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Understanding sprawl landscape change processes: Human preferences, agent behaviors and ecological effects.

Simulating large-lot residential landscape change

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Abstract

Rural residential developments have greatly changed rural landscapes and altered their ecology. Innovative alternative landscape design, which incorporates landscape ecological principles, could potentially alleviate adverse ecological effects associated with suburbanization in rural areas. Decision support tools that can visualize and evaluate future landscape design choices are needed to investigate the relationship between lot-scale landscape design and regional landscape patterns. We developed a GIS-based Monte Carlo simulation tool that generates land cover maps based on landscape design rules that specify types, proportions, spatial association, and pattern characteristics of land cover. The resulting maps represent the aggregate effects of lot-scale residential designs on landscape patterns and could be used in landscape pattern analysis that supports the planning and design of residential developments. As an illustration, we selected a 3 by 3 mile (4.8 km) rural site in Southeast Michigan and tested two landscape design scenarios, conventional and alternative, in an area that has low to medium density residential zoning. The conventional design is characterized in this research as having small-lot (i.e., < 1 acre (0.4 ha)) single family houses with more than fifty percent of lawn on the lot. The alternative design uses a large-lot (i.e., > 5 acres (2 ha)) residential design with more than sixty percent of the lot covered by ecologically beneficial land-cover types such as trees or perennial herbaceous plants. We divided the study site into 36 160-acre (65 ha) subdivisions and generated initial raster (20 by 20 meter) GIS maps with land cover proportions determined by zoning density and design scenarios. The land cover types simulated include impervious surface, tree, grass (lawn), soil, and herbaceous. We then applied pattern rules on these maps to reproduce the housing and yard patterns individual subdivisions and lots would have for each design scenario. The land cover proportions in the subdivisions were held constant throughout the process. Forty maps were simulated, twenty for each design scenario. We used FRAGSTATS to characterize landscape patterns on these maps and ANOVA to investigate the effects of alternative residential design on landscape pattern metrics. The results show that the alternative large-lot design creates landscape patterns that are more diverse, have better contiguity, and have more core areas for ecologically beneficial land cover types, than the conventional design does. This study illustrates how GIS simulation tools can support planners and landscape designers in making lot-scale design choices that have ecologically beneficial effects on regional landscape patterns.

Keywords: Monte Carlo simulation, GIS, residential land-use, land-cover, landscape design