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Appendix C. Definition and description of FRAGSTATS metrics.

In this section, each metric computed in FRAGSTATS is described. Metrics are grouped into patch, class, and landscape indices. Within each group, metrics are ordered in logical fashion according to the aspect of landscape structure measured. For example, the core area metrics (i.e., those based on core area measurements) are grouped together. Each metric is defined in mathematical terms, and the measurement units and theoretical range in values are reported. The acronym for the metric given on the left-hand side of the equation is the field name used in the ASCII output files. Where the vector and raster algorithms differ, we define both. A single notation scheme is used consistently for all metrics (Table. C.1). To facilitate interpretation of the algorithm, we intentionally separate from each equation any constants used to rescale the metric. For example, in many cases the right-hand side of the equation is multiplied by 100 to convert a proportion to a percentage, or multiplied or divided by 10,000 to convert m^2 to hectares. These conversion factors are separated out by parentheses even though they may be factored into the equation differently in the computational form of the algorithm. For each metric, the mathematical formula is described in narrative terms to facilitate interpretation of the formula.

Table C.1. Notation used in FRAGSTATS algorithms.

Subscripts

$i = 1, \ldots, m$ or m' patch types (classes)

$j = 1, \ldots, n$ patches

$k = 1, \ldots, m$ or m' patch types (classes)

$q = 1, \ldots, p$ disjunct core areas

$s = 1, \ldots, n$ patches, within specified neighborhood

Symbols

A =	Total landscape area (m^2).
a_{ij} =	area (m^2) of patch ij.
a_{ijs} =	area (m^2) of patch ijs within specified neighborhood (m) of patch ij.
a_{ij}^{c} =	core area (m^2) of patch ij based on specified buffer width (m).
a_{ijq}^{c} =	area (m^2) of disjunct core area q in patch ij based on specified buffer width (m).
p_{ij} =	perimeter (m) of patch ij.
p_{ijk} =	length (m) of edge of patch ij adjacent to patch type (class) k.

Table C.1. Continued.

E =	total length (m) of edge in landscape; includes landscape boundary and background edge segments if the user decides to treat boundary and background as edge; otherwise, only boundary segments representing true edge are included.
E' =	total length (m) of edge in landscape; includes entire landscape boundary and background edge segments regardless of whether they represent true edge.
e_{ik} =	total length (m) of edge in landscape between patch types (classes) i and k; includes landscape boundary segments representing true edge only involving patch type i.
e'_{ik} =	total length (m) of edge in landscape between patch types (classes) i and k; includes all landscape boundary and background edge segments involving patch type i, regardless of whether they represent true edge.
e''_{ik} =	total length (m) of edge in landscape between patch types (classes) i and k; includes the entire landscape boundary and all background edge segments, regardless of whether they represent true edge.
d_{ik} =	dissimilarity (edge contrast weight) between patch types i and k.
N =	total number of patches in the landscape, excluding any background patches.
N' =	total number of patches in the landscape that have nearest neighbors.
$n = n_i$ =	number of patches in the landscape of patch type (class) i.
$n' = n'_i$ =	number of patches in the landscape of patch type (class) i that have nearest neighbors.
n_{ij}^c =	number of disjunct core areas in patch ij based on specified buffer width (m).
m =	number of patch types (classes) present in the landscape, excluding the landscape border if present.
m' =	number of patch types (classes) present in the landscape, including the landscape border if present.
m_{max} =	maximum number of patch types (classes) present in a landscape.
h_{ij} =	distance (m) from patch ij to nearest neighboring patch of the same type (class), based on edge-to-edge distance.
h_{ijs} =	distance (m) between patch ijs [located within specified neighborhood distance (m) of patch ij] and patch ij, based on edge-to-edge distance.
g_{ik} =	number of adjacencies (joins) between pixels of patch types (classes) i and k.
P_i =	proportion of the landscape occupied by patch type (class) i.

Patch Indices

(P1) Landscape ID

The first field in the patch output file is landscape ID (LID). Landscape ID is set to the name of the input coverage (coverage) in the vector version and the name of the input image (in_image) in the raster version.

(P2) Patch ID

The second field in the patch output file is patch ID (PID). The vector version of FRAGSTATS contains an option (patch_id) to name an attribute that contains unique ID's for each patch. If an attribute is not specified, the "coverage"# attribute is used. Likewise, the raster version of FRAGSTATS contains an option (id_image) to name an image that contains unique ID's for each patch. If an image is not specified, FRAGSTATS will create unique ID's for each patch and optionally produce an image that contains patch ID's that correspond to the FRAGSTATS output.

(P3) Patch Type

The third field in the patch output file is patch type (TYPE). The vector version of FRAGSTATS contains an option (descriptor) to name an attribute that contains character descriptors for each patch type. Likewise, the raster version of FRAGSTATS contains an option (desc_file) to name an ASCII file that contains character descriptors for each patch type. In both versions, if the patch type options are not used, FRAGSTATS will write the numeric patch type codes to TYPE.

(P4) Area

Vector/Raster

$$AREA = a_{ij}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: AREA > 0, without limit.

The range in AREA is limited by the grain and extent of the image, and in a particular application, AREA may be further limited by the specification of a minimum patch size that is larger than the grain.

Description: AREA equals the area (m^2) of the patch, divided by 10,000 (to convert to hectares).

(P5) Landscape Similarity Index

Vector/Raster

$$LSIM = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A} (100)$$

Units: Percent

Range: 0 < LSIM ≤ 100

LSIM approaches 0 when the corresponding patch type (class) becomes increasingly rare in the landscape. LSIM = 100 when the entire landscape consists of the corresponding patch type; that is, when the entire image is comprised of a single patch.

Description: LSIM equals total class area (m^2) divided by total landscape area (m^2), multiplied by 100 (to convert to a percentage); in other words, LSIM equals the percentage of the landscape comprised of the corresponding patch type. Note that LSIM is equivalent to %LAND at the class level.

(P6) Perimeter

Vector/Raster

$$PERIM = p_{ij}$$

Units: Meters

Range: PERIM > 0, without limit.

Description: PERIM equals the perimeter (m) of the patch, including any internal holes in the patch.

(P7) Edge Contrast Index

Vector/Raster

$$EDGECON = \frac{\sum_{k=1}^{m'} (p_{ijk} \circ d_{ik})}{p_{ij}} (100)$$

Units: Percent

Range: $0 \le EDGECON \le 100$

EDGECON = 0 if the landscape consists of only 1 patch and either the landscape boundary contains no edge (when a border is present) or the boundary is not to be treated as edge (when a border is absent). Also, EDGECON = 0 when all of the patch perimeter segments involve patch type adjacencies that have been given a zero-contrast weight in the edge contrast weight file. EDGECON = 100 when the entire patch perimeter is maximum-contrast edge ($d = 1$). EDGECON < 100 when a portion of the patch perimeter is less than maximum-contrast edge ($d < 1$). EDGECON is reported as "NA" in the "basename".full file and a dot "." in the "basename".patch file if a contrast weight file is not specified by the user.

Description: EDGECON equals the sum of the patch perimeter segment lengths (m) multiplied by their corresponding contrast weights, divided by total patch perimeter (m), multiplied by 100 (to convert to a percentage). Any perimeter segment along the landscape boundary (if a border is absent) or bordering background is assigned the edge contrast weight specified by the user (see bound_wght option).

(P8) Shape Index

Vector

$$SHAPE = \frac{p_{ij}}{2\sqrt{\pi \circ a_{ij}}}$$

Raster

$$SHAPE = \frac{.25\ p_{ij}}{\sqrt{a_{ij}}}$$

Units: None

Range: SHAPE ≥ 1, without limit.

SHAPE = 1 when the patch is circular (vector) or square (raster) and increases without limit as patch shape becomes more irregular.

Description: SHAPE equals patch perimeter (m) divided by the square root of patch area (m^2), adjusted by a constant to adjust for a circular standard (vector) or square standard (raster).

(P9) Fractal Dimension

Vector

$$FRACT = \frac{2\ \ln p_{ij}}{\ln a_{ij}}$$

Raster

$$FRACT = \frac{2\ \ln (.25\ p_{ij})}{\ln a_{ij}}$$

Units: None

Range: $1 \leq FRACT \leq 2$

A fractal dimension greater than 1 for a 2-dimensional patch indicates a departure from euclidean geometry (i.e., an increase in shape complexity). FRACT approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters.

Description: FRACT equals 2 times the logarithm of patch perimeter (m) divided by the logarithm of patch area (m^2); the raster formula is adjusted to correct for the bias in perimeter (Li 1989).

(P10) Core Area

Vector/Raster

$$CORE = a_{ij}^{c}\left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: $CORE \geq 0$, without limit.

CORE = 0 when every location within the patch is within the specified edge distance from the patch perimeter (i.e., edge width). CORE approaches AREA as the specified edge distance decreases and as patch shape is simplified.

Description: CORE equals the area (m^2) within the patch that is further than the specified edge distance from the patch perimeter, divided by 10,000 (to convert to hectares). Note that raster version of FRAGSTATS employs the 4-neighbor approach when determining which cells are core and which are in the edge buffer.

(P11) Number of Core Areas

Vector/Raster

$$NCORE = n_{ij}^{c}$$

Units: None

Range: $NCORE \geq 0$, without limit.

NCORE = 0 when CORE = 0 [i.e., every location within the patch is within the specified edge distance from the patch perimeter (i.e., edge width)]. NCORE > 1 when, because of shape, the patch contains disjunct core areas.

Description: NCORE equals the number of disjunct core areas contained within the patch boundary.

(P12) Core Area Index

Vector/Raster

$$CAI = \frac{a_{ij}^{c}}{a_{ij}} (100)$$

Units: Percent

Range: $0 \leq CAI < 100$

CAI = 0 when CORE = 0 [i.e., every location within the patch is within the specified edge distance from the patch perimeter (i.e., edge width)]; that is, when the patch contains no core area. CAI approaches 100 when the patch, because of size, shape, and edge width, contains mostly core area.

Description: CAI equals the patch core area (m^2) divided by total patch area (m^2), multiplied by 100 (to convert to a percentage); in other words, CAI equals the percentage of a patch that is core area.

(P13) Nearest-Neighbor Distance

Raster

$$NEAR = h_{ij}$$

Units: Meters

Range: NEAR > 0, without limit.

NEAR is reported as "None" in the "basename.full" output file and a dot in the "basename.patch" output file if no other patch of the same type exists in the landscape.

Description: NEAR equals the distance (m) to the nearest neighboring patch of the same type, based on shortest edge-to-edge distance.

(P14) Proximity Index

Raster

$$\text{PROXIM} = \sum_{s=1}^{n} \frac{a_{ijs}}{h_{ijs}^2}$$

Units: None

Range: PROXIM ≥ 0.

PROXIM = 0 if a patch has no neighbors of the same patch type within the specified search radius. PROXIM increases as the neighborhood (defined by the specified search radius) is increasingly occupied by patches of the same type and as those patches become closer and more contiguous and less fragmented in distribution. The upper limit of PROXIM is affected by the search radius and minimum distance between patches. PROXIM is reported as "NA" in the "basename".full file and a dot "." in the "basename".patch file if a search radius is not specified by the user.

Description: PROXIM equals the sum of patch area (m^2) divided by the nearest edge-to-edge distance squared (m^2) between the patch and the focal patch of all patches of the corresponding patch type whose edges are within a specified distance (m) of the focal patch. Note, when the search buffer extends beyond the landscape boundary, only patches contained within the landscape are considered in the computations.

Class Indices

(C1) Landscape ID (LID)

The first field in the class output file is landscape ID (LID); it is defined as in the patch output file (see previous discussion).

(C2) Patch Type (TYPE)

The second field in the class output file is patch type (TYPE); it is defined as in the patch output file (see previous discussion).

(C3) Class Area

Vector/Raster

$$CA = \sum_{j=1}^{n} a_{ij} \left(\frac{1}{10,000} \right)$$

Units: Hectares

Range: CA > 0, without limit.

CA approaches 0 as the patch type becomes increasing rare in the landscape. CA = TA when the entire landscape consists of a single patch type; that is, when the entire image is comprised of a single patch.

Description: CA equals the sum of the areas (m^2) of all patches of the corresponding patch type, divided by 10,000 (to convert to hectares); that is, total class area.

(C4) Total Landscape Area

Vector/Raster

$$TA = A \left(\frac{1}{10,000} \right)$$

Units: Hectares

Range: TA > 0, without limit.

Description: TA equals the area (m^2) of the landscape, divided by 10,000 (to convert to hectares). TA excludes the area of any background patches within the landscape.

(C5) Percent of Landscape

Vector/Raster

$$\%LAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100)$$

Units: Percent

Range: $0 < \%LAND \leq 100$

%LAND approaches 0 when the corresponding patch type (class) becomes increasingly rare in the landscape. %LAND = 100 when the entire landscape consists of a single patch type; that is, when the entire image is comprised of a single patch.

Description: %LAND equals the sum of the areas (m^2) of all patches of the corresponding patch type, divided by total landscape area (m^2), multiplied by 100 (to convert to a percentage); in other words, %LAND equals the percentage the landscape comprised of the corresponding patch type. Note that %LAND is equivalent to LSIM at the patch level.

(C6) Largest Patch Index

Vector/Raster

$$LPI = \frac{\max_{j=1}^{n}(a_{ij})}{A}(100)$$

Units: Percent

Range: $0 < LPI \leq 100$

LPI approaches 0 when the largest patch of the corresponding patch type is increasing small. LPI = 100 when the entire landscape consists of a single patch of the corresponding patch type; that is, when the largest patch comprises 100% of the landscape.

Description: LPI equals the area (m^2) of the largest patch of the corresponding patch type divided by total landscape area, multiplied by 100 (to convert to a percentage); in other words, LPI equals the percentage of the landscape comprised by the largest patch.

(C7) Number of Patches

Vector/Raster

$$NP = n_i$$

Units: None

Range: NP ≥ 1, without limit.

NP = 1 when the landscape contains only 1 patch of the corresponding patch type; that is, when the class consists of a single patch.

Description: NP equals the number of patches of the corresponding patch type (class).

(C8) Patch Density

Vector/Raster

$$PD = \frac{n_i}{A}(10{,}000)(100)$$

Units: Number per 100 hectares

Range: PD > 0, without limit.

Description: PD equals the number of patches of the corresponding patch type (NP) divided by total landscape area, multiplied by 10,000 and 100 (to convert to 100 hectares).

(C9) Mean Patch Size

Vector/Raster

$$MPS = \frac{\sum_{j=1}^{n} a_{ij}}{n_i}\left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: MPS > 0, without limit.

The range in MPS is limited by the grain and extent of the image and the minimum patch size in the same manner as patch area (AREA).

Description: MPS equals the sum of the areas (m^2) of all patches of the corresponding patch type, divided by the number of patches of the same type, divided by 10,000 (to convert to hectares).

(C10) Patch Size Standard Deviation

Vector/Raster

$$PSSD = \sqrt{\frac{\sum_{j=1}^{n}\left[a_{ij} - \left(\frac{\sum_{j=1}^{n} a_{ij}}{n_i}\right)\right]^2}{n_i}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: PSSD ≥ 0, without limit.

PSSD = 0 when all patches in the class are the same size or when there is only 1 patch (i.e., no variability in patch size).

Description: PSSD equals the square root of the sum of the squared deviations of each patch area (m^2) from the mean patch size of the corresponding patch type, divided by the number of patches of the same type, divided by 10,000 (to convert to hectares); that is, the root mean squared error (deviation from the mean) in patch size. Note, this is the population standard deviation, not the sample standard deviation.

(C11) Patch Size Coefficient of Variation

Vector/Raster

$$PSCV = \frac{PSSD}{MPS}(100)$$

Units: Percent

Range: PSCV ≥ 0, without limit.

PSCV = 0 when all patches in the class are the same size or when there is only 1 patch (i.e., no variability in patch size).

Description: PSCV equals the standard deviation in patch size (PSSD) divided by the mean patch size of the corresponding patch type (MPS), multiplied by 100 (to convert to percent); that is, the variability in patch size relative to the mean patch size. Note, this is the population coefficient of variation, not the sample coefficient of variation.

(C12) Total Edge

Vector/Raster

$$TE = \sum_{k=1}^{m'} e_{ik}$$

Units: Meters

Range: TE ≥ 0, without limit.

TE = 0 when there is no class edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of the corresponding patch type and the user specifies that none of the landscape boundary and background edge be treated as edge.

Description: TE equals the sum of the lengths (m) of all edge segments involving the corresponding patch type. If a landscape border is present, TE includes landscape boundary segments involving the corresponding patch type and representing true edge only (i.e., contrast weight > 0). If a landscape border is absent, TE includes a user-specified proportion of landscape boundary segments involving the corresponding patch type. Regardless of whether a landscape border is present or not, TE includes a user-specified proportion of background edge segments involving the corresponding patch type.

(C13) Edge Density

Vector/Raster

$$ED = \frac{\sum_{k=1}^{m'} e_{ik}}{A}(10{,}000)$$

Units: Meters per hectare.

Range: ED ≥ 0, without limit.

ED = 0 when there is no class edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of the corresponding patch type and the user specifies that none of the landscape boundary and background edge be treated as edge.

Description: ED equals the sum of the lengths (m) of all edge segments involving the corresponding patch type, divided by the total landscape area (m^2), multiplied by 10,000 (to convert to hectares). If a landscape border is present, ED includes landscape boundary segments involving the corresponding patch type and representing true edge only (i.e., contrast weight > 0). If a landscape border is absent, ED includes a user-specified proportion of landscape boundary segments involving the corresponding patch type. Regardless of whether a landscape border is present or not, ED includes a user-specified proportion of background edge segments involving the corresponding patch type.

(C14) Contrast-Weighted Edge Density

Vector/Raster

$$CWED = \frac{\sum_{k=1}^{m'} (e_{ik} \circ d_{ik})}{A} (10{,}000)$$

Units: Meters per hectare.

Range: CWED ≥ 0, without limit.

CWED = 0 when there is no class edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of the corresponding patch type and the user specifies that none of the landscape boundary and background edge be treated as edge. CWED increases as the amount of class edge in the landscape increases and/or as the contrast in edges involving the corresponding patch type increase (i.e., contrast weight approaches 1). CWED is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if a contrast weight file is not specified by the user.

Description: CWED equals the sum of the lengths (m) of each edge segment involving the corresponding patch type multiplied by the corresponding contrast weight, divided by the total landscape area (m^2), multiplied by 10,000 (to convert to hectares). If a landscape border is present, CWED includes landscape boundary segments involving the corresponding patch type and representing true edge only (i.e., contrast weight > 0). If a landscape border is absent, all landscape boundary edge segments involving the corresponding patch type are assigned the edge contrast weight specified by the user (see bound_wght option). This is equivalent to treating the specified proportion of all boundary edge segments involving the corresponding patch type as maximum-contrast edge. Regardless of whether a landscape border is present or not, all background edge segments involving the corresponding patch type are assigned the edge contrast weight specified by the user. Again, this is equivalent to treating the specified proportion of all background edge segments involving the corresponding patch type as maximum-contrast edge.

(C15) Total Edge Contrast Index

Vector/Raster

$$\text{TECI} = \frac{\sum_{k=1}^{m'} (e_{ik} \circ d_{ik})}{\sum_{k=1}^{m'} e'_{ik}} (100)$$

Units: Percent.

Range: $0 \leq \text{TECI} \leq 100$

TECI = 0 when there is no class edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of the corresponding patch type and the user specifies that none of the landscape boundary and background edge be treated as edge. TECI approaches 0 as the contrast in edges involving the corresponding patch type lesson (i.e., contrast weight approaches 0). TECI = 100 when all class edge is maximum contrast (i.e., contrast weight = 1). TECI is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if a contrast weight file is not specified by the user.

Description: TECI equals the sum of the lengths (m) of each edge segment involving the corresponding patch type multiplied by the corresponding contrast weight, divided by the sum of the lengths (m) of all edge segments involving the same type, multiplied by 100 (to convert to a percentage). In the numerator, if a landscape border is present, all edge segments along the landscape boundary involving the corresponding patch type are treated according to their edge contrast weights as designated in the contrast weight file. If a landscape border is absent, all landscape boundary segments involving the corresponding patch type are assigned the edge contrast weight specified by the user (see bound_wght option). Note that this is equivalent to treating the specified proportion of all boundary edge segments involving the corresponding patch type as maximum-contrast edge and the remainder as zero-contrast edge. Regardless of whether a landscape border is present or not, all background edge segments involving the corresponding patch type are assigned the edge contrast weight specified by the user. Again, note that this is equivalent to treating the specified proportion of all background edge segments involving the corresponding patch type as maximum-contrast edge and the remainder as zero-contrast edge. In the denominator, all edges involving the corresponding patch type are included, including the landscape boundary and background edge segments, regardless of whether they represent true edge or not or how the user chooses to handle boundary and background edges.

(C16) Mean Edge Contrast Index

Vector/Raster

$$MECI = \frac{\sum_{j=1}^{n} \left[\frac{\sum_{k=1}^{m'} (p_{ijk} \circ d_{ik})}{p_{ij}} \right]}{n_i} (100)$$

Units: Percent.

Range: $0 \leq MECI \leq 100$

MECI = 0 when there is no class edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of the corresponding patch type and the user specifies that none of the landscape boundary and background edge be treated as edge. MECI approaches 0 as the contrast in edges involving the corresponding patch type lesson (i.e., contrast weight approaches 0). MECI = 100 when all class edge is maximum contrast (i.e., contrast weight = 1). MECI is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if a contrast weight file is not specified by the user.

Description: MECI equals the sum of the segment lengths (m) of each patches' perimeter multiplied by their corresponding contrast weights, divided by total patch perimeter (m), summed across all patches of the corresponding patch type, divided by the number of patches of the same type, multiplied by 100 (to convert to a percentage). If a landscape border is present, any patch perimeter segments along the landscape boundary are treated according to their edge contrast weights as designated in the contrast weight file. If a landscape border is absent, any patch perimeter segments along the landscape boundary are assigned the edge contrast weight specified by the user (see bound_wght option). Regardless of whether a landscape border is present or not, all patch perimeter segments bordering background are assigned the edge contrast weight specified by the user.

(C17) Area-Weighted Mean Edge Contrast Index

Vector/Raster

$$AWMECI = \sum_{j=1}^{n}\left(\left[\frac{\sum_{k=1}^{m'}(p_{ijk} \circ d_{ik})}{p_{ij}}\right]\left[\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}\right]\right)(100)$$

Units: Percent.

Range: $0 \leq AWMECI \leq 100$

AWMECI = 0 when there is no class edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of the corresponding patch type and the user specifies that none of the landscape boundary and background edge be treated as edge. AWMECI approaches 0 as the contrast in edges involving the corresponding patch type lesson (i.e., contrast weight approaches 0). AWMECI = 100 when all class edge is maximum contrast (i.e., contrast weight = 1). AWMECI is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if a contrast weight file is not specified by the user.

Description: AWMECI equals the sum of the segment lengths (m) of each patches' perimeter multiplied by their corresponding contrast weights, divided by total patch perimeter (m), multiplied by patch area (m^2) divided by the sum of patch areas, summed across all patches of the corresponding patch type, multiplied by 100 (to convert to a percentage). If a landscape border is present, any patch perimeter segments along the landscape boundary are treated according to their edge contrast weights as designated in the contrast weight file. If a landscape border is absent, any patch perimeter segments along the landscape boundary are assigned the edge contrast weight specified by the user (see bound_wght option). Regardless of whether a landscape border is present or not, all patch perimeter segments bordering background are assigned the edge contrast weight specified by the user. AWMECI is similar to MECI except that each patch weighted by its size in computing the average patch edge contrast index.

(C18) Landscape Shape Index

Vector

$$LSI = \frac{\sum_{k=1}^{m} e''_{ik}}{2\sqrt{\pi \circ A}}$$

Raster

$$LSI = \frac{.25\sum_{k=1}^{m} e''_{ik}}{\sqrt{A}}$$

Units: None

Range: LSI ≥ 1, without limit.

LSI = 1 when the landscape consists of a single patch of the corresponding type and is circular (vector) or square (raster); LSI increases without limit as landscape shape becomes more irregular and/or as the length of edge within the landscape of the corresponding patch type increases.

Description: LSI equals the sum of the landscape boundary (regardless of whether it represents true edge or not) and all edge segments (m) within the landscape boundary involving the corresponding patch type (including those bordering background), divided by the square root of the total landscape area (m^2), adjusted by a constant for a circular standard (vector) or square standard (raster).

(C19) Mean Shape Index

Vector

$$MSI = \frac{\sum_{j=1}^{n} \left(\frac{p_{ij}}{2\sqrt{\pi \circ a_{ij}}} \right)}{n_i}$$

Raster

$$MSI = \frac{\sum_{j=1}^{n} \left(\frac{.25\, p_{ij}}{\sqrt{a_{ij}}} \right)}{n_i}$$

Units: None

Range: MSI ≥ 1, without limit.

MSI = 1 when all patches of the corresponding patch type are circular (vector) or square (raster); MSI increases without limit as the patch shapes become more irregular.

Description: MSI equals the sum of the patch perimeter (m) divided by the square root of patch area (m^2) for each patch of the corresponding patch type, adjusted by a constant to adjust for a circular standard (vector) or square standard (raster), divided by the number of patches of the same type; in other words, MSI equals the average shape index (SHAPE) of patches of the corresponding patch type.

(C20) Area-Weighted Mean Shape Index

Vector

$$AWMSI = \sum_{j=1}^{n} \left[\left(\frac{p_{ij}}{2\sqrt{\pi \cdot a_{ij}}} \right) \left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \right) \right]$$

Raster

$$AWMSI = \sum_{j=1}^{n} \left[\left(\frac{.25 p_{ij}}{\sqrt{a_{ij}}} \right) \left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \right) \right]$$

Units: None

Range: AWMSI ≥ 1, without limit.

AWMSI = 1 when all patches of the corresponding patch type are circular (vector) or square (raster); AWMSI increases without limit as the patch shapes become more irregular.

Description: AWMSI equals the sum, across all patches of the corresponding patch type, of each patch perimeter (m) divided by the square root of patch area (m^2), adjusted by a constant to adjust for a circular standard (vector) or square standard (raster), multiplied by the patch area (m^2) divided by total class area (sum of patch area for each patch of the corresponding patch type). In other words, AWMSI equals the average shape index (SHAPE) of patches of the corresponding patch type, weighted by patch area so that larger patches weigh more than smaller patches.

(C21) Double Log Fractal Dimension

Vector/Raster

$$DLFD = \frac{2}{\dfrac{\left[n_i \sum_{j=1}^{n} (\ln p_{ij} \cdot \ln a_{ij}) \right] - \left[\left(\sum_{j=1}^{n} \ln p_{ij} \right) \left(\sum_{j=1}^{n} \ln a_{ij} \right) \right]}{\left(n_i \sum_{j=1}^{n} \ln p_{ij}^2 \right) - \left(\sum_{j=1}^{n} \ln p_{ij} \right)^2}}$$

Units: None

Range: 1 ≤ DLFD ≤ 2

A fractal dimension greater than 1 for a 2-dimensional landscape mosaic indicates a departure from a euclidean geometry (i.e., an increase in patch shape complexity). DLFD approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters. DLFD employs regression techniques and is subject to small sample problems. Specifically, DLFD may greatly exceed the theoretical range in values when the number of patches is small (e.g.,

<10), and its use should be avoided in such cases. In addition, DLFD requires patches to vary in size. Thus, DLFD is undefined and reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if all patches are the same size or there is only 1 patch.

Description: DLFD equals 2 divided by the slope of regression line obtained by regressing the logarithm of patch area (m^2) against the logarithm of patch perimeter (m).

(C22) Mean Patch Fractal Dimension

Vector

$$MPFD = \frac{\sum_{j=1}^{n} \left(\frac{2 \ln p_{ij}}{\ln a_{ij}} \right)}{n_i}$$

Raster

$$MPFD = \frac{\sum_{j=1}^{n} \left(\frac{2 \ln (.25 p_{ij})}{\ln a_{ij}} \right)}{n_i}$$

Units: None

Range: $1 \le MPFD \le 2$

A fractal dimension greater than 1 for a 2-dimensional landscape mosaic indicates a departure from a euclidean geometry (i.e., an increase in patch shape complexity). MPFD approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters.

Description: MPFD equals the sum of 2 times the logarithm of patch perimeter (m) divided by the logarithm of patch area (m^2) for each patch of the corresponding patch type, divided by the number of patches of the same type; the raster formula is adjusted to correct for the bias in perimeter (Li 1989).

(C23) Area-Weighted Mean Patch Fractal Dimension

Vector

$$AWMPFD = \sum_{j=1}^{n} \left[\left(\frac{2 \ln p_{ij}}{\ln a_{ij}} \right) \left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \right) \right]$$

Raster

$$AWMPFD = \sum_{j=1}^{n} \left[\left(\frac{2 \ln (.25 p_{ij})}{\ln a_{ij}} \right) \left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \right) \right]$$

Units: None

Range: $1 \le AWMPFD \le 2$

A fractal dimension greater than 1 for a 2-dimensional landscape mosaic indicates a departure from a euclidean geometry (i.e., an increase in patch shape complexity). AWMPFD approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters.

Description: AWMPFD equals the sum, across all patches of the corresponding patch type, of 2 times the logarithm of patch perimeter (m) divided by the logarithm of patch area (m^2), multiplied by the patch area (m^2) divided by total class area (sum of patch area for each patch of the corresponding patch type); the raster formula is adjusted to correct for the bias in perimeter (Li 1989). In other words, AWMPFD equals the average patch fractal dimension (FRACT) of patches of the corresponding patch type, weighted by patch area so that larger patches weigh more than smaller patches.

(C24) Core Area Percent of Landscape

Vector/Raster

$$C\%LAND = \frac{\sum_{j=1}^{n} a_{ij}^{c}}{A}(100)$$

Units: Percent

Range: $0 \leq C\%LAND < 100$

C%LAND approaches 0 when core area of the corresponding patch type (class) becomes increasingly rare in the landscape, because of increasing smaller patches and/or more convoluted patch shapes. C%LAND approaches 100 when the entire landscape consists of a single patch type (i.e., when the entire image is comprised of a single patch) and the specified edge width approaches zero.

Description: C%LAND equals the sum of the core areas of each patch (m^2) of the corresponding patch type, divided by total landscape area (m^2), multiplied by 100 (to convert to a percentage); in other words, C%LAND equals the percentage the landscape comprised of core area of the corresponding patch type.

(C25) Total Core Area

Vector/Raster

$$TCA = \sum_{j=1}^{n} a_{ij}^{c}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: TCA ≥ 0, without limit.

TCA = 0 when every location within each patch of the corresponding patch type is within the specified edge distance from the patch perimeters. TCA approaches CA as the specified edge distance decreases and as patch shapes are simplified.

Description: TCA equals the sum of the core areas of each patch (m^2) of the corresponding patch type, divided by 10,000 (to convert to hectares).

(C26) Number of Core Areas

Vector/Raster

$$NCA = \sum_{j=1}^{n} n_{ij}^{c}$$

Units: None

Range: NCA ≥ 0, without limit.

NCA = 0 when TCA = 0 (i.e., every location within patches of the corresponding patch type are within the specified edge distance from the patch perimeters). NCA > 1 when, due to patch shape complexity, a patch contains more than 1 core area.

Description: NCA equals the sum of the number of disjunct core areas contained within each patch of the corresponding patch type; that is, the number of disjunct core areas contained within the landscape.

(C27) Core Area Density

Vector/Raster

$$CAD = \frac{\sum_{j=1}^{n} n_{ij}^{c}}{A}(10{,}000)(100)$$

Units: Number per 100 hectares

Range: CAD ≥ 0, without limit.

CAD = 0 when TCA = 0 (i.e., every location within patches of the corresponding patch type are within the specified edge distance from the patch perimeters); in other words, when there are no core areas.

Description: CAD equals the sum of number of disjunct core areas contained within each patch of the corresponding patch type, divided by total landscape area, multiplied by 10,000 and 100 (to convert to 100 hectares).

(C28) Mean Core Area Per Patch

Vector/Raster

$$MCA1 = \frac{\sum_{j=1}^{n} a_{ij}^{c}}{n_i} \left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: MCA1 ≥ 0, without limit.

Ultimately, the range in MCA1 is limited by the grain and extent of the image and the minimum patch size in the same manner as mean patch size (MPS), but MCA1 is also effected by the specified edge width. MCA1 = 0 when total core area = 0 (i.e., every location within patches of the corresponding patch type are within the specified edge distance from the patch perimeters); in other words, when there are no core areas. MCA1 approaches MPS as the specified edge width decreases and as patch shapes are simplified.

Description: MCA1 equals the sum of the core areas of each patch (m^2) of the corresponding patch type, divided by the number of patches of the same type, divided by 10,000 (to convert to hectares). Note that MCA1 equals the average core area per patch, not the average size of disjunct core areas, as in MCA2.

(C29) Patch Core Area Standard Deviation

Vector/Raster

$$CASD1 = \sqrt{\frac{\sum_{j=1}^{n}\left[a_{ij}^{c} - \left(\frac{\sum_{j=1}^{n} a_{ij}^{c}}{n_i}\right)\right]^2}{n_i}} \left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: CASD1 ≥ 0, without limit.

CASD1 = 0 when all patches in the class have the same core area or when there is only 1 patch (i.e., no variability in core area).

Description: CASD1 equals the square root of the sum of the squared deviations of each patch core area (m^2) from the mean core area per patch (MCA1) of the corresponding patch type, divided by the number of patches of the same type, divided by 10,000 (to convert to hectares); that is, the root mean squared error (deviation from the mean) in patch core area. Note, this is the population standard deviation, not the sample standard deviation, and that CASD1 represents the variation in core area among patches, not among disjunct core areas, as in CASD2.

(C30) Patch Core Area Coefficient of Variation

Vector/Raster

$$CACV1 = \frac{CASD1}{MCA1}(100)$$

Units: Percent

Range: CACV1 ≥ 0, without limit.

CACV1 = 0 when all patches in the class have the same core area or when there is only 1 patch (i.e., no variability in core area).

Description: CACV1 equals the standard deviation in core area of patches (CASD1) divided by the mean core area per patch (MCA1) of the corresponding patch type, multiplied by 100 (to convert to percent); that is, the variability in core area relative to the mean core area. Note, this is the population coefficient of variation, not the sample coefficient of variation, and that CACV1 represents the variation in core area among patches, not among disjunct core areas, as in CACV2.

(C31) Mean Area Per Disjunct Core

Vector/Raster

$$MCA2 = \frac{\sum_{j=1}^{n}\sum_{q=1}^{p} a_{ijq}^{c}}{\sum_{j=1}^{n} n_{ij}^{c}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: MCA2 ≥ 0, without limit.

Ultimately, the range in MCA2 is limited by the grain and extent of the image and the minimum patch size in the same manner as mean patch size (MPS), but MCA2 is also effected by the specified edge width. MCA2 = 0 when total core area = 0 (i.e., every location within patches of the corresponding patch type are within the specified edge distance from the patch perimeters); in other words, when there are no core areas. MCA2 approaches MPS as the specified edge width decreases and as patch shapes are simplified.

Description: MCA2 equals the sum of the disjunct core areas of each patch (m^2) of the corresponding patch type, divided by the number of disjunct core areas of the same type, divided by 10,000 (to convert to hectares). Note that MCA2 equals the average size of disjunct core areas, not the average core area per patch, as in MCA1.

(C32) Disjunct Core Area Standard Deviation

Vector/Raster

$$CASD2 = \sqrt{\frac{\sum_{j=1}^{n}\sum_{q=1}^{p}\left[a_{ijq}^{c} - \left(\frac{\sum_{j=1}^{n}\sum_{q=1}^{p} a_{ijq}^{c}}{\sum_{j=1}^{n} n_{ij}^{c}}\right)\right]^2}{\sum_{j=1}^{n} n_{ij}^{c}}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: CASD2 ≥ 0, without limit.

CASD2 = 0 when all disjunct core areas are the same size or when there is only 1 core area (i.e., no variability in core area).

Description: CASD2 equals the square root of the sum of the squared deviations of each disjunct core area (m^2) from the mean size of disjunct core areas (MCA2) of the corresponding patch type, divided by the number of disjunct core areas of the same type, divided by 10,000 (to convert to hectares); that is, the root mean squared error (deviation from the mean) in the size of disjunct core areas. Note, this is the population standard deviation, not the sample standard deviation, and that CASD2 represents the variation in size of disjunct core areas, not patch core areas, as in CASD1.

(C33) Disjunct Core Area Coefficient of Variation

Vector/Raster

$$CACV2 = \frac{CASD2}{MCA2}(100)$$

Units: Percent

Range: CACV2 ≥ 0, without limit.

CACV2 = 0 when all disjunct core areas are the same size or when there is only 1 core area (i.e., no variability in core area).

Description: CACV2 equals the standard deviation in the size of disjunct core areas (CASD2) divided by the mean size of disjunct core areas (MCA2) of the corresponding patch type, multiplied by 100 (to convert to percent); that is, the variability in core area relative to the mean core area. Note, this is the population coefficient of variation, not the sample coefficient of variation, and that CACV2 represents the variation in size of disjunct core areas, not patch core areas, as in CACV1.

(C34) Total Core Area Index

Vector/Raster

$$TCAI = \frac{\sum_{j=1}^{n} a_{ij}^{c}}{\sum_{j=1}^{n} a_{ij}}(100)$$

Units: Percent

Range: 0 ≤ TCAI < 100

TCAI = 0 when none of the patches of the corresponding patch type contain any core area (i.e., CORE = 0 for every patch); that is, when the landscape contains no core area for the corresponding patch type. TCAI approaches 100 when the patches of the corresponding patch type, because of size, shape, and edge width, contain mostly core area.

Description: TCAI equals the sum of the core areas of each patch (m^2) of the corresponding patch type, divided by the sum of the areas of each patch (m^2) of the same type, multiplied by 100 (to convert to a percentage); that is, TCAI equals the percentage of a patch type in the landscape that is core area based on a specified edge width.

(C35) Mean Core Area Index

Vector/Raster

$$MCAI = \frac{\sum_{j=1}^{n} \left(\frac{a_{ij}^{c}}{a_{ij}} \right)}{n_i} (100)$$

Units: Percent

Range: $0 \leq MCAI < 100$

MCAI = 0 when none of the patches of the corresponding patch type contain any core area (i.e., CORE = 0 for every patch); that is, when the landscape contains no core area for the corresponding patch type. MCAI approaches 100 when the patches of the corresponding patch type, because of size, shape, and edge width, contain mostly core area.

Description: MCAI equals the sum of the proportion of each patch that is core area {i.e., core area of each patch (m^2) divided by the area of each patch (m^2)} of the corresponding patch type, divided by the number of patches of the same type, multiplied by 100 (to convert to a percentage); In other words, MCAI equals the average percentage of a patch of the corresponding patch type in the landscape that is core area based on a specified edge width.

(C36) Mean Nearest-Neighbor Distance

Raster

$$MNN = \frac{\sum_{j=1}^{n'} h_{ij}}{n'_i}$$

Units: Meters

Range: MNN > 0, without limit.

MNN is reported as "None" in the "basename".full file and a dot "." in the "basename".class file if there is only 1 patch of the corresponding patch type. Similarly, MNN is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if the user chooses not to calculate nearest neighbor distance.

Description: MNN equals the sum of the distance (m) to the nearest neighboring patch of the same type, based on nearest edge-to-edge distance, for each patch of the corresponding patch type, divided by the number of patches of the same type.

(C37) Nearest-Neighbor Standard Deviation

Raster

$$NNSD = \sqrt{\frac{\sum_{j=1}^{n'} \left[h_{ij} - \left(\frac{\sum_{j=1}^{n'} h_{ij}}{n'_i} \right) \right]^2}{n'_i}}$$

Units: Meters

Range: NNSD ≥ 0, without limit.

NNSD = 0 when there are only 2 patches in the class or all patches have the same nearest-neighbor distance (i.e., no variability in nearest-neighbor distance). NNSD is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if there is only 1 patch of the corresponding patch type. Similarly, NNSD is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if the user chooses not to calculate nearest neighbor distance.

Description: NNSD equals the square root of the sum of the squared deviations of each patches' nearest-neighbor distance (m) from the mean nearest-neighbor distance (MNN) of the corresponding patch type, divided by the number of patches of the same type; that is, the root mean squared error (deviation from the mean) in patch nearest neighbor distance. Note, this is the population standard deviation, not the sample standard deviation.

(C38) Nearest-Neighbor Coefficient of Variation

Raster

$$NNCV = \frac{NNSD}{MNN}(100)$$

Units: Percent

Range: NNCV ≥ 0, without limit.

NNCV = 0 when there are only 2 patches in the class or all patches have the same nearest-neighbor distance (i.e., no variability in nearest-neighbor distance; NNSD = 0). NNCV is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if there is only 1 patch of the corresponding patch type. Similarly, NNCV is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if the user chooses not to calculate nearest neighbor distance.

Description: NNCV equals the standard deviation in nearest-neighbor distances (NNSD) divided by the mean nearest-neighbor distance (MNN) of the corresponding patch type, multiplied by 100 (to convert to percent); that is, the variability in nearest neighbor distance relative to the mean nearest neighbor distance. Note, this is the population coefficient of variation, not the sample coefficient of variation.

(C39) Mean Proximity Index

Raster

$$MPI = \frac{\sum_{j=1}^{n} \sum_{s=1}^{n} \frac{a_{ijs}}{h_{ijs}^2}}{n_i}$$

Units: None

Range: MPI ≥ 0

MPI = 0 if all patches of the corresponding patch type have no neighbors of the same type within the specified search radius. MPI increases as patches of the corresponding patch type become less isolated and the patch type becomes less fragmented in distribution. The upper limit of MPI is determined by the search radius and minimum distance between patches. MPI is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if the user chooses not to calculate nearest neighbor distance.

Description: MPI equals the sum of patch area (m^2) divided by the nearest edge-to-edge distance squared (m^2) between the patch and the focal patch of all patches of the corresponding patch type whose edges are within a specified distance (m) of the focal patch, summed across all patches of the same type and divided by the total number of patches in the class. In other words, MPI equals the average proximity index for patches in the class. Note, when the search buffer extends beyond the landscape boundary for focal patches near the boundary, only patches contained within the landscape are considered in the computations.

(C40) Interspersion and Juxtaposition Index

Vector/Raster

$$IJI = \frac{-\sum_{k=1}^{m'}\left[\left(\frac{e_{ik}}{\sum_{k=1}^{m'} e_{ik}}\right)\ln\left(\frac{e_{ik}}{\sum_{k=1}^{m'} e_{ik}}\right)\right]}{\ln(m'-1)}(100)$$

Units: Percent

Range: $0 < IJI \le 100$

IJI approaches 0 when the corresponding patch type is adjacent to only 1 other patch type and the number of patch types increases. IJI = 100 when the corresponding patch type is equally adjacent to all other patch types (i.e., maximally interspersed and juxtaposed to other patch types). IJI is undefined and reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if the number of patch types is less than 3.

Description: IJI equals minus the sum of the length (m) of each unique edge type involving the corresponding patch type divided by the total length (m) of edge (m) involving the same type, multiplied by the logarithm of the same quantity, summed over each unique edge type; divided by the logarithm of the number of patch types minus 1; multiplied by 100 (to convert to a percentage). In other words, the observed interspersion over the maximum possible interspersion for the given number of patch types. Note, IJI considers all patch types present on an image, including any present in the landscape border, if present.

Landscape Indices

(L1) Landscape ID (LID)

The first field in the landscape output file is landscape ID (LID); it is defined as in the patch output file (see previous discussion).

(L2) Total Area

Vector/Raster

$$TA = A\left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: TA > 0, without limit.

Description: TA equals the total area (m^2) of the landscape, divided by 10,000 (to convert to hectares). TA excludes the area of any background patches within the landscape.

(L3) Largest Patch Index

Vector/Raster

$$LPI = \frac{\max_{j=1}^{n}(a_{ij})}{A}(100)$$

Units: Percent

Range: $0 < LPI \leq 100$

LPI approaches 0 when the largest patch in the landscape is increasingly small. LPI = 100 when the entire landscape consists of a single patch; that is, when the largest patch comprises 100% of the landscape.

Description: LPI equals the area (m^2) of the largest patch in the landscape divided by total landscape area (m^2), multiplied by 100 (to convert to a percentage); in other words, LPI equals the percent of the landscape that the largest patch comprises.

(L4) Number of Patches

Vector/Raster

$$NP = N$$

Units: None

Range: $NP \geq 1$, without limit.

$NP = 1$ when the landscape contains only 1 patch.

Description: NP equals the number of patches in the landscape. Note, NP does not include any background patches within the landscape or patches in the landscape border.

(L5) Patch Density

Vector/Raster

$$PD = \frac{N}{A}(10{,}000)(100)$$

Units: Number per 100 hectares

Range: $PD > 0$, without limit.

Description: PD equals the number of patches in the landscape divided by total landscape area, multiplied by 10,000 and 100 (to convert to 100 hectares).

(L6) Mean patch Size

Vector/Raster

$$MPS = \frac{A}{N}\left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: $MPS > 0$, without limit.

The range in MPS is limited by the grain and extent of the image and the minimum patch size in the same manner as patch area (AREA).

Description: MPS equals the total landscape area (m^2), divided by the total number of patches, divided by 10,000 (to convert to hectares).

(L7) Patch Size Standard Deviation

Vector/Raster

$$PSSD = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left[a_{ij} - \left(\frac{A}{N}\right)\right]^2}{N}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: PSSD ≥ 0, without limit.

PSSD = 0 when all patches in the landscape are the same size or when there is only 1 patch (i.e., no variability in patch size).

Description: PSSD equals the square root of the sum of the squared deviations of each patch area (m^2) from the mean patch size, divided by the total number of patches, divided by 10,000 (to convert to hectares); that is, the root mean squared error (deviation from the mean) in patch size. Note, this is the population standard deviation, not the sample standard deviation.

(L8) Patch Size Coefficient of Variation

Vector/Raster

$$PSCV = \frac{PSSD}{MPS}(100)$$

Units: Percent

Range: PSCV ≥ 0, without limit.

PSCV = 0 when all patches in the landscape are the same size or when there is only 1 patch (i.e., no variability in patch size).

Description: PSCV equals the standard deviation in patch size (PSSD) divided by the mean patch size (MPS), multiplied by 100 (to convert to percent); that is, the variability in patch size relative to the mean patch size. Note, this is the population coefficient of variation, not the sample coefficient of variation.

(L9) Total Edge

Vector/Raster

$$TE = E$$

Units: Meters

Range: TE ≥ 0, without limit.

TE = 0 when there is no edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of a single patch and the user specifies that none of the landscape boundary and background edge be treated as edge.

Description: TE equals the sum of the lengths (m) of all edge segments in the landscape. If a landscape border is present, TE includes landscape boundary segments representing true edge only (i.e., contrast weight > 0). If a landscape border is absent, TE includes a user-specified proportion of the landscape boundary. Regardless of whether a landscape border is present or not, TE includes a user-specified proportion of background edge.

(L10) Edge Density

Vector/Raster

$$ED = \frac{E}{A}(10{,}000)$$

Units: Meters per hectare

Range: ED ≥ 0, without limit.

ED = 0 when there is no edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of a single patch and the user specifies that none of the landscape boundary and background edge be treated as edge.

Description: ED equals the sum of the lengths (m) of all edge segments in the landscape, divided by the total landscape area (m^2), multiplied by 10,000 (to convert to hectares). If a landscape border is present, ED includes landscape boundary segments representing true edge only (i.e., contrast weight > 0). If a landscape border is absent, ED includes a user-specified proportion of the landscape boundary. Regardless of whether a landscape border is present or not, ED includes a user-specified proportion of background edge.

(L11) Contrast-Weighted Edge Density

Vector/Raster

$$CWED = \frac{\sum_{i=1}^{m'} \sum_{k=i+1}^{m'} (e_{ik} \circ d_{ik})}{A} (10{,}000)$$

Units: Meters per hectare

Range: CWED ≥ 0, without limit.

CWED = 0 when there is no edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of a single patch and the user specifies that none of the landscape boundary and background edge be treated as edge. CWED increases as the amount of edge in the landscape increases and/or as the contrast in edges increase (i.e., contrast weight approaches 1). CWED is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if a contrast weight file is not specified by the user.

Description: CWED equals the sum of the lengths (m) of each edge segment in the landscape multiplied by the corresponding contrast weight, divided by the total landscape area (m^2), multiplied by 10,000 (to convert to hectares). If a landscape border is present, CWED includes landscape boundary segments representing true edge only (i.e., contrast weight > 0). If a landscape border is absent, all landscape boundary edge segments are assigned the edge contrast weight specified by the user (see bound_wght option). This is equivalent to treating the specified proportion of all boundary edge segments as maximum-contrast edge. Regardless of whether a landscape border is present or not, all background edge segments are assigned the edge contrast weight specified by the user. Again, this is equivalent to treating the specified proportion of all background edge segments as maximum-contrast edge.

(L12) Total Edge Contrast Index

Vector/Raster

$$TECI = \frac{\sum_{i=1}^{m'} \sum_{k=i+1}^{m'} (e_{ik} \circ d_{ik})}{E'} (100)$$

Units: Percent

Range: 0 ≤ TECI ≤ 100

TECI = 0 when there is no edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of a single patch and the user specifies that none of the landscape boundary and background edge be treated as edge. TECI approaches 0 as the contrast in edges lesson (i.e., contrast weight approaches 0). TECI = 100 when all edge is maximum contrast (i.e., contrast weight = 1). TECI is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if a contrast weight file is not specified by the user.

Description: TECI equals the sum of the lengths (m) of each edge segment in the landscape multiplied by the corresponding contrast weight, divided by the total length (m) of edge in the landscape, multiplied by 100 (to convert to a percentage). In the numerator, if a landscape border is present, all edge segments along the landscape boundary are treated according to their edge contrast weights as designated in the contrast weight file. If a landscape border is absent, all landscape boundary segments are assigned the edge contrast weight specified by the user (see bound_wght option). Note that this is equivalent to treating the specified proportion of the landscape boundary as maximum-contrast edge and the remainder as zero-contrast edge. Regardless of whether a landscape border is present or not, all background edge segments are assigned the edge contrast weight specified by the user. Again, note that this is equivalent to treating the specified proportion of all background edge as maximum-contrast edge and the remainder as zero-contrast edge. In the denominator, all edges are included, including the landscape boundary and background edge segments, regardless of whether they represent true edge or not or how the user chooses to handle boundary and background edges.

(L13) Mean Edge Contrast Index

Vector/Raster

$$MECI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left[\frac{\sum_{k=1}^{m'}(p_{ijk} \circ d_{ik})}{p_{ij}}\right]}{N}(100)$$

Units: Percent

Range: $0 \leq MECI \leq 100$

MECI = 0 when there is no edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of a single patch type and the user specifies that none of the landscape boundary and background edge be treated as edge. MECI approaches 0 as the contrast in edges lesson (i.e., contrast weight approaches 0). MECI = 100 when all edge is maximum contrast (i.e., contrast weight = 1). MECI is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if a contrast weight file is not specified by the user.

Description: MECI equals the sum of the segment lengths (m) of each patches' perimeter multiplied by their corresponding contrast weights, divided by total patch perimeter (m), divided by the total number of patches, multiplied by 100 (to convert to a percentage). If a landscape border is present, any patch perimeter segments along the landscape boundary are treated according to their edge contrast weights as designated in the contrast weight file. If a landscape border is absent, any patch perimeter segments along the landscape boundary are assigned the edge contrast weight specified by the user (see bound_wght option). Regardless of whether a landscape border is present or not, all patch perimeter segments bordering background are assigned the edge contrast weight specified by the user.

(L14) Area-Weighted Mean Edge Contrast Index

Vector/Raster

$$AWMECI = \sum_{i=1}^{m} \sum_{j=1}^{n} \left(\left[\frac{\sum_{k=1}^{m'} (p_{ijk} \circ d_{ik})}{p_{ij}} \right] \left[\frac{a_{ij}}{A} \right] \right) (100)$$

Units: Percent

Range: 0 ≤ AWMECI ≤ 100

AWMECI = 0 when there is no edge in the landscape; that is, when the entire landscape and landscape border, if present, consists of a single patch type and the user specifies that none of the landscape boundary and background edge be treated as edge. AWMECI approaches 0 as the contrast in edges lesson (i.e., contrast weight approaches 0). AWMECI = 100 when all edge is maximum contrast (i.e., contrast weight = 1). AWMECI is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if a contrast weight file is not specified by the user.

Description: AWMECI equals the sum of the segment lengths (m) of each patches' perimeter multiplied by their corresponding contrast weights, divided by total patch perimeter (m), multiplied by patch area (m^2) divided by total landscape area (m^2), summed across all patches in the landscape, multiplied by 100 (to convert to a percentage). If a landscape border is present, any patch perimeter segments along the landscape boundary are treated according to their edge contrast weights as designated in the contrast weight file. If a landscape border is absent, any patch perimeter segments along the landscape boundary are assigned the edge contrast weight specified by the user (see bound_wght option). Regardless of whether a landscape border is present or not, all patch perimeter segments bordering background are assigned the edge contrast weight specified by the user. AWMECI is similar to MECI except that each patch weighted by its size in computing the average patch edge contrast index.

(L15) Landscape Shape Index

Vector

$$LSI = \frac{E'}{2\sqrt{\pi \circ A}}$$

Raster

$$LSI = \frac{.25\ E'}{\sqrt{A}}$$

Units: None

Range: LSI ≥ 1, without limit.

LSI = 1 when the landscape consists of a single circular (vector) or square (raster) patch; LSI increases without limit as landscape shape becomes more irregular and/or as the length of edge within the landscape increases.

Description: LSI equals the sum of the landscape boundary (regardless of whether it represents true edge or not) and all edge segments (m) within the landscape boundary (including those bordering background), divided by the square root of the total landscape area (m^2), adjusted by a constant for a circular standard (vector) or square standard (raster).

(L16) Mean Shape Index

Vector

$$MSI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{p_{ij}}{2\sqrt{\pi \circ a_{ij}}}\right)}{N}$$

Raster

$$MSI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{.25p_{ij}}{\sqrt{a_{ij}}}\right)}{N}$$

Units: None

Range: MSI ≥ 1, without limit.

MSI = 1 when all patches in the landscape are circular (vector) or square (raster); MSI increases without limit as the patch shapes become more irregular.

Description: MSI equals the sum of the patch perimeter (m) divided by the square root of patch area (m^2) for each patch in the landscape, adjusted by a constant to adjust for a circular standard (vector) or square standard (raster), divided by the number of patches (NP); in other words, MSI equals the average shape index (SHAPE) of patches in the landscape.

(L17) Area-Weighted Mean Shape Index

Vector

$$AWMSI = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{p_{ij}}{2\sqrt{\pi \cdot a_{ij}}}\right)\left(\frac{a_{ij}}{A}\right)\right]$$

Raster

$$AWMSI = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{.25p_{ij}}{\sqrt{a_{ij}}}\right)\left(\frac{a_{ij}}{A}\right)\right]$$

Units: None

Range: AWMSI ≥ 1, without limit.

AWMSI = 1 when all patches in the landscape are circular (vector) or square (raster); AWMSI increases without limit as the patch shapes become more irregular.

Description: AWMSI equals the sum, across all patches, of each patch perimeter (m) divided by the square root of patch area (m^2), adjusted by a constant to adjust for a circular standard (vector) or square standard (raster), multiplied by the patch area (m^2) divided by total landscape area. In other words, AWMSI equals the average shape index (SHAPE) of patches, weighted by patch area so that larger patches weigh more than smaller ones.

(L18) Double Log Fractal Dimension

Vector/Raster

$$DLFD = \frac{2}{\dfrac{\left[N\sum_{i=1}^{m}\sum_{j=1}^{n}(\ln p_{ij} \cdot \ln a_{ij})\right] - \left[\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\ln p_{ij}\right)\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\ln a_{ij}\right)\right]}{\left(N\sum_{i=1}^{m}\sum_{j=1}^{n}\ln p_{ij}^{2}\right) - \left(\sum_{i=1}^{m}\sum_{j=1}^{n}\ln p_{ij}\right)^{2}}}$$

Units: None

Range: 1 ≤ DLFD ≤ 2

A fractal dimension greater than 1 for a 2-dimensional landscape mosaic indicates a departure from a euclidean geometry (i.e., an increase in patch shape complexity). DLFD approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters. DLFD employs regression techniques and is subject to small sample problems. Specifically, DLFD may greatly exceed the theoretical range in values when the number of patches is small (e.g., <10), and its use should be avoided in such cases. In addition, DLFD requires patches to vary in size. Thus, DLFD is undefined and reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if all patches are the same size or there is only 1 patch.

Description: DLFD equals 2 divided by the slope of the regression line obtained by regressing the logarithm of patch area (m^2) against the logarithm of patch perimeter (m).

(L19) Mean Patch Fractal Dimension

Vector

$$MPFD = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)}{N}$$

Raster

$$MPFD = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{2\ln(.25p_{ij})}{\ln a_{ij}}\right)}{N}$$

Units: None

Range: $1 \le MPFD \le 2$

A fractal dimension greater than 1 for a 2-dimensional landscape mosaic indicates a departure from a euclidean geometry (i.e., an increase in patch shape complexity). MPFD approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters.

Description: MPFD equals the sum of 2 times the logarithm of patch perimeter (m) divided by the logarithm of patch area (m^2) for each patch in the landscape, divided by the number of patches; the raster formula is adjusted to correct for the bias in perimeter (Li 1989).

(L20) Area-Weighted Mean Patch Fractal Dimension

Vector

$$AWMPFD = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)\left(\frac{a_{ij}}{A}\right)\right]$$

Raster

$$AWMPFD = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{2\ln(.25p_{ij})}{\ln a_{ij}}\right)\left(\frac{a_{ij}}{A}\right)\right]$$

Units: None

Range: $1 \le AWMPFD \le 2$

A fractal dimension greater than 1 for a 2-dimensional landscape mosaic indicates a departure from a euclidean geometry (i.e., an increase in patch shape complexity). AWMPFD approaches 1 for shapes with very simple perimeters such as circles or squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters.

Description: AWMPFD equals the sum, across all patches, of 2 times the logarithm of patch perimeter (m) divided by the logarithm of patch area (m^2), multiplied by the patch area (m^2) divided by total landscape area; the raster formula is adjusted to correct for the bias in perimeter (Li 1989). In other words, AWMPFD equals the average patch fractal dimension (FRACT) of patches in the landscape, weighted by patch area.

(L21) Total Core Area

Vector/Raster

$$TCA = \sum_{i=1}^{m} \sum_{j=1}^{n} a_{ij}^{c} \left(\frac{1}{10{,}000} \right)$$

Units: Hectares

Range: TCA ≥ 0, without limit.

TCA = 0 when every location within every patch is within the specified edge distance from the patch perimeters. TCA approaches total landscape area as the specified edge distance decreases and as patch shapes are simplified.

Description: TCA equals the sum of the core areas of each patch (m^2), divided by 10,000 (to convert to hectares).

(L22) Number of Core Areas

Vector/Raster

$$NCA = \sum_{i=j}^{m} \sum_{j=1}^{n} n_{ij}^{c}$$

Units: None

Range: NCA ≥ 0, without limit.

NCA = 0 when TCA = 0 (i.e., every location within every patch is within the specified edge distance from the patch perimeters).

Description: NCA equals the sum of the number of disjunct core areas contained within each patch in the landscape; that is, the number of disjunct core areas contained within the landscape.

(L23) Core Area Density

Vector/Raster

$$CAD = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} n_{ij}^{c}}{A}(10{,}000)(100)$$

Units: Number per 100 hectares

Range: CAD ≥ 0, without limit.

CAD = 0 when TCA = 0 (i.e., every location within every patch is within the specified edge distance from the patch perimeters); in other words, when there are no core areas.

Description: CAD equals the sum of number of disjunct core areas contained within each patch, divided by total landscape area, multiplied by 10,000 and 100 (to convert to 100 hectares).

(L24) Mean Core Area Per Patch

Vector/Raster

$$MCA1 = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}^{c}}{N}\left(\frac{1}{10{,}000}\right)$$

Units: Hectares

Range: MCA1 ≥ 0, without limit.

Ultimately, the range in MCA1 is limited by the grain and extent of the image and the minimum patch size in the same manner as mean patch size (MPS), but MCA1 is also affected by the specified edge width. MCA1 = 0 when TCA = 0 (i.e., every location within every patch is within the specified edge distance from the patch perimeters); in other words, when there are no core areas. MCA1 approaches MPS as the specified edge width decreases and as patch shapes are simplified.

Description: MCA1 equals the sum of the core areas of each patch (m^2), divided by the number of patches, divided by 10,000 (to convert to hectares). Note that MCA1 equals the average core area per patch, not the average size of disjunct core areas, as in MCA2.

(L25) Patch Core Area Standard Deviation

Vector/Raster

$$CASD1 = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left[a_{ij}^{c} - \left(\frac{\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}^{c}}{N}\right)\right]^2}{N}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: CASD1 ≥ 0, without limit.

CASD1 = 0 when all patches in the landscape have the same core area or when there is only 1 patch (i.e., no variability in core area).

Description: CASD1 equals the square root of the sum of the squared deviations of each patch core area (m^2) from the mean core area per patch (MCA1), divided by the number of patches, divided by 10,000 (to convert to hectares); that is, the root mean squared error (deviation from the mean) in patch core area. Note, this is the population standard deviation, not the sample standard deviation, and that CASD1 represents the variation in core area among patches, not among disjunct core areas, as in CASD2.

(L26) Patch Core Area Coefficient of Variation

Vector/Raster

$$CACV1 = \frac{CASD1}{MCA1}(100)$$

Units: Percent

Range: CACV1 ≥ 0, without limit.

CACV1 = 0 when all patches in the landscape have the same core area or when there is only 1 patch (i.e., no variability in core area).

Description: CACV1 equals the standard deviation in core area (CASD1) divided by the mean core area per patch (MCA1), multiplied by 100 (to convert to percent); that is, the variability in core area relative to the mean core area. Note, this is the population coefficient of variation, not the sample coefficient of variation, and that CACV1 represents the variation in core area among patches, not among disjunct core areas, as in CACV2.

(L27) Mean Area Per Disjunct Core

Vector/Raster

$$MCA2 = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{q=1}^{p} a_{ijq}^{c}}{\sum_{i=1}^{m}\sum_{j=1}^{n} n_{ij}^{c}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: MCA2 ≥ 0, without limit.

Ultimately, the range in MCA2 is limited by the grain and extent of the image and the minimum patch size in the same manner as mean patch size (MPS), but MCA2 is also effected by the specified edge width. MCA2 = 0 when total core area = 0 (i.e., every location within patches of the corresponding patch type are within the specified edge distance from the patch perimeters); in other words, when there are no core areas. MCA2 approaches MPS as the specified edge width decreases and as patch shapes are simplified.

Description: MCA2 equals the sum of the disjunct core areas of each patch (m^2), divided by the number of disjunct core areas, divided by 10,000 (to convert to hectares). Note that MCA2 equals the average size of disjunct core areas, not the average core area per patch, as in MCA1.

(L28) Disjunct Core Area Standard Deviation

Vector/Raster

$$CASD2 = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{q=1}^{p}\left[a_{ijq}^{c} - \left(\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{q=1}^{p} a_{ijq}^{c}}{\sum_{i=1}^{m}\sum_{j=1}^{n} n_{ij}^{c}}\right)\right]^2}{\sum_{i=1}^{m}\sum_{j=1}^{n} n_{ij}^{c}}}\left(\frac{1}{10,000}\right)$$

Units: Hectares

Range: CASD2 ≥ 0, without limit.

CASD2 = 0 when all disjunct core areas are the same size or when there is only 1 core area (i.e., no variability in core area).

Description: CASD2 equals the square root of the sum of the squared deviations of each disjunct core area (m^2) from the mean size of disjunct core areas (MCA2), divided by the number of disjunct core areas, divided by 10,000 (to convert to hectares); that is, the root mean squared error (deviation from the mean) in the size of disjunct core areas. Note, this is the population standard deviation, not the sample standard deviation, and that CASD2 represents the variation in size of disjunct core areas, not patch core areas, as in CASD1.

(L29) Disjunct Core Area Coefficient of Variation

Vector/Raster

$$CACV2 = \frac{CASD2}{MCA2}(100)$$

Units: Percent

Range: CACV2 ≥ 0, without limit.

CACV2 = 0 when all disjunct core areas are the same size or when there is only 1 core area (i.e., no variability in core area).

Description: CACV2 equals the standard deviation in the size of disjunct core areas (CASD2) divided by the mean size of disjunct core areas (MCA2), multiplied by 100 (to convert to percent); that is, the variability in core area relative to the mean core area. Note, this is the population coefficient of variation, not the sample coefficient of variation, and that CACV2 represents the variation in size of disjunct core areas, not patch core areas, as in CACV1.

(L30) Total Core Area Index

Vector/Raster

$$TCAI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}^{c}}{A}(100)$$

Units: Percent

Range: 0 ≤ TCAI < 100

TCAI = 0 when none of the patches in the landscape contain any core area (i.e., CORE = 0 for every patch); that is, when the landscape contains no core area. TCAI approaches 100 when the patches, because of size, shape, and edge width, contain mostly core area.

Description: TCAI equals the sum of the core areas of each patch (m^2), divided by the total landscape area (m^2), multiplied by 100 (to convert to a percentage); that is, TCAI equals the percentage of the landscape that is core area.

(L31) Mean Core Area Index

Vector/Raster

$$MCAI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{a_{ij}^{c}}{a_{ij}}\right)}{N}(100)$$

Units: Percent

Range: $0 \leq MCAI < 100$

MCAI = 0 when none of the patches in the landscape contain any core area (i.e., CORE = 0 for every patch); that is, when the landscape contains no core area. MCAI approaches 100 when the patches, because of size, shape, and edge width, contain mostly core area.

Description: MCAI equals the sum of the proportion of each patch that is core area {i.e., core area of each patch (m^2) divided by the area of each patch (m^2)}, divided by the number of patches, multiplied by 100 (to convert to a percentage); in other words, MCAI equals the average percentage of a patch in the landscape that is core area.

(L32) Mean Nearest-Neighbor Distance

Raster

$$MNN = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n'} h_{ij}}{N'}$$

Units: Meters

Range: MNN > 0, without limit.

MNN is reported as "None" in the "basename".full file and a dot "." in the "basename".land file if none of the patches have a nearest neighbor (i.e., every patch type consists of only 1 patch). MNN is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the user chooses not to calculate nearest neighbor distance.

Description: MNN equals the sum of the distance (m) to the nearest patch of the same type, based on nearest edge-to-edge distance, for each patch in the landscape with a neighbor, divided by the number of patches with a neighbor.

(L33) Nearest-Neighbor Standard Deviation

Raster

$$NNSD = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n'}\left[h_{ij} - \left(\frac{\sum_{i=1}^{m}\sum_{j=1}^{n'} h_{ij}}{N'}\right)\right]^2}{N'}}$$

Units: Meters

Range: NNSD ≥ 0, without limit.

NNSD = 0 when all patches have the same nearest-neighbor distance (i.e., no variability in nearest-neighbor distance). NNSD is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if none of the patches have a nearest neighbor. Similarly, NNSD is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the user chooses not to calculate nearest neighbor distance.

Description: NNSD equals the square root of the sum of the squared deviations of each patches' nearest-neighbor distance (m) from the mean nearest-neighbor distance of the corresponding patch type (MNN), divided by the number of patches; that is, the root mean squared error (deviation from the mean) in patch nearest-neighbor distance. Note, this is the population standard deviation, not the sample standard deviation.

(L34) Nearest-Neighbor Coefficient of Variation

Raster

$$NNCV = \frac{NNSD}{MNN}(100)$$

Units: Percent

Range: NNCV ≥ 0, without limit.

NNCV = 0 when all patches have the same nearest-neighbor distance (i.e., no variability in nearest-neighbor distance; NNSD = 0). NNCV is reported as "NA" in the "basename".full file and a dot "." in the "basename".class file if none of the patches have a nearest neighbor. Similarly, NNCV is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the user chooses not to calculate nearest neighbor distance.

Description: NNCV equals the standard deviation in nearest-neighbor distances (NNSD) divided by the mean nearest-neighbor distance (MNN), multiplied by 100 (to convert to percent); that is, the variability in nearest-neighbor distance relative to the mean nearest-neighbor distance. Note, this is the population coefficient of variation, not the sample coefficient of variation.

(L35) Mean Proximity Index

Raster

$$MPI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{s=1}^{n}\frac{a_{ijs}}{h_{ijs}^{2}}}{N}$$

Units: None

Range: MPI ≥ 0.

MPI = 0 if no patch has a neighbor of the same type within the specified search radius. MPI increases as patches become less isolated from patches of the same type and the patch types become less fragmented in distribution. The upper limit of MPI is determined by the search radius and minimum distance between patches. MPI is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the user chooses not to calculate nearest neighbor distance.

Description: MPI equals the sum of patch area (m^2) divided by the squared nearest edge-to-edge distance (m) between the patch and the focal patch of all patches of the corresponding patch type whose edges are within a specified distance (m) of the focal patch, summed across all patches in the landscape and divided by the total number of patches. In other words, MPI equals the average proximity index for patches in the landscape. Note, when the search buffer extends beyond the landscape boundary for focal patches near the boundary, only patches contained within the landscape are considered in the computations.

(L36) Shannon's Diversity Index

Vector/Raster

$$SHDI = -\sum_{i=1}^{m} (P_i \circ \ln P_i)$$

Units: None

Range: SHDI ≥ 0, without limit

SHDI = 0 when the landscape contains only 1 patch (i.e., no diversity). SHDI increases as the number of different patch types (i.e., patch richness, PR) increases and/or the proportional distribution of area among patch types becomes more equitable.

Description: SHDI equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion.

(L37) Simpson's Diversity Index

Vector/Raster

$$SIDI = 1 - \sum_{i=1}^{m} P_i^2$$

Units: None

Range: $0 \leq SIDI < 1$

SIDI = 0 when the landscape contains only 1 patch (i.e., no diversity). SIDI approaches 1 as the number of different patch types (i.e., patch richness, PR) increases and the proportional distribution of area among patch types becomes more equitable.

Description: SIDI equals 1 minus the sum, across all patch types, of the proportional abundance of each patch type squared.

(L38) Modified Simpson's Diversity Index

Vector/Raster

$$MSIDI = -\ln \sum_{i=1}^{m} P_i^2$$

Units: None

Range: MSIDI ≥ 0

MSIDI = 0 when the landscape contains only 1 patch (i.e., no diversity). MSIDI increases as the number of different patch types (i.e., patch richness, PR) increases and the proportional distribution of area among patch types becomes more equitable.

Description: MSIDI equals minus the logarithm of the sum, across all patch types, of the proportional abundance of each patch type squared.

(L39) Patch Richness

Vector/Raster

$$PR = m$$

Units: None

Range: PR ≥ 1, without limit

Description: PR equals the number of different patch types present within the landscape boundary.

(L40) Patch Richness Density

Vector/Raster

$$PRD = \frac{m}{A}(10{,}000)(100)$$

Units: Number per 100 hectares

Range: PRD > 0, without limit

Description: PR equals the number of different patch types present within the landscape boundary divided by total landscape area (m^2), multiplied by 10,000 and 100 (to convert to 100 hectares).

(L41) Relative Patch Richness

Vector/Raster

$$RPR = \frac{m}{m_{max}}(100)$$

Units: Percent

Range: $0 < RPR \leq 100$

RPR approaches 0 when the landscape contains a single patch type, yet the number of potential patch types is very large. RPR = 100 when all possible patch types are represented in the landscape. RPR is reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the maximum number of classes is not specified by the user.

Description: RPR equals the number of different patch types present within the landscape boundary divided by the maximum potential number of patch types based on the patch type classification scheme, multiplied by 100 (to convert to percent).

(L42) Shannon's Evenness Index

Vector/Raster

$$SHEI = \frac{-\sum_{i=1}^{m}(P_i \circ \ln P_i)}{\ln m}$$

Units: None

Range: $0 \leq SHEI \leq 1$

SHDI = 0 when the landscape contains only 1 patch (i.e., no diversity) and approaches 0 as the distribution of area among the different patch types becomes increasingly uneven (i.e., dominated by 1 type). SHDI = 1 when distribution of area among patch types is perfectly even (i.e., proportional abundances are the same).

Description: SHEI equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion, divided by the logarithm of the number of patch types. In other words, the observed Shannon's Diversity Index divided by the maximum Shannon's Diversity Index for that number of patch types.

(L43) Simpson's Evenness Index

Vector/Raster

$$SIEI = \frac{1 - \sum_{i=1}^{m} P_i^2}{1 - \left(\frac{1}{m}\right)}$$

Units: None

Range: 0 ≤ SIEI ≤ 1

SIDI = 0 when the landscape contains only 1 patch (i.e., no diversity) and approaches 0 as the distribution of area among the different patch types becomes increasingly uneven (i.e., dominated by 1 type). SIDI = 1 when distribution of area among patch types is perfectly even (i.e., proportional abundances are the same).

Description: SIEI equals 1 minus the sum, across all patch types, of the proportional abundance of each patch type squared, divided by 1 minus 1 divided by the number of patch types. In other words, the observed Simpson's Diversity Index divided by the maximum Simpson's Diversity Index for that number of patch types.

(L44) Modified Simpson's Evenness Index

Vector/Raster

$$MSIEI = \frac{-\ln \sum_{i=1}^{m} P_i^2}{\ln m}$$

Units: None

Range: 0 ≤ MSIEI ≤ 1

MSIDI = 0 when the landscape contains only 1 patch (i.e., no diversity) and approaches 0 as the distribution of area among the different patch types becomes increasingly uneven (i.e., dominated by 1 type). MSIDI = 1 when distribution of area among patch types is perfectly even (i.e., proportional abundances are the same).

Description: MSIEI equals minus the logarithm of the sum, across all patch types, of the proportional abundance of each patch type squared, divided by the logarithm of the number of patch types. In other words, the observed modified Simpson's diversity index divided by the maximum modified Simpson's diversity index for that number of patch types.

(L45) Interspersion and Juxtaposition Index

Vector/Raster

$$IJI = \frac{-\sum_{i=1}^{m'} \sum_{k=i+1}^{m'} \left[\left(\frac{e_{ik}}{E} \right) \cdot \ln \left(\frac{e_{ik}}{E} \right) \right]}{\ln(1/2 [m'(m' - 1)])} (100)$$

Units: Percent

Range: $0 < IJI \leq 100$

IJI approaches 0 when the distribution of adjacencies among unique patch types becomes increasingly uneven. IJI = 100 when all patch types are equally adjacent to all other patch types (i.e., maximum interspersion and juxtaposition. IJI is undefined and reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the number of patch types is less than 3.

Description: IJI equals minus the sum of the length (m) of each unique edge type divided by the total landscape edge (m), multiplied by the logarithm of the same quantity, summed over each unique edge type; divided by the logarithm of the number of patch types times the number of patch types minus 1 divided by 2; multiplied by 100 (to convert to a percentage). In other words, the observed interspersion over the maximum possible interspersion for the given number of patch types. Note, IJI considers all patch types present on an image, including any present in the landscape border, if a border was included. All background edge segments are ignored, as are landscape boundary segments if a border is not provided, because adjacency information for these edge segments is not available.

(L46) Contagion Index

Raster

$$CONTAG = \left[1 + \frac{\sum_{i=1}^{m}\sum_{k=1}^{m}\left[(P_i)\left(\frac{g_{ik}}{\sum_{k=1}^{m} g_{ik}}\right)\right] \cdot \left[\ln (P_i)\left(\frac{g_{ik}}{\sum_{k=1}^{m} g_{ik}}\right)\right]}{2\ln(m)}\right](100)$$

Units: Percent

Range: 0 < CONTAG ≤ 100

CONTAG approaches 0 when the distribution of adjacencies (at the level of individual cells) among unique patch types becomes increasingly uneven. CONTAG = 100 when all patch types are equally adjacent to all other patch types (i.e., maximum interspersion and juxtaposition. CONTAG is undefined and reported as "NA" in the "basename".full file and a dot "." in the "basename".land file if the number of patch types is less than 2.

Description: CONTAG equals minus the sum of the proportional abundance of each patch type multiplied by number of adjacencies between cells of that patch type and all other patch types, multiplied by the logarithm of the same quantity, summed over each patch type; divided by 2 times the logarithm of the number of patch types; multiplied by 100 (to convert to a percentage). In other words, the observed contagion over the maximum possible contagion for the given number of patch types. Note, CONTAG considers all patch types present on an image, including any present in the landscape border, if present, and considers like adjacencies (i.e., cells of a patch type adjacent to cells of the same type). All background edge segments are ignored, as are landscape boundary segments if a border is not provided, because adjacency information for these edge segments is not available.