vice versa.
- Single numbers, numerical distributions, and maps are all useful in characterizing forests.

Suggested student deliverables

- A 3D map of the Woodlot's watersheds
- Tally and map of clearcuts and roads within the watersheds
- Tally and map of stream crossings within the watersheds
- Based on lab results, a paragraph detailing an assessment of clearcutting and road construction in the Woodlot (Is it good news or bad?)
- Answers to the questions posed in the exercise
    - Why did watershed 2 end up as two polygons when the raster-to-polygon conversion was made?
    - Could you use the Tabulate Area tool (Spatial Analyst Tools > Zonal) to compile the tabular summary of clearcut areas by watershed?
    - How might you have ArcGIS tally the number of road-stream crossings by watershed?
- A summary of the exercise, indicating where and how related reclassify and characterize concepts and analysis techniques are exposed (This could take the form of a check-off table that maps the exercise's coverage.)
- Using techniques similar to those employed in the exercise, carrying out of a watershed assessment of clearcutting for a different forest

Model

A model, *Watershed Impacts*, located in the *Clearcutting* toolbox implements this exercise. Running the model while varying clearcut selection criteria or the stream threshold parameter may be instructive for students. Inputting the *DEM_IDW* elevation raster, rather than *DEM_Woodlot*, may be instructive too.

Lesson review questions

Short-answer written questions, where students are required to describe or explain in their own words, are a good way to demonstrate comprehension, especially of the conceptual material. Following are some possibilities:

- Clearcut harvesting has _______ and ______ considerations, as well as economic ones.
- Can you think of two examples each for characterizing a forest with a single number, a numerical distribution, and a map?
- Reclassifying forest features creates a new attribute that labels, ____, or ____. Can you identify examples from lesson exercises?
- Provide an example of aspatial forest reclassifying.
- What ArcMap functions are useful in thematic and locational attribute filtering/selecting?
- Is reclassifying, aspatial or spatial, limited to polygon features?
- Can you distinguish between AND and OR logical operators as used in query expressions?
- What is map algebra?
- In Raster Calculator, what purpose does the & operator serve?

- Aside from polygon-on-polygon overlay, what other overlay possibilities exist? What ArcToolbox tool implements all these?
- What purpose do brackets serve in query expressions? In Field Calculator expressions?
- What does feature dissolving involve? What purpose does it serve?
- Aside from short integer, what other types of attribute fields are there?
- What's the difference between a one-to-one table join and a many-to-one join?
- What factor determines the boundaries of watersheds?
- What is the function of the threshold value in watershed delineation?
- What does DEM stand for?
- What factors, in addition to observer location(s), are involved in calculating a viewshed?
- What feature types may be used as observers in viewshed analyses?
- A coverage contains both polygon and arc features. The attributes table associated with the polygons is called the ______________, while the table associated with arcs is called the ______________.
- What are the names of the two fields in the arc attributes table that record the identity of left and right polygons?
- How is the arc-polygon topology recorded in an AAT useful?

Credits

Figure 1: courtesy of University of New Brunswick.

Figure 2: courtesy of Western Forest Products