A GIS-based dynamical programming model for landscape pattern optimizing and its convergent algorithm

Qingguo Zhang[1] and Li Xu[2] .

GIS is an essential tool for large-scale land use planning. The spatio-temporal dynamic changes of landscape patterns are an important issue for researches in landscape ecology. The transitions among various land use types over time, studied by the Markov chain model and combined with economic factors, were conducted for the management and planning of land use system. These models, however, only depend on the transition matrix, whose elements were constant, to describe the dynamic change of spatial patterns. In addition, the human and natural disturbances were not considered in these models, which made them somehow ineffective in their applications. This paper, based on GIS and taken account of human and natural disturbances, propose a multi-dimension landscape patterns dynamic optimizing decision model

$$\mathbf{s}(t+1) = \mathbf{s}(t)\ \left(\mathbf{Q}(t) + \mathbf{w}^t(t)\,\mathbf{r}(t)\right)$$

for the dynamic programming of land use system, where the vector s(t) is the distribution of areas of land use, and develop a preliminary computer decision support system for land use planning and management. Aimed at certain given objectives, a series of decision variables were generated and the land use system can be made to reach their optimum composition as a whole. The algorithm for the model was provided and proved to be convergent. Linked with GIS, the dynamic simulation using this model for the spatial patterns of land use system can be quantitatively and visually illustrated.

References

[1] Burrough, P.A. 1988. Principles of Geographical Information Systems for Land Resources Assessment. Oxford: Clarendon Press.

[1]Department of Mathematics, Anhui Agricultural University, Hefei, Anhui 230036, P.R.China (e-mail: zhang_qg@mail.hf.ah.cn).

[2](e-mail:).

[2] Coulson, R.N., Lovelady, C.N., and Flamm, R.O. et al 1992. Intelligent geographic information systems for natural resource management. In: Quantitative Methods in Landscape Ecology, eds. M.G. Turner and R.H. Gardner, pp153-172. New York: Springer-Verlag.

[3] Forman, R.T.T. and M.Godron. 1981. Patches and structural components for landscape ecology. BioScience 31:733-740

[4] Hazell, P.B., and Norton, R.D. 1986. Mathematical Programming for Economic Analysis in Agriculture. New York: MacMillan

[5] Krummel, J.R. R.H.Gardner, G.Sugihara, and R.V.ONeill. 1987. Landscape patterns in a disturbed environment. Oikos, 48:321-324

[6] Lippe, E. J.T.de Smidt and D.C.Glenn-Lewin. 1985. Markov models and succession: A test from a heathland in the Netherlands. J. Ecology 73:775-791

[7] Parks, P.J. 1992. Models of forested and agricultural landscape: integrating economics. In: Quantitative Methods in Landscape Ecology, eds. M.G. Turner and R.H. Gardner, pp153-172. New York: Springer-Verlag.

[8] Sklar, F.H.,R.Costanza and J.W.Day,Jr. 1985. Dynamic spatial simulation modeling of coastal wetland habitat succession. Ecol. Modelling 29:261-281

[9] Turner, M.G. 1987. Spatial simulation of landscape changes in Georgia: a comparison of 3 transition models. Landscape Ecology 1:29-36

[10] Turner, M.G. 1988. A spatial simulation model of land use changes in a piedmont county in Georgia. Applied Mathematics and Computation 27:39-51

[11] Turner, M.G. and Dale, V.H. 1992. Modeling landscape disturbance. In: Quantitative Methods in Landscape Ecology, eds. M.G. Turner and R.H. Gardner, pp 323-351 New York: Springer-Verlag.

[12] Zhang, Qingguo 1998. Studies on the quantitative methods in landscape ecology and their applications in land use system — A case study on Hangzhou City. Ph.D dissertation, Zhejiang Agricultural University, Hangzhou, China

[13] Zhang, Qingguo, Bingmin Hu 1998. A matrix model for population dynamics within opening system with immigration and emigration of individuals. In: Chen, L.S. et al, eds, Advanced topics in biomathematics. World Scientific Publication Company, New York, U.S.A. 303-308

[14] Zhang, Qingguo and Minghua Zhang. 2001, A GIS-based dynamic optimizing model applied in land use planning. Journal of Anhui Agricultural University, 28,3:83-92

[15] Zhang, Qingguo. 2002, Deconvolution as a systems analysis approach to study the complexity of ecosystems. Proceedings of International Conference of Mathematics 2002 Satellite Conference in Mathematical Biology, August 15-18, 2002, Guilin, China