Comparison of the Accuracy of Land Change Models: Cellular Automata Markov versus Geomod

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Abstract

It is difficult to determine how much trust should be placed in results of land-use change simulation models because the methods to measure the accuracy of such models are insufficiently developed. This project addresses this problem by presenting methods to quantify the uncertainty in different types of models and in various runs of the same model.

Area of Study

The area of study for this project is Worcester, Massachusetts, USA and the nine towns surrounding it. The map at the right (Figure 1) displays HERO-CM's four study areas, the area for this project is in red.

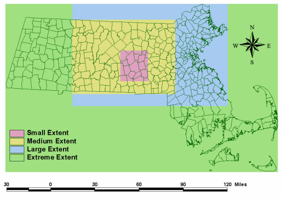

Figure 1

Methods

This project compares two land change models, Cellular Automata Markov (CA_Markov) and Geomod. The following charts demonstrate the basic differences between these two models (Table 1) and the different variables taken into account for each model run that was conducted (Figure 2).

Characteristic	CA_Markov	GEOMOD
1) Number of Categories	Many	Two
2) Transitions	Gains and losses	Gain or loss
3) Information for Quantities	Computed from 2 maps	Must be supplied
4) Quantity Change	Multiplicative	Additive
5) Suitability Map	Must be supplied for each transition	Can be created from land-use map of 1 point in time
6) Proximity Method	Filter	Constraint
7) Stratification	Not designed	Part of the design

Table 1

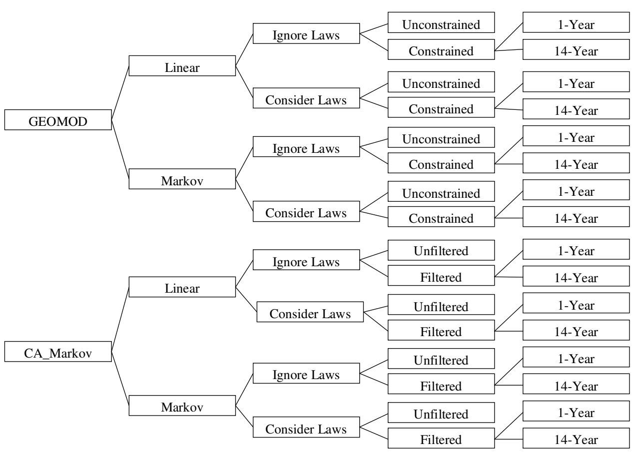

Figure 2

Methods, Con't

Land use data from 1971, 1985, and 1999 are available. Data from 1971 and 1985 are used to calibrate the model runs (Figure 3) in an effort to predict what change takes place over the period from 1985 to 1999 (Figure 4).

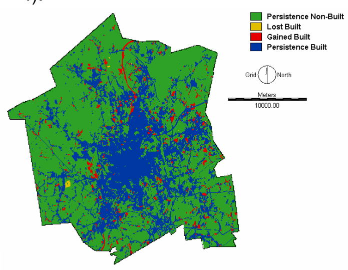

Figure 3. Signal to Calibrate.

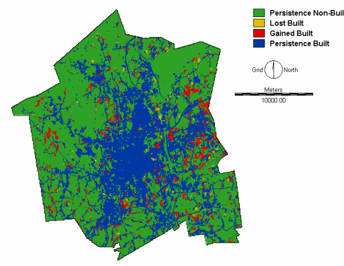

Figure 4. Signal to Predict.

Location of change is predicted by each of the models. Quantity of change is predicted using a linear extrapolation, or through a Markov chain analysis. Figure 5 displays predicted and actual quantities for the Built category in 1971, 1985, and 1999 as a percent of the landscape

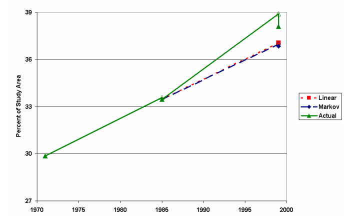

Figure 5. Land use quantities.

Validation is carried out by comparing each model run to 1) the existing map of real land use of 1999 (as seen in Figure 4) and 2) the map of 1985 land use. The 1985 map represents a null scenario where the prediction is that no change occurs on the landscape. Another means of comparing the prediction to the null model is to determine at which resolution the prediction will perform better than a null model.

It is important to compare the prediction to a null model because most land change models fail to consider landscape persistence when analyzing model performance. Figures 6 and 7 below demonstrate that only a very small percentage of the landscape changes, so it is vital that this be taken into account.

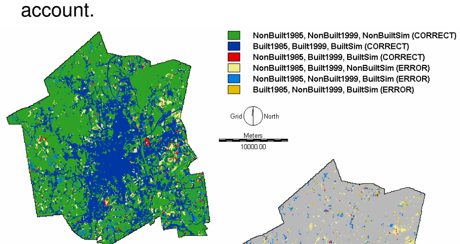

Figure 6.

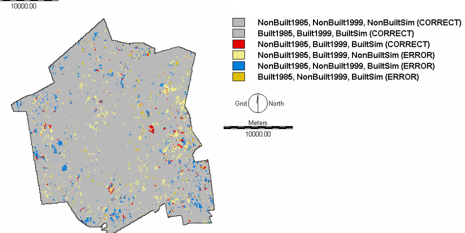

Figure 7.

Results

Figures 8 and 9 display the profile of change for the null model (Fig. 8) and the best prediction (Fig. 9). The profile displays the different components of agreement and disagreement.

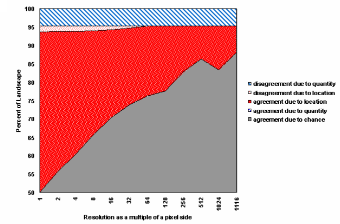

Figure 8. Profile of Null Model.

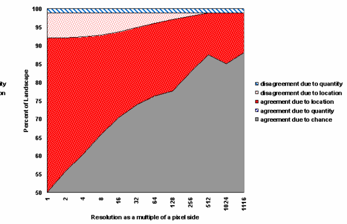

Figure 9. Profile of Best Prediction.

The accuracy of each model depends on the prediction of both location and quantity. When conducting the analysis of null resolution, as the resolution gets coarser, the error due to location will shrink, but the error due to quantity will always remain the same. It is this error due to quantity that dictates the maximum possible percent correct (it is the top band on each profile). Figure 10 displays a comparison of the null model with the best prediction. Figure 11 displays the percent correct and null resolution for all model runs.

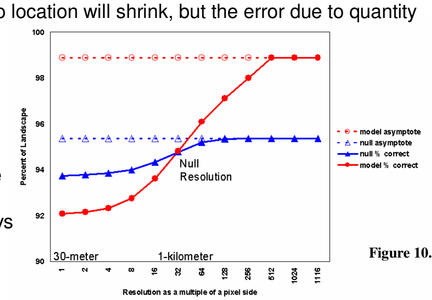

Figure 10.

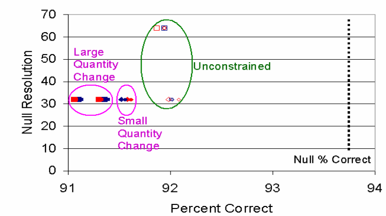

Figure 11.

Geomod = Diamond	Linear Quantity = Blue	Large = No Laws
CA_Markov = Square	Gain&Loss Quantity = Red	Small = With Laws

Discussion

The null model was 93.75% correct, surpassing the best of the predictions made by either model. This clearly demonstrates the importance of comparing the predictions with the null model, because it helps to put into perspective what a figure of 92% correct actually means. In this case, it means that a prediction of the 1999 landscape does better when no change is predicted whatsoever. Knowing what resolution the model performs better than the null model is also important because it lets the modeler better understand the scale at which s/he is making an effective prediction.

Acknowledgements

This research was made possible through the HERO program that NSF supports through the grant "Infrastructure to Develop a Human-Environment Regional Observatory Network" (Award ID 9978052). I acknowledge also the Center for Integrated Study of the Human Dimensions of Global Change. This Center has been created through a cooperative agreement between the National Science Foundation (SRB-9521914) and Carnegie Mellon University, and has been generously supported by additional grants from the Electric Power Research Institute, the ExxonMobil Foundation, and the American Petroleum Institute. I thank also Clarklabs, which has made the methods of this paper available in the GIS software *Idrisi*. I would also like to thank Professor Gil Pontius, Ke Chen, and my fellow HEROs.