

How to Calculate Vector-Based Landscape Metrics in ArcGIS

These instructions enable you to calculate metrics comparable to those in FragStats 3.3, but applied to **vector** shapefiles within the ArcGIS 9 environment. Using a class layer that has previously been intersected with landscape sites of interest, you may batch process patch-, class-, and landscape-level metrics for use in landscape ecology analyses. The first set of metrics is area-based and easily performed with the ArcView level of licensing for ArcGIS; to calculate edge-based metrics you will need the ArcInfo level of licensing for ArcGIS software.

The example data used is from Alberta Vegetation Index (AVI). Substitute your file names and field headings, and note that you may also simplify the instructions to apply to a single landscape.

ORIGINAL DATA

Landclass.shp A polygon shapefile of land classes (CLASS) and unique landscape IDs (SITE)

CREATED DATA

Landclass_Dissolve.shp A polygon shapefile created by dissolving the SITE_Class field – the attribute table will contain *patch-level metrics*

Landclass_Polyline.shp A polyline shapefile created by converting the polygons to lines – the attribute table will contain *patch-level metrics*

Class_Name.dbf DBase table of unique class values with full descriptive names

Total_site_area.dbf DBase table of summed area within each site landscape

Class_area_summary.dbf DBase tables of *class-level metrics*

Class_edge_summary.dbf

Site_area_summary.dbf DBase tables of *landscape-level metrics*

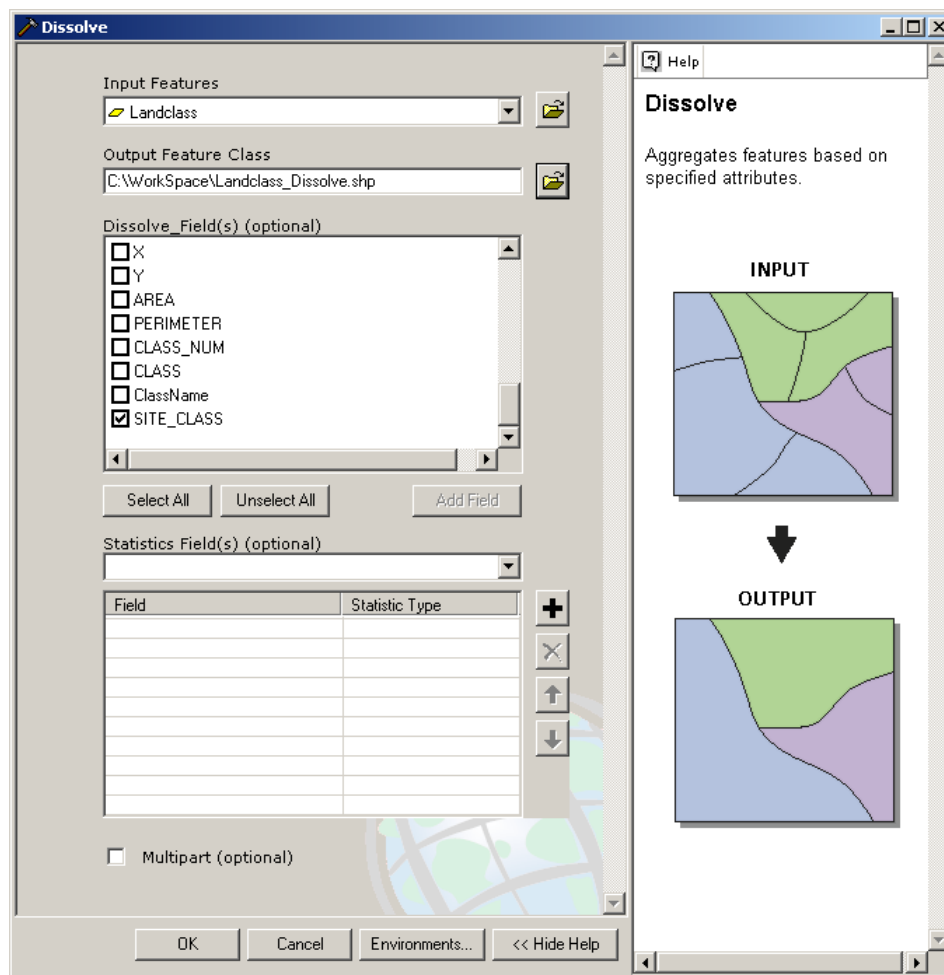
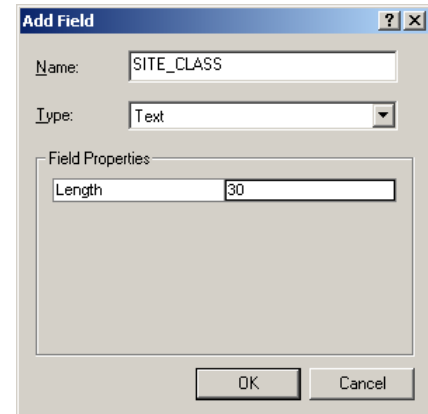
Site_edge_summary.dbf

Site_variety_summary.dbf

Add a dissolve field and create patches by site and class:

The classes may have been generalized from other attributes and you may wish to retain information on different sites for analysis without needing to create separate layers for each site. Therefore, to ensure that there are no boundaries between adjacent similar types – this will cause erroneous results such as higher number of patches – use the dissolve operation on a new concatenated field: SITE_CLASS.

1. In ArcMap, add the **Landclass.shp** layer, and right click on the name to OPEN ATTRIBUTE TABLE
2. Choose OPTIONS >>> ADD FIELD
3. Name the new field **SITE_CLASS** (Text, 30)
4. Right click on the new heading and choose CALCULATE VALUES
5. Enter the following expression: `[SITE] & " - " & [ClassName]` and click OK
6. In ArcToolbox, locate the DISSOLVE tool
7. Dissolve Landclass.shp by the SITE_CLASS field – uncheck Multipart – and name the output **Landclass_Dissolve.shp**



Calculate area-based patch-level metrics:

1. In the attribute table of Landclass_Dissolve.shp, add the following new fields:
 - **AREA** (Double, 12, 4)
 - **PERIMETER** (Double, 12, 4)
2. Calculate expressions from the table or copied and pasted from the Help Button:

Check ‘Advanced’ in the Field Calculator

Type into Pre-Logic VBA Script Code box:

Type into second box:

AREA

```
Dim Output as double
Dim pArea as IArea
Set pArea = [shape]
Output = pArea.Area
```

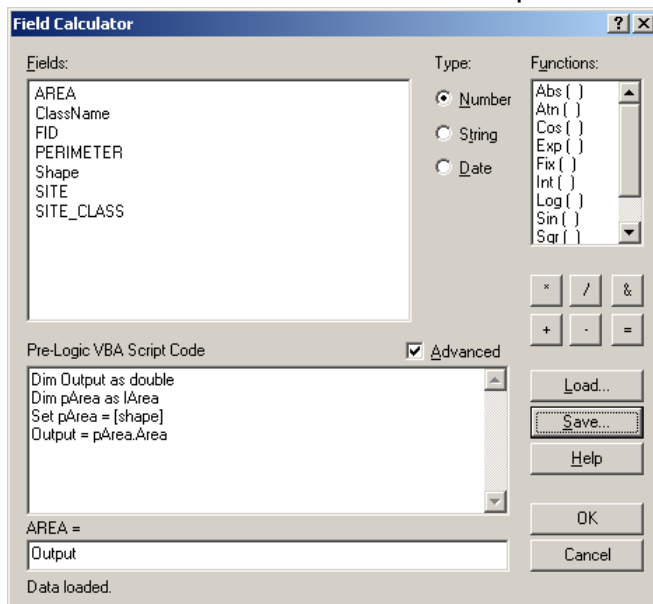
Output

PERIMETER (LENGTH)

```
Dim Output as double
Dim pCurve as ICurve
Set pCurve = [shape]
Output = pCurve.Length
```

Output

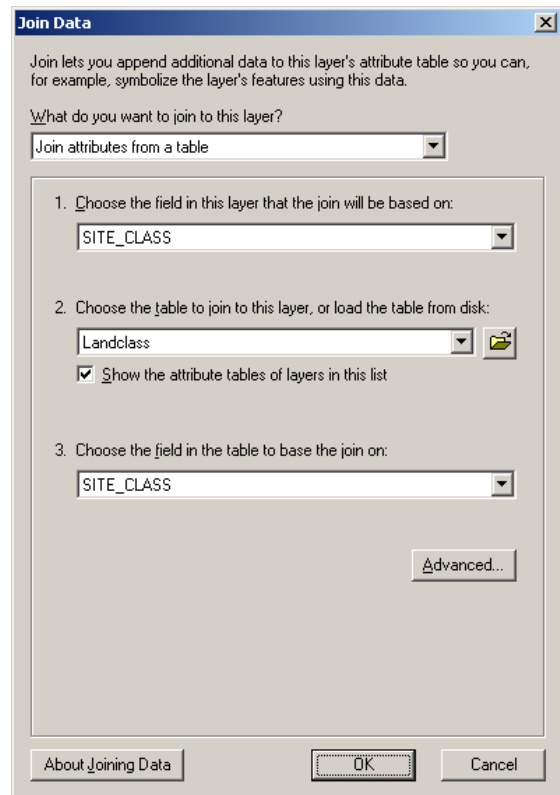
3. Remember to SAVE each expression



You now have the area and perimeter of each patch. To help you identify which site and class the patches belong to, perform a table join to calculate new fields that split apart the SITE_CLASS.

4. In the attribute table of Landclass_Dissolve.shp, add the following new fields:

- **SITE** (Short, 2)
- **ClassName** (Text, 30)



5. In the table of contents, right click on Landclass_Dissolve.shp and choose JOINS AND RELATES >>> JOIN
6. Join by SITE_CLASS field to Landclass.shp
7. Click YES to automatically create and index for the join field
8. Calculate Landclass_Dissolve.SITE equal to Landclass.SITE
9. Calculate Landclass_Dissolve.ClassName equal to Landclass.ClassName
10. Remove the table join by right clicking on Landclass_Dissolve.shp and choose JOINS AND RELATES >>> JOINS >>> REMOVE ALL JOINS

Optionally, perform a *Select By Attributes* to isolate each set of patches by *SITE* and view the patch-level metrics.

11. In the attribute table, choose **OPTIONS >>> SELECT BY ATTRIBUTES** and enter an expression to view one of the sites; e.g. "**SITE**" = 1
12. Click **APPLY**
13. Repeat for each *SITE* value
14. Close all tables and choose **SELECTION >>> CLEAR SELECTED FEATURES** when finished

Summarize class-level metrics:

The following instructs on how to obtain aggregate statistics for each class within each landscape site. This is easily done with summary statistics for the attribute table.

1. Right click on *Landclass_Dissolve.shp* and choose **OPEN ATTRIBUTE TABLE**
2. Make sure there are no selected records (choose **OPTIONS >>> CLEAR SELECTION**)

3. Right click on the **SITE_CLASS** heading and choose **SUMMARIZE**

FID	Shape	SITE_CLASS	AREA	PERIMETER	SITE	ClassName
0	Polygon	1 - Aspen	1101.1551	1101.1551	1	Aspen
1	Polygon	1 - Aspen	1942.4281	1942.4281	1	Aspen
2	Polygon	1 - Aspen	406.8821	406.8821	1	Aspen
3	Polygon	1 - Aspen	647.7931	647.7931	1	Aspen
4	Polygon	1 - Aspen	509.4635	509.4635	1	Aspen
5	Polygon	1 - Aspen	591.9123	591.9123	1	Aspen
6	Polygon	1 - Aspen	1418.5706	1418.5706	1	Aspen
7	Polygon	1 - Aspen	955.7077	955.7077	1	Aspen

4. Select all statistics for *AREA* and all statistics for *PERIMETER*
5. Specify the output table; e.g. **Class_area_summary.dbf**
6. Click **OK** and then **YES** to add the table to the map document
7. In the **SOURCE** tab of the table of contents, right click on *Class_area_summary* and choose **OPEN**

8. Break apart the *SITE* and *CLASS* into separate columns by following steps 4 through 10 in the previous section on page 3 (NOTE: substitute *Class_area_summary* for 'attribute table of *Landclass_Dissolve*')
 - Calculate *Class_area_summary.SITE* equal to *Landclass.SITE*
 - Calculate *Class_area_summary.ClassName* equal to *Landclass.ClassName*

Summarize landscape-level metrics:

The following instructs on how to obtain aggregate statistics for each landscape site. This is easily done with summary statistics for the attribute table.

1. Right click on Landclass_Dissolve.shp and choose OPEN ATTRIBUTE TABLE
2. Make sure there are no selected records (choose OPTIONS >>> CLEAR SELECTION)
3. Right click on the **SITE** heading and choose SUMMARIZE
4. Select all statistics for AREA and all statistics for PERIMETER
5. Specify the output table; e.g. **Site_area_summary.dbf**
6. Click OK and then YES to add the table to the map document
7. In the SOURCE tab of the table of contents, right click on Site_area_summary and choose OPEN
8. Break apart the SITE and CLASS into separate columns by following steps 4 through 10 in the previous section on page 3 (NOTE: *substitute Site_area_summary for 'attribute table of Landclass_Dissolve'*)
 - Calculate Site_area_summary.**SITE** equal to **Landclass.SITE**
 - Calculate Site_area_summary.**ClassName** equal to **Landclass.ClassName**

Do one more table summarization to obtain the number of classes for each site (a variety-type statistic).

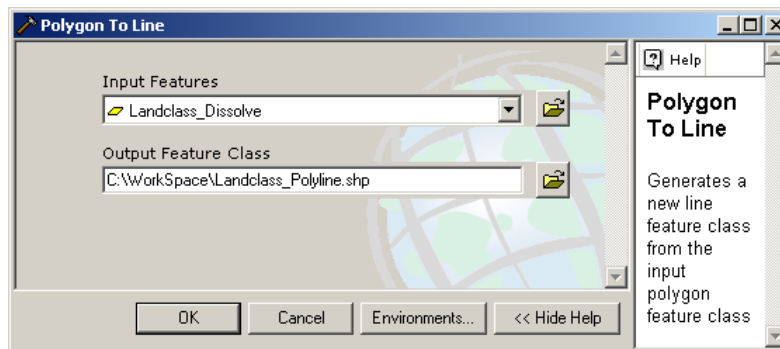
9. Open the attribute table for Class_area_summary.dbf
10. Right click on the SITE heading and choose SUMMARIZE
11. Select SUM – Sum_AREA as the only summary statistic
12. Specify and output table name; e.g. **Site_variety.dbf**
13. Click OK and open the table

The Count_SITE field indicates the total number of unique classes for each landscape site and the Sum_Sum_AREA indicates the total area for each landscape site.

Convert to polylines and calculate EDGE-based metrics:

The following requires access to functionality only available in ArcGIS' ArcInfo license:

1. Close all tables
2. Choose SELECTION >>> CLEAR SELECTED FEATURES
3. In ArcToolbox, locate the POLYGON TO LINE tool



4. Drag and drop Landclass_Dissolve as the input
5. Specify the directory and output name; e.g. **Landclass_Polyline.shp**
6. Click OK
7. Turn off all layers except for the new Landclass_Polyline

8. Open its attribute table

You now need to join the attributes from the original polygon layer to make this one more useful. Add some new fields to copy those attributes into.

9. Choose OPTION >>> ADD FIELD and add the following fields:

- **LClassName** (Text, 30)
- **RClassName** (Text, 30)
- **SITE** (Short, 2)
- **SITE_L_R** (Text, 50)
- **NAT_EDGE** (Text, 3)
- **LENGTH** (Double, 12, 4)
- **SITE_AREA** (Double, 12, 4)

10. In the table of contents, right click on Landclass_Polyline and choose JOINS AND RELATES >>> JOIN

11. Join Landclass_Polyline LEFT_FID to Landclass_Dissolve FID

12. Calculate Landclass_Polyline.**LClassName** equal to
Landclass_Dissolve.ClassName

The warning indicates that it cannot copy the null values.

13. Remove the join

14. Click the OPTIONS button >>> SELECT BY ATTRIBUTES: "**LEFT_FID**" = -1

15. CLOSE the selection dialog

16. Calculate **LClassName** equal to "Outside"

17. Click OPTIONS >>> CLEAR SELECTED FEATURES

18. Join Landclass_Polyline RIGHT_FID to Landclass_Dissolve FID

19. Calculate Landclass_Polyline.**RClassName** equal to
Landclass_Dissolve.ClassName

20. Calculate Landclass_Polyline.**SITE** equal to **Landclass_Dissolve.SITE**

21. Remove the join

22. Calculate **SITE_L_R** equal to [SITE] & " - " & [LClassName] & "_" & [RClassName]

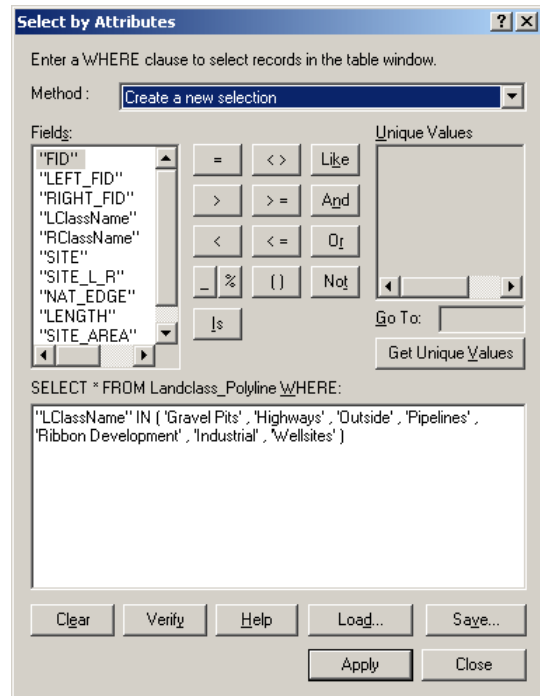
The "secret" for the following step is to select the human-related built-up classes to then code as being not natural edge – useful if you're interested in discerning landscape metrics for natural and non-natural edge. The following list summarizes the possible built-up classes in the example AVI data:

- Gravel Pits
- Highways
- Outside
- Pipelines
- Ribbon Development
- Industrial
- Wellsites

Examine your data and list your non-natural edge classes and substitute in the subsequent step. The IN keyword is used to select values in a list.

23. Access the SELECT BY ATTRIBUTES dialog and perform the following two steps in the exact order presented:

- CREATE a new selection:
`"LClassName" IN ('Gravel Pits' , 'Highways' , 'Outside' , 'Pipelines' , 'Ribbon Development' , 'Industrial' , 'Wellsites')`
- Click APPLY and then CLEAR
- ADD to current selection:
`"RClassName" IN ('Gravel Pits' , 'Highways' , 'Outside' , 'Pipelines' , 'Ribbon Development' , 'Industrial' , 'Wellsites')`
- Click APPLY



24. CLOSE the selection dialog

25. Calculate **NAT_EDGE** equal to "no"

26. Choose OPTIONS >>> SWITCH SELECTION

27. Calculate **NAT_EDGE** equal to "yes"

28. Choose OPTIONS >>> CLEAR SELECTED FEATURES

29. Calculate **LENGTH** using expressions copied and pasted from the Help Button (or load from saved expression used on page 3)

30. Join Landclass_Polyline SITE to Site_variety SITE

31. Calculate Landclass_Polyline.**SITE_AREA** equal to `Site_variety.Sum_Sum_AREA`

32. Remove the join

To calculate class-level edge metrics, summarize Landclass_Polyline by SITE_L_R:

33. Right click on the SITE_L_R heading and choose SUMMARIZE

34. Select all statistics for LENGTH and Min_SITE_AREA (this last one means you won't have to do a table join later to get the landscape site areas for edge densities)

35. Specify the output table name; e.g. **Class_edge_summary.dbf**

36. Click OK and open the table to examine it

37. Decide on the units for your edge density (length per area) metric:

Density Units	Add Field	Calculate Values...
meters per square meter	DENSITYm (Double, 12, 10)	<code>Sum_LENGTH / Min_SITE_AREA</code>
kilometers per square kilometer	DENSITYk (Double, 12, 4)	<code>([Sum_LENGTH] / 1000) / ([Min_SITE_A] / 1000000)</code>

38. To calculate landscape-level edge metrics, summarize Landclass_Polyline by SITE
39. Right click on the SITE heading and choose SUMMARIZE
40. Select all statistics for LENGTH and Min_SITE_AREA (*this last one means you won't have to do a table join later to get the landscape site areas for edge densities*)
41. Specify the output table name; e.g. **Site_edge_summary.dbf**
42. Click OK and open the table to examine it
43. Repeat steps 37 above for the landscape-level edge density

More metrics:

- Consult the FragStats documentation, scientific literature, and other landscape ecology resources to help you calculate additional metrics of use:
McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. USDA For. Serv. Gen. Tech. Rep. PNW-351.
<http://www.umass.edu/landeco/research/fragstats/fragstats.html>
<http://www.innovativegis.com/products/fragstatsarc/manual/index.html>
<http://flash.lakeheadu.ca/~rrempe/patch>
- Keep in mind the various differences between vector-based and raster-based calculations.; because FragStats 3.3 is raster-based values obtained through FragStats 3.3 may differ from what you calculate.
- Hopefully the above instructions have provided you with the skills to add the base attributes of area, perimeter, and length to your patches; it's now simply a matter of determining the join tables, copy values, and calculate the formulae comprised of the base attributes to obtain more complex patch-, class, and landscape- level metrics.

The screenshot displays two summary tables and two maps. The top table, 'Attributes of Site_edge_metrics', shows metrics for five sites. The bottom table, 'Attributes of Class_area_summary', shows metrics for five landclass categories. The maps show landclass polygons with blue highlighted lines representing non-natural edges.

OID	SITE	Count	Minimum_LEN	Maximum_LEN	Average_LEN	Sum_LENGTH	StdDev_LEN	Variance_LEN	Minimum_SITE_AREA	DENSITYk
0	1	261	0.13	5142.4305	312.6149	81592.4624	515.4967	265736.637	7847674.9513	10.397024
1	2	292	0.3109	2665.3913	220.1474	64283.0317	336.1363	112987.5961	5529616.5104	11.624900
2	3	200	4.2583	1423.5173	242.4928	48498.553	269.8786	72834.475	8439614.526	5.746537
3	4	130	4.7733	1188.2489	260.9267	33920.4687	258.4978	66821.1168	5649129.4067	6.004548
4	5	148	2.2681	2909.674	294.4011	43571.3673	464.8098	216048.173	6886932.9675	6.326672

SITE CLASS	Cnt.	Min AREA	Max AREA	Ave AREA	Sum AREA	SD AREA	Var AREA	Min PERIM	Max PERIM	Ave PERIM	Sum PERIME	SD PERIM	Var PERIM	SITE
2 - Jack Pine	6	1346.975	68803.3683	28779.3155	172675.692	23654.43	55953245	257.7506	2869.5426	1004.5461	6027.2764	948.9691	900542.296	2
2 - Tamarack	3	253.8659	139321.170	52310.689	156932.067	75836.97	57512475	73.5867	2623.1095	1234.3921	3703.1762	1423.833	2027300.45	2
2 - White Spruce	10	2.5113	106111.843	33755.8593	337558.593	47284.87	22358595	7.275	4021.7502	1111.3427	11113.4272	1428.2424	2039876.32	2
3 - Aspen	28	119.8496	103617.867	21893.0473	613005.323	28084.57	78874314	75.5358	2796.2254	707.1712	19800.7944	638.5868	407793.060	3
3 - Black Spruce	8	1650.4853	7000872.92	888608.975	7108871.80	2469798.	60999052	225.9306	38198.2155	5291.3988	42331.1901	13303.256	176976639.	3

The open tables show example output from the table summarizations; the blue highlighted lines indicate non-natural edges.