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Appendix B: Definitions of Quantitative Metrics of Vegetation Configuration

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Table B-1 Descriptions of the 31 metrics used to quantify marsh vegetation configuration at the observation area (a.k.a. "landscape") scale (adapted from McGarigal and Marks 1995)

Abbreviation	Metric Name	Equation [a]	Metric Definition
Observation Area Size and Shape			
TLA	Total Landscape Area	$TLA = \left(\sum a_i\right) * 0.0001$	Total area of observation area, in hectares. Including this metric in the multiple variable regression analysis enabled testing for effects due to truncated observation area shapes.
TE	Total Edge	$TE = \sum e_i$	Sum of total lengths of all patch edge segments within the observation area. Describes dissection of landscape.
ED	Edge Density	$ED = \left(TE/TLA\right) * 10000$	*TE* normalized by observation area; expressed in hectares. Describes dissection of landscape.
LSI	Landscape Shape Index	$LSI = 0.25TE/\sqrt{TLA}$	Total edge, including observation area boundary in this case, normalized by square root of total area. Close to 1 if observation area is composed of a single patch. *LSI* increases as observation area becomes more irregular or as dissection into many patches increases.
LPI	Largest Patch Index	$LPI = \left(\max a_{ij} / TLA\right) * 100$	Percent of observation area covered by largest patch.
Patch Regularity and Compactness			
PSSD	Patch Size Standard Deviation	$PSSD = \sqrt{\left(\sum\sum\left(a_{ij} - (TLA/N)\right)^2\right)/N} * 0.0001$	Reflects average deviation in patch area from mean patch area within a given cover type, expressed in hectares.
PSCOV	Patch Size Coefficient of Variation	$PSCOV = \left(PSSD/\left[TLA/(N * 10000)\right]\right) * 100$	*PSSD* normalized by mean patch size in hectares, expressed as percent.
MSI	Mean Shape Index	$MSI = \left(\sum\sum 0.25 p_{ij}/\sqrt{a_{ij}}\right)/N$	Mean raster patch perimeter-to-area ratio compared to a square patch. *MSI* increases above 1 for less square patch shapes.

Abbreviation	Metric Name	Equation[a]	Metric Definition
AWMSI	Area-Weighted Mean Shape Index	$AWMSI = \sum\sum \left(0.25 p_{ij}/\sqrt{a_{ij}}\right)\left(a_{ij}/TLA\right)$	Same as *MSI* but weights average by patch size; a better metric of apparent (but not absolute) patch shape index within each observation area, less skewed by many small point-like patches.
MPFD	Mean Patch Fractal Dimension	$MPFD = \left(\sum\sum 2\ln\left(0.25 p_{ij}\right)/\ln a_{ij}\right)/N$	Mean of patch fractal dimensions, which approach 1 for simple Euclidean shapes and 2 for highly complex, plane-filling shapes. Very low values in this analysis likely skewed by many small, point-like patches.
AWMPFD	Area-Weighted Mean Patch Fractal Dimension	$AWMPFD = \sum\sum \left(2\ln\left(0.25 p_{ij}\right)/\ln a_{ij}\right)\left(a_{ij}/TLA\right)$	A better metric of apparent (but not absolute) patch fractal dimension within each observation area than *MPFD*, less skewed by many point-like patches.
Number of Patches and Classes			
NUMP	Number of Patches	---	Count of number of patches in the observation area.
PR	Patch Richness	---	Number of cover types in the observation area.
PRD	Patch Richness Density	$PRD = \left(PR/TLA\right) * 10000 * 100$	Number of cover types normalized by total observation area, expressed per 100 hectares.
SDI	Shannon's Diversity Index	$SDI = -\sum P_i \ln P_i$	for P_i proportion of observation area occupied by cover type i. Larger SDI reflects greater number of cover types and/or more even proportions of area among cover types.
MSIDI	Modified Simpson's Diversity Index	$MSIDI = -\ln \sum P_i^2$	Larger $MSIDI$ reflects greater number of cover types and/or more even proportions of area among cover types.
Pattern Configuration and Evenness			
MNN	Mean Nearest Neighbor	$MNN = \left(\sum\sum h_{ij}\right)/N$	Mean distance to nearest patch of same type.
MPI	Mean Proximity Index	$MPI = \left(\sum\sum a_{ij}/h_{ij}^2\right)/N$	Increases as edge-to-edge distance to nearest patch of the same type h_{ij} decreases.
IJI	Interspersion Juxtaposition Index	---	IJI is based on the ratio of unique patch edge to total edge. IJI is near zero when a cover type is adjacent to only one other cover type; $IJI = 100$ when cover types are all equally adjacent. Affected only by patch type interspersion and juxtaposition, not size, contiguity or dispersion of patches.
SHEI	Shannon's Evenness Index	$SHEI = SDI/\ln PR$	$SHEI$ is 1 when each cover type has same proportional abundance and is 0 when there is no cover diversity.
SEI	Simpson's Evenness Index	$SEI = \left(1 - \sum P_i^2\right)/\left(1 - 1/PR\right)$	SEI is 1 when each cover type has same proportional abundance and is 0 when there is no cover diversity.
MSIEI	Modified Simpson's Evenness Index	$MSIEI = MSIDI/\ln PR$	$MSIEI$ is 1 when each cover type has same proportional abundance and is 0 when there is no cover diversity.

Abbreviation	Metric Name	Equation[a]	Metric Definition
Patch Core Area Metrics			
NCA	Number of Core Areas	---	Core area is that area of a patch greater than a specified distance from the edge (1 pixel in this study). *NCA* is the number of core areas within the observation area. *NCA* can be greater than the number of patches if some complex patch shapes contain two or more disjunct (unconnected) core areas.
TCA	Total Core Area	$TCA = \sum\sum a_{ijcore} * 0.0001$	Expressed in hectares.
CAD	Core Area Density	$CAD = (NCA / TLA) * 10000 * 100$	Core area as fraction of total area, expressed per 100 hectares.
MCAI	Mean Core Area Index	$MCAI = \left(\sum\sum a_{ijcore} / a_{ij}\right) / N \ * 100$	Average percentage of area of patches within the observation area that is core area. Low *MCAI* values for observation areas in this study resulted from an abundance of very small patches each with little core area.
TCAI	Total Core Area Index	$TCAI = \left(\sum\sum a_{ijcore} / TLA\right) * 100$	Percent core area per observation area.
CASD1	Patch Core Area Standard Deviation	$CASD1 = \sqrt{\sum\sum\left(a_{ijcore} - \left(\sum\sum a_{ijcore}\right)/N\right)^2 / N} * 0.0001$	Represents standard deviation in total core area per patch, expressed in hectares.
CASD	Disjunct Core Area Standard Deviation	---	Mean root squared deviation of each disjunct core area's size from the mean disjunct core area size for that patch, for all patches, expressed in hectares. *CASD* generally > *CASD*1 if disjunct core areas within a patch are of different sizes.
CACV1	Patch Core Area Coefficient of Variation	$CACV1 = \left(CASD1 / \sum\sum a_{ijcore} / (N * 10000)\right) * 100$	Represents variation in core area among patches, as percent of mean core area per patch.
CACOV	Disjunct Core Area Coefficient of Variation	---	*CACOV* = *CASD* normalized by mean size of disjunct core areas for a given cover type, expressed as percent of mean size. Represents variation in size of disjunct core areas.

a. In equations: p denotes patch perimeter, a patch area, h distance between patches, e patch edge segment; subscript i refers to each patch ($i = 1{:}N$), j to each cover class. Other variables defined among the metric equations.

REFERENCE

McGarigal K, Marks BJ. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure, Appendix 3 subsection, landscape indices. Portland (OR): USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-351 [Internet]. [cited 2013 Sep 6]; 122 p. Available from: *http://treesearch.fs.fed.us/pubs/3064*