OJF> Vol.3 No.1, January 2013

OPEN ACCESS

Enhanced Structural Complexity Index: An Improved Index for Describing Forest Structural Complexity

PDF (Size:968KB) PP. 23-29 DOI: 10.4236/ojf.2013.31005

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ABSTRACT

The horizontal distribution of stems, stand density and the differentiation of tree dimensions are among the most important aspects of stand structure. An increasing complexity of stand structure is often linked to a higher number of species and to greater ecological stability. For quantification, the Structural Complexity Index (*SCI*) describes structural complexity by means of an area ratio of the surface that is generated by connecting the tree tops of neighbouring trees to form triangles to the surface that is covered by all triangles if projected on a flat plane. Here, we propose two ecologically relevant modifications of the *SCI*: The degree of mingling of tree attributes, quantified by a vector ruggedness measure, and a stem density term. We investigate how these two modifications influence index values. Data come from forest inventory field plots sampled along a disturbance gradient from heavily disturbed shrub land, through secondary regrowth to mature montane rainforest stands in Mengsong, Xishuangbanna,Yunnan,China. An application is described linking structural complexity, as described by the *SCI* and its modified versions, to changes in species composition of insect communities. The results of this study show that the Enhanced Structural Complexity Index (*ESCI*) can serve as a valuable tool for forest managers and ecologists for describing the structural complexity of forest stands and is particularly valuable for natural forests with a high degree of structural complexity.

KEYWORDS

Forest Structure Index; Structural Complexity; Stem Map; Species Composition; NMDS

Cite this paper

Beckschäfer, P. , Mundhenk, P. , Kleinn, C. , Ji, Y. , Yu, D. & Harrison, R. (2013). Enhanced Structural Complexity Index: An Improved Index for Describing Forest Structural Complexity. *Open Journal of Forestry, 3,* 23-29. doi: 10.4236/ojf.2013.31005.

References

[1] Aber, J. (1979). Foliage-height profiles and succession in northern hardwood forests. Ecology, 60, 18-23. doi:10.2307/1936462

[2] Ambuel, B., & Temple, S. (1983). Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecology, 64, 1057-1068. doi:10.2307/1937814

[3] Cramer, M., & Willig, M. (2005). Habitat heterogeneity, species diversity and null models. Oikos, 108, 209-218. doi:10.1111/j.0030-1299.2005.12944.x

[4] Davis, L., Johnson, K., Bettinger, P., & Howard, T. (2005). Forest management—To sustain ecological, economic, and social values. Prospect Heights: Waveland Press, Inc.

[5] Doherty, M., Kearns, A., Barnett, G., Sarre, A., Hochuli, D., Gibb, H., & Dickman, C. (2000). The interaction between habitat conditions, ecosystem processes and terrestrial biodiversity: A review. State of the Environment, Second Technical Paper Series (Biodiversity), Environment Australia, Department of Environment and Heritage.

[6] Franklin, J., Spies, T., Pelt, R., Carey, A., Thornburgh, D., Berg, D. et al. (2002). Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir

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forests as an example. Forest Ecology and Management, 155, 399-423. doi:10.1016/S0378-1127(01)00575-8

[7] Franzreb, K. (1978). Tree species used by birds in logged and unlogged mixed-coniferous forests. The Wilson Bulletin, 90, 221-238.

[8] Freemark, K., & Merriam, H. (1986). Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. Biological Conservation, 36, 115-141. doi:10.1016/0006-3207(86)90002-9

[9] Grasman, R., Gramacy, R.B., & Sterratt, D. C. (2011). Geometry: Mesh generation and surface tesselation. R Package Version 0.2-0. URL (last checked 5 June 2012). http://CRAN.R-project.org/package=geometry

[10] Kimmins, J. (2005). Forest ecology: A foundation for sustainable forest management and environmental ethics in forestry (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

[11] Lawton, J. (1983). Plant architecture and the diversity of phytophagous insects. Annual Review of Entomology, 28, 23-39. doi:10.1146/annurev.en.28.010183.000323

[12] Legendre, P., & Legendre, L. (1998). Numerical ecology. Elsevier Science & Technology, 20, 853.

[13] LeMay, V., & Staudhammer, C. (2005). Indices of stand structural diversity: Mixing discrete, continuous, and spatial variables. In Proceedings of the IUFRO Sustainable Forestry in Theory and Practice: Recent Advances in Inventory & Monitoring, Statistics, Information & Knowledge Management, and Policy Science Conference (p. 4). Edinburgh, 5-8 April 2005.

[14] MacArthur, R., & MacArthur, J. (1961). On bird species diversity. Ecology, 42, 594-598. doi:10.2307/1932254

[15] MacArthur, R., & Wilson, E. (1967). The theory of island biogeography. Princeton, NJ: Princeton University Press.

[16] McCoy, E., & Bell, S. (1991). Habitat structure: The evolution and diversi?cation of a complex topic (pp. 3-27). London: Chapman and Hall.

[17] McDonald, R., & Urban, D. (2006). Edge effects on species composition and exotic species abundance in the North Carolina piedmont. Biological Invasions, 8, 1049-1060. doi:10.1007/s10530-005-5227-5

[18] McElhinny, C., Gibbons, P., Brack, C., & Bauhus, J. (2005). Forest and woodland stand structural complexity: Its de?nition and measure- ment. Forest Ecology and Management, 218, 1-24. doi:10.1016/j.foreco.2005.08.034

[19] Minchin, P. (1987). An evaluation of the relative robustness of techniques for ecological ordination. Plant Ecology, 69, 89-107. doi:10.1007/BF00038690

[20] Moen, C., & Gutierrez, R. (1997). California spotted owl habitat seletion in the central Sierra Nevada. The Journal of Wildlife Management, 61, 1281-1287. doi:10.2307/3802127

[21] Oksanen, J., Kindt, R., Legendre, P., O ' Hara, B., Stevens, M., Oksanen, M., & Suggests, M. (2007). The vegan package. Community ecology package. URL (last checked 5 June 2012). http://www.R-project.org

[22] Polley, H. (2007). Survey instructions for federal forest inventory II (2001-2002), 2nd corrected translation, February 2006, of the 2nd corrected and revised reprint, May 2001. Federal Ministry of Food, Agriculture and Consumer Protection, Bundesministerium für Verbraucherschutz, Ernahrung und Landwirtschaft (BMVEL). URL (last checked 10 September 2012). http://www.bundeswaldinventur.de/media/archive/513.pdf

[23] Pommerening, A. (2002). Approaches to quantifying forest structures. Forestry, 75, 305-324. doi:10.1093/forestry/75.3.305

[24] Pretzsch, H. (1997). Analysis and modeling of spatial stand structures. Methodological considerations based on mixed beech-larch stands in Lower Saxony. Forest Ecology and Management, 97, 237-253. doi:10.1016/S0378-1127(97)00069-8

[25] Pretzsch, H. (2009). Forest dynamics, growth and yield: From measurement to model. Berlin: Springer Verlag.

[26] Quinn, G., & Keough, M. (2002). Experimental design and data analysis for biologists. Cambridge:

Cambridge University Press. doi:10.1017/CBO9780511806384

[27] R Core Team (2012). R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing.

[28] Recher, H., Majer, J., & Ganesh, S. (1996). Eucalypts, arthropods and birds: On the relation between foliar nutrients and species richness. Forest Ecology and Management, 85, 177-195. doi:10.1016/S0378-1127(96)03758-9

[29] Sappington, J., Longshore, K., & Thompson, D. (2007). Quantifying landscape ruggedness for animal habitat analysis: A case study using bighorn sheep in the Mojave Desert. The Journal of Wildlife Management, 71, 1419-1426. doi:10.2193/2005-723

[30] Simpson, E. (1949). Measurement of diversity. Nature, 163, 688. doi:10.1038/163688a0

[31] Spanos, K., & Feest, A. (2007). A review of the assessment of biodiversity in forest ecosystems. Management of Environmental Quality: An International Journal, 18, 475-486. doi:10.1108/14777830710753857

[32] Temple, S., Mossman, M., & Ambuel, B. (1979). The ecology and management of avian communities in mixed hardwood-coniferous forests. In Management of north-central and northeastern forests for nongame birds (pp. 132-153). USDA.

[33] Tews, J., Brose, U., Grimm, V., Tielb?rger, K., Wichmann, M., Schwager, M., & Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. Journal of Biogeography, 31, 79-92. doi:10.1046/j.0305-0270.2003.00994.x

[34] United States Department of Agriculture—Forest Service (2011). Forest inventory and analysis,