Calculating Forest Values

—by Glen Jordan

Instructor notes

This lesson shows your students how they can leverage their existing GIS knowledge in calculating forest values, including reclassifying and characterizing, whether economic, social, or ecological. It's assumed that students have at least intermediate ArcGIS® skills.

In the *Lesson background* and *Methods background* sections that follow, you'll find details on forest values, 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 background material will not expose your students to new ArcGIS functionality. In fact, the examples provided should be quite familiar, with the possible exception of spatial join and zonal statistics. The purpose of the background material is to establish the conceptual context for the lesson.

The lesson's four lab exercises are detailed in the *Lab exercises* section that follows. Labs are structured to engage students with the background material in real application settings. 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

Forests have often-competing economic, social, and ecological values.

Forests have economic value since the raw products they produce—pulpwood, sawlogs, and other timber products—are used in the manufacture of a host of secondary products, like paper and lumber. But nontimber products also have value, like the taxanes-derived chemotherapy drugs extracted from the Canadian yew shrub (*Taxus canadensis*), fuel wood, Christmas trees, maple sap, and edible mushrooms, to name just a few.

In many parts of the world, forests are also an important part of the social fabric of communities. While many individuals in rural communities find employment in forest and related industries, many simply enjoy being in the forest or involved in forest recreational activities.

Of course, forests are ecologically valuable—even invaluable. They sustain dynamic populations of plants and animals. They store carbon and produce oxygen. They intercept rainfall and regulate the quantity and quality of water flow that countless cities, towns, and villages depend on.

Forest values, whether economic, social, or ecological, are a function of forest structure, in other words, the array of stand conditions and their location and spatial arrangement across the landscape.

It's important that your students can distinguish between economic, social, and ecological forest values before attempting to measure them using GIS.

Economic value

Economic value of a forest is easy to document. Timber extracted from forests contributes significantly to the gross domestic product (GDP) of many countries by providing the raw material (i.e., wood fiber and chemicals), which are manufactured into a variety of commodities, such as paper, lumber, and rayon. Likewise, it's easy to place a market value on nontimber products: fuel wood, medicinal plants, and such. In both cases, forest structure is an important determinant.

For example, a forest with a large area of stands in the mature age classes, containing a high concentration of valuable species, and distributed in large patches on relatively flat terrain will have a high dollar value. Nontimber product value, on the other hand, like that for maple sap, would be found in a forest with large patches of mature sugar maple stands on south-facing slopes.

Figure 1. Sap collected in springtime from sugar maple trees is boiled to produce maple syrup.

Social value

Calculating the social value of a forest is more challenging. You can tally the payroll contribution of wood harvesting, processing, and manufacturing in a community, but how do you measure the value of forest recreational activities, such as camping, hiking, fishing, four-wheeling, snowmobiling, and skiing? Again, the answer lies in the forest structure.

For example, a forest with high economic value, as discussed previously, will provide a community with a high standard of living, but does the same forest structure that makes a forest a valuable timber asset also make it a valuable recreational property? It probably doesn't. Recreationists typically prefer undisturbed forest in its natural state. That means the presence of large areas of majestic old-growth stands and lesser amounts of younger stands. Industrial forestry, however, usually eliminates old-growth stands, as they are high value, but they are slow growing and better replaced with younger, fast-growing trees. This difference explains the common conflict between industrial and recreational users of forests.

Figure 2. The value of forest recreational activities lies in the forest structure.
Photo by Sally Pierce

Ecological value

While the social value of forests can be hard to quantify, ecological values are even more intangible. It is obvious that the ecological well-being of forests is critical for the myriad of systems that they support and, in the end, the very survival of humankind. Therein lies the ecological value of forests, but how do you measure the ecological well-being of forests? How do you know when one is not healthy? Those are questions that forest ecologists and others struggle to answer. Clearly, the ecological well-being of a forest is connected to its biodiversity, in other words, the variety and variability of its conditions, including geographic distribution. As before, with economic and social values, forest structure is a basis for assessing ecological well-being.

For example, a natural forest, subject only to natural disturbances such as windstorms, fire, insects, and disease, will exhibit a variety of conditions and spatial arrangements that in turn support various ecological systems. That's not to say that all such forests have the same or even constant biodiversity, since lots of variation can be seen in different forests in different parts of the world at different times. Nor does it say that a forest is not healthy if it's managed for timber production. It is possible to have both a healthy forest and one that sustains a high timber value, but the risk of ecological degradation is high. Extensive tree plantations, for example, sacrifice biodiversity for maximum timber production.

A balancing act

Forest managers strive to maintain a balance between economic, social, and ecological forest values by controlling forest structure, often favoring one value over the others as the forest owner, public or private, dictates. As the following diagram illustrates, the common ground among the three is small:
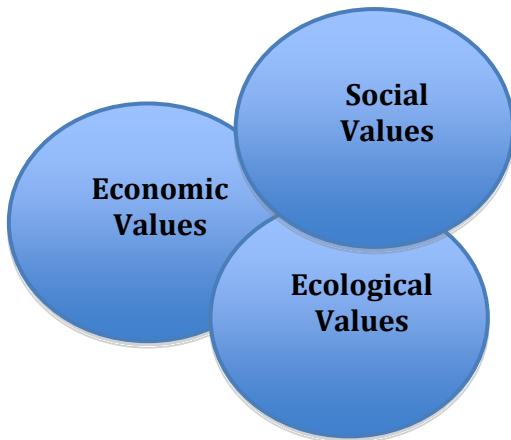

Figure 3. The common ground among economic, social, and ecological forest values is small.

GIS technology, at least, makes the forest manager's job a little easier by providing the wherewithal to characterize a forest's structure.

Methods background

As with forest analysis generally, calculating economic, social, and ecological values involves characterizing a forest in some fashion. What's not so obvious is that to effectively do so more often than not requires some reclassifying of forest features.

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

Characterizing forests

There are three ways to characterize forests: single numbers, numerical distributions, and geographic distributions (i.e., 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/hectares (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

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:

Explore

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 m 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.

Explore

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 (i.e., 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.

Explore

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

Using Definition Query, limit *cover* 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.

Explore

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.

Following are examples that 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.

Explore

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 (km).

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 three geoprocessing procedures that your students may need some instruction in before proceeding with the lab exercises. These include using Visual Basic (VB) expressions and scripting in Field Calculator and accessing ArcGIS data from Microsoft (MS) Excel.

Using Visual Basic

Computer programming, even with something named Basic, is not for the faint of heart, but a little know-how goes a long way.

The Basic programming language is one of the oldest and easiest to learn and use and quite common. Today, in the Windows operating system environment, it comes in three flavors—VB, Visual Basic for Applications (VBA), and VBScript.

VB

The most recent implementation of VB, Visual Basic .NET, is an object programming language like C++ and Python. It can be used to program free-standing executables (.exe extension) or application-dependent modules (.dll extension). In both cases, however, objects (methods and properties) exposed by another application are often used. For example, ArcGIS provides access to its constituent objects in a collection called ArcObjects.

VBA

VBA is found embedded in Windows applications like Word and Excel. At ArcGIS 10, it is no longer embedded in ArcMap or ArcCatalog.

VBScript

VBScript, like JavaScript, allows web page developers to create dynamic web pages for viewing with a web browser. It can also be exposed by any Windows application.

VBScript can be particularly useful in Field Calculator, where it's often used to populate a field with values where otherwise a series of select-by-attribute queries would be needed.

Explore

Explore

Here you'll classify Woodlot stands into three harvest operability classes—inoperable, marginal, and operable—based on their volume yields (m^3/ha).

In ArcMap, add the *cover* feature class.

Use Definition Query to limit the *Cover Types* layer to just the 533 stands (AGE <> -99).

Open the attributes table and add a new field named "Operability" of type Text and a width of 10 characters.

Use the m^3/ha values stored in the *Cover Types VH* field to classify stand operability as follows:

0–50 m^3/ha	Inoperable
51–90 m^3/ha	Marginal
91+ m^3/ha	Operable

Normally, you'd proceed to populate the *Operability* field using a series of query/Field Calculator operations as follows:

Using Select By Attributes, select stands with *VH* <=50 and calculate *Operability* = "Inoperable" using Field Calculator.

Using Select By Attributes, select stands with *VH* > 50 and *VH* <= 90 and calculate *Operability* = "Marginal" using Field Calculator.

Finally, using Select By Attributes, select stands with *VH* > 90 and calculate *Operability* = "Operable" using Field Calculator.

However, you can accomplish the above in one step using a little VB coding in Field Calculator. Here's how:

Open Field Calculator for the *Operability* field.

In Field Calculator, click the `Show Codeblock` option and enter the following code in the `Pre-Logic Script Code` area:

```
Dim Res
If [VH] <= 50 Then
Res = "Inoperable"
ElseIf [VH] > 50 and [VH] <= 90 Then
Res = "Marginal"
Else
Res = "Operable"
End If
```

Then, simply type *Res* into the *Operability* = assignment box.

Even without extensive experience with Visual Basic, the logic of the VB code should be quite apparent.

So, a little VB know-how can prove quite useful. Following are some more details that your students will need if they are to have any success in using VBScript in Field Calculator.

VB has the same basic components as found in any programming language: variables (data) and statements (instructions).

Variables

Program variables are simply named containers for holding data. Unlike in some programming languages, VBScript containers are typeless, capable of holding just about any type of data—text strings, whole numbers, decimal numbers, and so forth.

Statements

There are numerous types of statements in VBScript, but assignment, decision, and looping statements are the mainstays.

Statement	Syntax	Description
DIM	DIM variable(s)	Declares a variable, or list of variables separated by commas
variable assignment	variable = constant, expression, or variable	Assigns a variable a value—either a constant, an expression, or another variable

IF THEN END IF	IF condition THEN
	    statements
	END IF
		Executes one or more statements if the condition is true

IF ELSEIF END IF	IF condition THEN
	    statements
	ELSEIF condition THEN
	    statements
	ELSEIF condition THEN
	    statements
	ELSE
	    statements
	END IF
		Proceeds in cascading fashion until a condition is found true, whereby the associated statements are executed, or if none of the conditions are true, executes the last block of statements

FOR NEXT	FOR index start TO finish STEP n statements NEXT	Executes the enclosed steps from start to finish in STEP increments

For most applications, this is enough, but your students can find much more information in the online Microsoft **VBScript User Guide**.

Using MS Excel

MS Excel is not a GIS, but its powerful spreadsheet and charting capabilities make it indispensable. Fortunately, Excel can both retrieve tabular data from and supply tabular data to ArcGIS. Procedures are relatively simple.

Accessing ArcGIS shapefiles and feature classes

Explore

Explore

Here, you'll use Excel to access the attributes table of the Woodlot's *cover* shapefile in the *Shapes* folder, as well as the corresponding feature class in the *Woodlot* geodatabase. Then you'll use Pivot Table functionality to compile a table and chart that display the total area occupied by each of the Woodlot's 12 management compartments.

In ArcMap, open Excel, click Open (or Ctrl+O), then navigate to the *Shapes* folder. With `Files of type` set to dBASE files, open the *cover* attributes table.

As you can see, that imports all *cover* fields and their values as a worksheet, where you have access to Excel's powerful tabular processing capabilities.
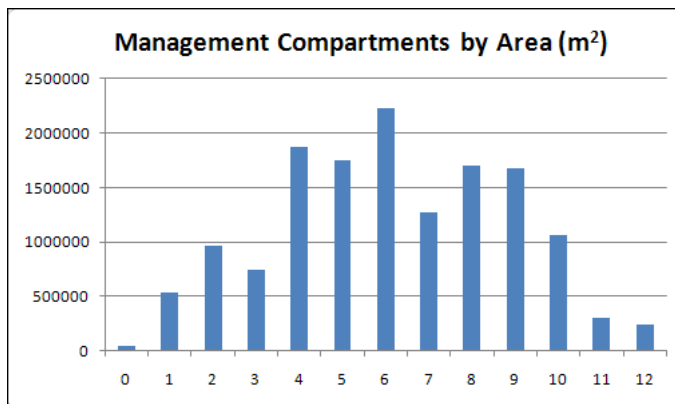
Using the following Pivot Table setup (`Insert > Pivot Table`), summarize the *BLK* field (management compartments) by *AREA*.
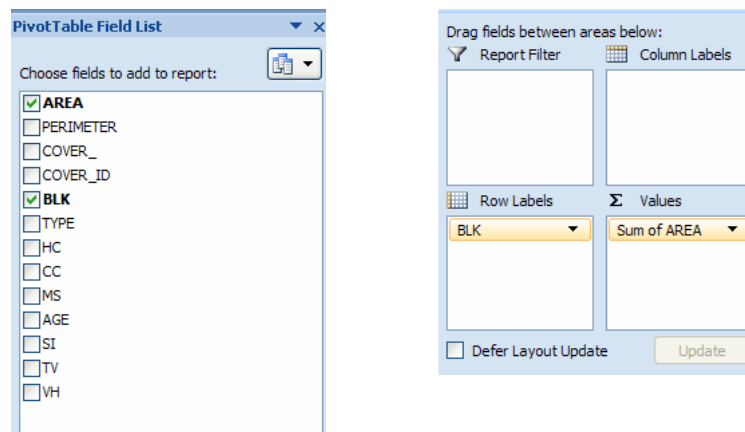
This produces a tabular distribution of management compartment areas (m^2) in quick order. Compartment 0, by the way, refers to roads.

Now, using Pivot Chart (`PivotTable Tools > PivotChart`), compile a bar chart as follows:

It would appear that area across the Woodlot's 12 management compartments is distributed normally.

ArcGIS (ArcInfo license only) also has a Pivot Table tool. It does not, however, perform tabular summaries as above.

You can also use Excel (at least the 2007 version) to access feature class data in a geodatabase. Here's how that might be done using the *Woodlot* geodatabase as an illustration:

In Excel, use Data > From Access (or Open Other Sources if your geodatabase is not a personal MS Access geodatabase) to access the *Woodlot* geodatabase.

In the `Select Table` dialog box, navigate to the desired attributes table.

That produces the same spreadsheet as opened earlier.

Accessing Excel data using ArcGIS

Explore

Here, you'll use ArcCatalog to preview an Excel workbook.

In ArcCatalog, navigate to the *Codes* folder and expand it.

Explore

ArcCatalog recognizes Excel files (.xls and .xlsx), so you'll see a *Woodlot_Codes* file listed.

Expand *Woodlot_Codes.xls*.

Three worksheets are revealed: CC$, MS$, and Type$.

Click one, *Type$*, for example, and preview its contents.

These worksheets provide documentation of the various one- and two-letter codes found in the CC, MS, and TYPE fields in the *cover* shapefile.

Opening Excel workbooks is not limited to ArcCatalog. ArcMap can also access them and even join worksheets to attribute tables.

Lab exercises

The lesson comprises four lab exercises—Calculating an HSI for an Old-Growth Species, Summarizing Timber Value by Stand Type and Accessibility, Evaluating Maple Sap Production Potential, and Assessing Forest Recreation Value. The four explore how forest values might be measured in economic, social, and ecological terms.

In the first exercise, students examine the Woodlot's ecological value by calculating a habitat suitability index (HSI) for an old-growth species. In the second exercise, they summarize economic timber value in the Woodlot and compare amounts accessible by road and those that are not. In the third exercise, students evaluate the economic value of the Woodlot from a nontimber product perspective. In the fourth and final exercise, students measure the Woodlot's potential social and economic value for forest recreation.

While the lab exercises present instructive ways of measuring forest value, 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:

|	*Calculating an HSI for an Old-Growth Species*	*Summarizing Timber Value by Stand Type and Accessibility*	*Evaluating Maple Sap Production Potential*	*Assessing Forest Recreation Value*
Forest Value				
Economic		√	√	√
Social				√
Ecological	√			
Reclassify				
Label		√		
Rank	√		√	√
Quantify	√	√		
Spatial	Dissolve	√	Overlay; buffer	Slope; buffer
Characterize				
Number	√	√		√
Numerical distribution	√	√	√	√
Geographic distribution		√		√

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

Calculate an HSI for an Old-Growth Species

What is the status of old growth in the Woodlot, using the Blackburnian warbler as an indicator species? What is the average size and density (#/ha) of HSI patches? What does it tell you about ecological well-being in the Woodlot?

General procedure

1 Using the following Blackburnian warbler habitat relationships as guides, assign Woodlot stands age and softwood content ratings on a scale of 0 (worst) to 5 (best).
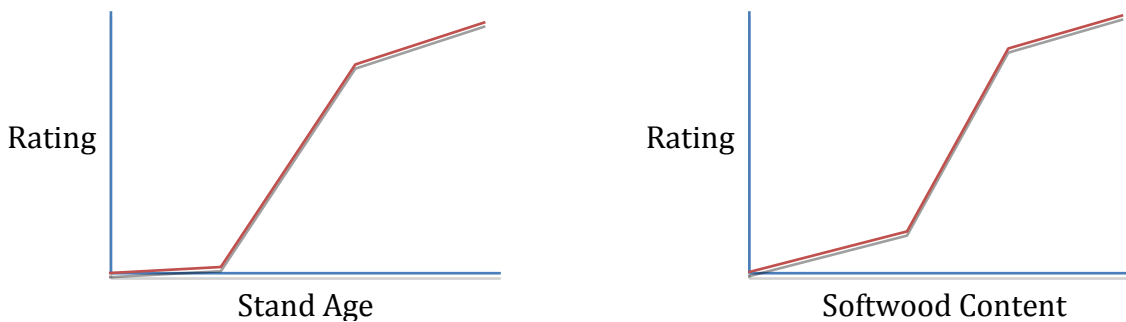
2 Multiply ratings, producing composite values ranging from 0 to 25.

3 Classify composite values into HSI values ranging from 1 (worst) to 8 (best).

4 Form HSI patches (Dissolve tool) where adjacent stands share the same HSI value.

5 Summarize HSI patches by area sum and average.

6 Calculate patch densities (#/100 ha).

Concluding observations

- The Woodlot, or any forest, can be characterized using single numbers, distributions (table and charts), and maps.
- Tables 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 field may be summarized in some fashion—totaled or averaged, for example—for the unique values of another attribute.
- Forest features may be reclassified aspatially as a function of their thematic attributes, such as reclassifying stands by species composition and ages, as in this exercise.
- 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 stands sharing a common HSI value, as in this exercise.
- Reclassifying spatially and calculating the characteristics of the patches that emerge finds common application in forestry.
- By default, the Dissolve tool produces multipart features. Generally, in forestry applications, this is not what you want.

- The VB *If Then ElseIf* construction is a powerful tool for implementing reclassify logic in Field Calculator.
- Keeping only matching records in a table join, although optional, is one way of reducing the number of table records that subsequent processing must deal with.
- Likewise, it's never necessary to remove a table join when no longer needed, but it will improve processing efficiency.
- Field aliases are a convenient way to overcome the limitations placed on field names, like having no spaces or a number of special characters.
- There are 10,000 m^2 in one hectare.

Suggested student deliverables

- Summary table of HSI patch statistics—total area (ha), average size (ha), patch density (#/100 ha)
- Based on lab results, a paragraph detailing an assessment of value in the Woodlot from an ecological perspective (Is it good news or bad?)
- Answers to the questions posed in the exercise

  - When joining tables, what effect does the *Keep only matching records* option have?
  - What is the consequence of not removing <Null> values prior to running Dissolve on an attribute field?

- 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 used in developing the Blackburnian warbler HSI, design and calculation of an HSI for another indicator species

Model

A model, *HSI Model*, located in the *Forest Values* toolbox implements this exercise. Students might find it instructive to examine and run the model.

Students can run the model and vary specifications for calculating HSI age or type ratings. How sensitive are results to variations in the specifications? For example, if the minimum age for old stands is lowered to 80 from 100, what effect does it have on results? What if the minimum is increased?

Summarize Timber Value by Stand Type and Accessibility

How valuable is the Woodlot's standing timber? How is value distributed across broad stand types (softwood, hardwood, mixed wood) and between accessible and inaccessible stands?

General procedure

1   Calculate a dollar value for each Woodlot stand as m^3/ha * \$/m^3 * ha.

2   Sum the dollar value of individual stands to get a gross timber value for the Woodlot.

3   Isolate stands accessible by main or secondary roads, calculate a dollar value, then compare to the gross value.

4   Reclassify stands into categories of accessibility (accessible, inaccessible) by stand type (softwood, hardwood, mixed wood, treed bog, nonforested).

5   Summarize the categories by dollar value total, area total, and average stand yield.

Concluding observations

- The Woodlot, or any forest, can be characterized using single numbers, distributions (table and charts), and maps.
- Tables 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 field may be summarized in some fashion—totaled or averaged, for example—for the unique values of another attribute.
- Select By Attributes may create a new selection, add to an existing one, or remove from an existing one.
- Forest features may be reclassified aspatially as a function of their thematic attributes, such as reclassifying stands by species composition, as in this exercise.
- Forest features may be reclassified spatially by using their locational attributes, such as selecting stands adjacent to roads, as in this exercise.
- Brackets in Field Calculator expressions serve an important purpose—they override the default left-to-right evaluation of an expression and cause calculations within brackets to be completed first. The complex expression you used in calculating the dollar value of stands used brackets to control the order of calculations.
- The VB *If Then ElseIf* construction is a powerful tool for implementing complex reclassifying logic in Field Calculator, like your reclassification of stands by accessibility and stand type.
- MS Access geodatabase tables (.mdb) can be opened and manipulated in MS Excel.
- Analyzing a forest doesn't always have to produce a map; in fact, quantitative data, like the summary table produced in this exercise, is generally a much more useful result.
- There are 10,000 m^2 in one hectare.

Suggested student deliverables

- Summary table of timber values by accessibility and stand type categories—market value ($), area (ha), average stand yield (m³/ha), and a pie chart of timber values by accessibility and stand type
- Based on lab results, a paragraph detailing an assessment of value in the Woodlot from an economic perspective (Is it good news or bad?)
- Answers to the questions posed in the exercise

  - When joining tables, what does the *Keep only matching records* option accomplish?
  - What purpose do brackets () serve in a Field Calculator expression?
  - What purpose does the asterisk (*) serve in query expressions?

- 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 used in this exercise, calculation of timber value in another forest property

Model

A model, *Timber Value*, located in the *Forest Values* toolbox implements this exercise.

It may be instructive to run the model while varying road classes included in the analysis. How sensitive are results to removing the poorest class of secondary roads, trails (Class C4), from the analysis? If there was some reason to suspect the quality of access provided by trails, this revision to the analysis might prove insightful. Or, you can vary product market prices and rerun the model.

Evaluate Maple Sap Production Potential

Is there a viable site or sites in the Woodlot where a viable maple syrup operation, now or in the future, might be established? Where? This involves two stand variables—presence of sugar maples and distance to roads or trails for sap transportation.

General procedure

1 Create haul zones of 25, 50, and 75 m around roads and trails in the Woodlot using the Multiple Ring Buffer script tool.

2 Select tolerant hardwood stands and intersect overlay with the buffers.

3 Label stands by their sap production potential within each haul zone as follows:

Label	Description	Stand Condition
PP	Present Potential	Large-size sugar maple >= 10% of stand volume
FP	Future Potential	Small-size sugar maple >= 10% of stand volume
LP	Limited Potential	None of the above

4   Using MS Excel, compile a cross tabulation of Woodlot areas by sap production potential and haul zone.

Concluding observations

- Query expressions for selecting features may include arithmetic operators and brackets.
- In an expression, brackets modify default operator precedence, in other words, the order in which operations are performed.
- Feature buffering with the Multiple Ring Buffer script or Buffer tool produces multipart polygon features.
- An intersect overlay retains only the area common to the inputs, whereas a union overlay retains the combined areas.
- Forest features may be reclassified aspatially as a function of their thematic attributes, such as reclassifying stands by species volume, as in this exercise.
- Forest features may be reclassified spatially as a function of their overlap (intersection) with other features, such as partitioning of tolerant hardwood stands with buffer zones, as in this exercise.
- MS Excel can open MS Access-based geodatabase tables.
- MS Excel Pivot Table functionality is very handy where cross tabulation summaries are needed.
- There are 10,000 m^2 in one hectare.

Suggested student deliverables

- A cross tabulation of 25 m haul zones by three sap production potential categories—present potential, future potential, and limited potential

  Answers to the questions posed in the exercise
  - Why were there just three features (records) in the multiring buffer result?
  - When joining tables, what does the *Keep only matching records* option accomplish?
  - What's the difference between intersect and union overlays?
  - What purpose do brackets () serve in a Field Calculator expression?
  - How would you compile your cross tabulation in hectares rather than square meters?

- 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 used in this exercise, calculation of sap production potential in another forest property
- Explanation of how one would limit the analysis to south-facing slopes, the preferred location of maple syrup operations

Model

A model, *Sap Potential*, located in the *Forest Values* toolbox implements this exercise.

It may be instructive to run the model while varying or adding buffer distances or changing query expressions. Perhaps there is greater maple sap potential if selection criteria are broadened somewhat. Note that if you change the name of the output *sap_zones* feature class, you'll have to change this in model query expressions accordingly.

Assess Forest Recreation Value

Generally, most forest recreation activities are best served where a variety of terrain conditions exist; old-growth conditions occur; streams, bogs, and wetlands are close by; and easy access is available.

Are there recreational development opportunities in the Woodlot? How much and where?
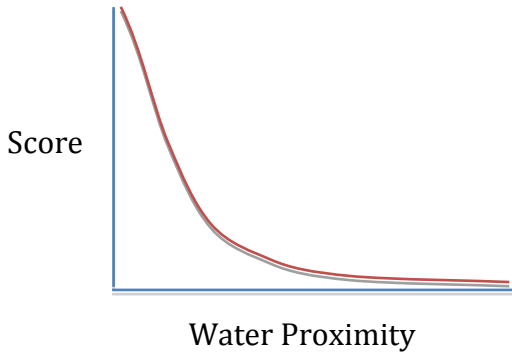
General procedure

1   Calculate a terrain diversity raster based on slope ranges within 200 m, then create a recreation score raster by reclassifying (1 being worst and 10 best) using the following relationship:
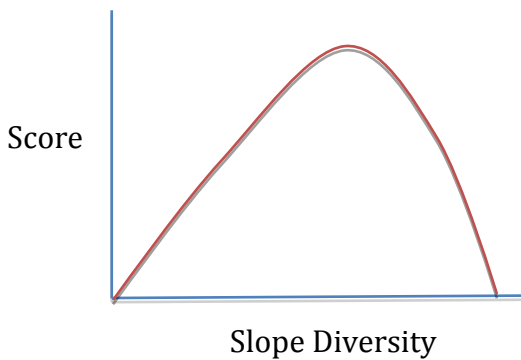
2   Based on the following relationship, calculate a recreation score raster by reclassifying all stands aged 60–100 with a 10:
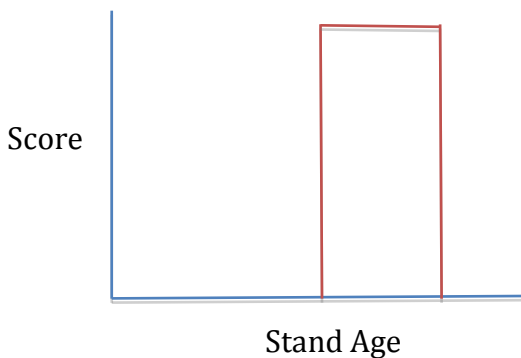
3 Calculate a wetlands proximity raster by measuring distances around bogs, marshes, and ponds to a maximum of 200 m, then create a recreation score raster by reclassifying (1 being worst and 10 best) using the following relationship:

Score

Water Proximity

4 Calculate a streams proximity raster by measuring distances around streams to a maximum of 200 m, then create a recreation score raster by reclassifying (1 being worst and 10 best) using the above relationship.

5 Calculate a final recreation score raster by adding the four individual score rasters.

6 Compute the amount of Woodlot area with a score of at least 20. Chart its distribution by score.

7 Examine the accessibility of areas with high scores.

Concluding observations

- A feature class can be converted to a raster using one of its attribute fields.
- Rasters open up additional geoprocessing opportunities, like calculating slopes, measuring distance, calculating neighborhood (focal) statistics, and performing map algebra.
- Rasters are particularly useful when working with continuous, as opposed to discrete, data.
- Scoring is one way to integrate a number of factors into an assessment of potential or suitability of forest areas for a particular activity.
- Specific scoring details are greatly aided by graphing relationships between scores and factors.
- The Reclassify tool makes the process of reclassifying very easy and efficient, but it only works with rasters.
- Single numbers, numerical distributions, and maps are all useful in characterizing a forest.

Suggested student deliverables

- A recreation score raster and tally and chart of recreation amounts by score
- Based on lab results, a paragraph detailing an assessment of value in the Woodlot from an economic perspective (Is it good news or bad?)
- Answers to the questions posed in the exercise
  - Why was a cell size of 10 used?
  - What would happen if a processing extent were not specified when using the Euclidian Distance tool?

- 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 used in this exercise, calculation of recreation value in another forest property

Model

A model, *Recreation Potential*, located in the *Forest Values* toolbox implements this exercise.

It may be instructive to run the model while varying some of the input parameters, especially the score reclassifications. Is recreation scoring particularly sensitive to changes in specifications for any one of terrain (slope) diversity, water proximity, or old growth?

How would results change if old growth were treated like the other factors, with a continuous relationship of some sort between score and age, rather than a discrete window?

How would results change if a min function were used in combining individual scores rather than sum?

Lesson review questions

- Provide examples of economic, social, and ecological values in a forest.
- Forest structure refers to what? Can you think of examples of how forest structure influences forest values, whether economic, social, or ecological?
- There are three ways to characterize a forest using GIS. What are they?
- Can you think of two examples for characterizing a forest with a single number, a numerical distribution, and a map?
- What ArcMap functions are useful in characterizing forests with a numerical distribution? What MS Excel functions are likewise useful?
- ArcMap and MS Excel share similar functionality, but what distinguishes ArcGIS, or any GIS?
- Use MS Excel Pivot Table functionality to compile a summary table of total stand volume amounts (TV field in *cover*) by management compartment (BLK field in *cover*) in the Woodlot.

- Use MS Excel Pivot Table functionality to compile a summary table of total stand volume amounts (TV field in *cover*) by management compartment (BLK field in *cover*) and cover type (TYPE field in *cover*) in the Woodlot.
- Are forest maps quantitative or qualitative?
- Reclassifying forest features creates a new attribute that labels, ___, or ___.
- Reclassifying is a two-stage process. What are these stages?
- Provide an example of aspatial forest reclassifying.
- Can you distinguish between thematic and locational attribute filtering/selecting? Provide examples of each.
- What ArcMap functions are useful in thematic and locational attribute filtering/selecting?
- Spatially reclassifying forest features, like aspatial, involves repackaging features. Can you distinguish between the two, though?
- What ArcToolbox tools are used in some types of spatial reclassification?
- Is reclassifying, aspatial or spatial, limited to polygon features?
- VBScript, like any programming language, includes what basic components?
- What VB statement allows you to implement Select By Attributes logic in Field Calculator?

Credits

Figure 2: Photo by Sally Pierce