**Supplementary Material**

**AREA METRICS**

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| **(P4) Area** | | |
| area.jpg | | aij =     area (m2) of patch ij. |
| *Description* | AREA equals the area (m2) of the patch, divided by 10,000 (to convert to hectares). | |
| *Units* | Hectares | |
| *Range* | AREA > 0, without limit.  The range in AREA is limited by the grain and extent of the image; in a particular application, AREA may be further limited by the specification of a minimum patch size that is larger than the grain. | |
| *Comments* | The *area* of each patch comprising a landscape mosaic is perhaps the single most important and useful piece of information contained in the landscape. Not only is this information the basis for many of the patch, class, and landscape indices, but patch area has a great deal of ecological utility in its own right. Note that the choice of the 4-neighbor or 8-neighbor rule for delineating patches will have an impact on this metric. | |

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| **(P5) Perimeter** | | | |
| perim.jpg | | | pij =    perimeter (m) of patch ij. |
| *Description* | PERIM equals the perimeter (m) of the patch, including any internal holes in the patch, regardless of whether the perimeter represents ‘true’ edge or not (e.g., the case when a patch is artificially bisected by the landscape boundary when a landscape border is present). | | |
| *Units* | Meters | | |
| *Range* | PERIM > 0, without limit. | | |
| *Comments* | Patch*perimeter* is another fundamental piece of information available about a landscape and is the basis for many class and landscape metrics. Specifically, the perimeter of a patch is treated as an edge, and the intensity and distribution of edges constitutes a major aspect of landscape pattern. In addition, the relationship between patch perimeter and patch area is the basis for most shape indices. | | |
| **(P6) Radius of Gyration** | | | |
| gyrate.jpg | | hijr =   distance (m) between cell ijr [located within patch ij] and the centroid of patch ij (the average location), based on cell center-to-cell center distance.  z =                   number of cells in patch ij. | |
| *Description* | GYRATE equals the mean distance (m) between each cell in the patch and the patch centroid. | | |
| *Units* | Meters | | |
| *Range* | GYRATE ≥ 0, without limit.  GYRATE = 0 when the patch consists of a single cell and increases without limit as the patch increases in extent. GYRATE achieves its maximum value when the patch comprises the entire landscape. | | |
| *Comments* | *Radius of gyration* is a measure of patch extent; thus it is effected by both patch size and patch compaction. Note that the choice of the 4-neighbor or 8-neighbor rule for delineating patches will have an impact on this metric. | | |

**SHAPE METRICS**

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| **(P7) Perimeter-Area Ratio** | | |
| para.jpg | | pij =    perimeter (m) of patch ij.  aij =     area (m2) of patch ij. |
| *Description* | PARA equals the ratio of the patch perimeter (m) to area (m2). | |
| *Units* | None | |
| *Range* | PARA > 0, without limit. | |
| *Comments* | *Perimeter-area ratio* is a simple measure of shape complexity, but without standardization to a simple Euclidean shape (e.g., square). A problem with this metric as a shape index is that it varies with the size of the patch. For example, holding shape constant, an increase in patch size will cause a decrease in the perimeter-area ratio. | |

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| **(P8) Shape Index** | | |
| shape.jpg | | pij =                perimeter of patch ij in terms of number of cell surfaces.  min pij =         minimum perimeter of patch ij in terms of number of cell surfaces (see below). |
| *Description* | SHAPE equals patch perimeter (given in number of cell surfaces) divided by the minimum perimeter (given in number of cell surfaces) possible for a maximally compact patch (in a square raster format) of the corresponding patch area. If aij is the area of patch ij (in terms of number of cells) and n is the side of a largest integer square smaller than aij, and m = aij - n2, then the minimum perimeter of patch ij, min-pii will take one of the three forms (Milne 1991, Bogaert et al. 2000):  min-pii = 4n, when m = 0, or  min-pii = 4n + 2, when n2< aij ≤ n(1+n), or  min-pii = 4n + 4, when aij > n(1+n). | |
| *Units* | None | |
| *Range* | SHAPE ≥ 1, without limit.  SHAPE = 1 when the patch is maximally compact (i.e., square or almost square) and increases without limit as patch shape becomes more irregular. | |
| *Comments* | *Shape index* corrects for the size problem of the perimeter-area ratio index (see previous description) by adjusting for a square (or almost square) standard and, as a result, is the simplest and perhaps most straightforward measure of overall shape complexity. Note, the minimum perimeter for an aggregate of like-valued square pixels (aij) is calculated as above. For large patches, say aij > 100 pixels, the minimum perimeter asymptotically approaches ole.gif , the perimeter of an exact square of size aij. Previous versions of FRAGSTATS used this large patch approximation in the shape index. Thus, the results will not agree exactly with previous runs, although the differences will be nontrivial only in cases involving very small patches. | |

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| **(P9) Fractal Dimension Index** | | |
| frac.jpg | | pij =    perimeter (m) of patch ij.  aij =     area (m2) of patch ij. |
| *Description* | FRAC equals 2 times the logarithm of patch perimeter (m) divided by the logarithm of patch area (m2); the perimeter is adjusted to correct for the raster bias in perimeter. | |
| *Units* | None | |
| *Range* | 1 ≤ FRAC ≤ 2  A fractal dimension greater than 1 for a 2-dimensional patch indicates a departure from Euclidean geometry (i.e., an increase in shape complexity). FRAC approaches 1 for shapes with very simple perimeters such as squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters. | |
| *Comments* | *Fractal dimension index* is appealing because it reflects shape complexity across a range of spatial scales (patch sizes). Thus, like the shape index (SHAPE), it overcomes one of the major limitations of the straight perimeter-area ratio as a measure of shape complexity. | |

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| **(P10) Linearity Index** | | |
| linear.jpg | | aij\* =   area of patch ij in terms of number of cells.  b =      average cell value of the medial axis transformation (MAT) of a patch.  r =                   0 if the MAT skeleton contains side-by-side rows; 1 if not. |
| *Description* | LINEAR equals the area of the patch (in number of pixels) divided by 2 times the average value of the MAT skeleton minus 0 if the MAT skeleton contains side-by-side rows, 1 if not, quantity squared, minus 1, over the area of the patch (in number of cells). | |
| *Units* | None | |
| *Range* | 0 ≤ LINEAR < 1  LINEAR = 0 for square patches and approaches 1 for large patches which are all edge. Dividing by patch area normalizes the index since the maximum possible value of the numerator for a patch equals its area (when b = 1). | |
| *Comments* | *Linearity index* (Gustafson and Parker 1992) is based on the medial axis transformation (MAT) of the patch. Note, this index is not influenced by patch size. | |

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| **(P11) Related Circumscribing Circle** | | |
| circle.jpg | | aij =     area (m2) of patch ij.  aijs =   area (m2) of smallest circumscribing circle around patch ij. |
| *Description* | CIRCLE equals 1 minus patch area (m2) divided by the area (m2) of the smallest circumscribing circle. Note, the smallest circumscribing circle is computed mathematically based on the geometry of a true circle, despite the raster data format. In addition, to ensure that the minimum value is always zero, the diameter of the circumscribing circle is computed as the maximum distance between periphery cells based on outer edge-to-outer edge distance, as opposed to cell center-to-cell center distance used in all nearest neighbor calculations. | |
| *Units* | None | |
| *Range* | 0 ≤ CIRCLE < 1  CIRCLE = 0 for circular patches and approaches 1 for elongated, linear patches one cell wide. CIRCLE = 0 for one cell patches. | |
| *Comments* | *Related circumscribing circle* (CIRCLE) uses the smallest circumscribing circle instead of the smallest circumscribing square despite the raster data format because it is much simpler to implement. In contrast to the linearity index, related circumscribing circle provides a measure of overall patch elongation. A highly convoluted but narrow patch can have a high linearity index if the medial axial skeleton is close to the patch edge, but have a low related circumscribing circle index due to the relative compactness of the patch. Conversely, a narrow and elongated patch can have a high linearity index as well as a high related circumscribing circle index. This index may be particularly useful for distinguishing patches that are both linear (narrow) and elongated. | |

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| **(P12) Contiguity Index** | | |
| contig.jpg | | cijr =    contiguity value for pixel r in patch ij.  v =      sum of the values in a 3-by-3 cell template (13 in this case).  aij =     area of patch ij in terms of number of cells. |
| *Description* | CONTIG equals the average contiguity value (see comments) for the cells in a patch (i.e., sum of the cell values divided by the total number of pixels in the patch) minus 1, divided by the sum of the template values (13 in this case) minus 1. Note, 1 is subtracted from both the numerator and denominator to confine the index to a range of 1 | |
| *Units* | None | |
| *Range* | 0 ≤ CONTIG ≤ 1  CONTIG equals 0 for a one-pixel patch and increases to a limit of 1 as patch contiguity, or connectedness, increases. | |
| *Comments* | *Contiguity index* assesses the spatial connectedness, or contiguity, of cells within a grid-cell patch to provide an index of patch boundary configuration and thus patch shape (LaGro 1991). CONTIG is quantified by convolving a 3x3 pixel template with a binary digital image in which the pixels within the patch of interest are assigned a value of 1 and the background pixels (all other patch types) are given a value of zero. A template value of 2 is assigned to quantify horizontal and vertical pixel relationships within the image and a value of 1 is assigned to quantify diagonal relationships. This combination of integer values weights orthogonally contiguous pixels more heavily than diagonally contiguous pixels, yet keeps computations relatively simple. The center pixel in the template is assigned a value of 1 to ensure that a single-pixel patch in the output image has a value of 1, rather than 0. The value of each pixel in the output image, computed when at the center of the moving template, is a function of the number and location of pixels, of the same class, within the nine cell image neighborhood. Specifically, the contiguity value for a pixel in the output image is the sum of the products, of each template value and the corresponding input image pixel value, within the nine cell neighborhood. Thus, large contiguous patches result in larger contiguity index values. | |