Urban Growth Modeling for the SAMBI Designing Sustainable Landscapes Project

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INTRODUCTION

In the Southeastern U.S. rapid urbanization is a major challenge to developing long-term conservation strategies. The SAMBI DSL project used predicted urban growth models described herein to inform future landscape conditions that were also based climate change impacts and vegetative community succession. These future landscape conditions were then applied as a context for land use and management decisions in conservation planning.

SLEUTH, named for the model input datasets (Slope, Land use, Excluded, Urban, Transportation and Hillshade) is the evolutionary product of the Clarke Urban Growth Model that uses cellular automata, terrain mapping and land cover change modeling to address urban growth (Jantz et al, 2009; NCGIA 2011). SLEUTH provides urban growth projections which are useful across a range of applications; including wildlife habitat analysis, conservation planning, and land cover dynamics analysis. SLEUTH incorporates four growth rules (Spontaneous Growth, New Spreading Centers, Edge Growth and Road-Influenced Growth) to model the rate and pattern of urbanization. The model simulates not only outward growth of existing urban areas, but also growth along transportation corridors and new centers of urbanization. SLEUTH incorporates five parameters (Dispersion, Breed, Spread, Slope and Road Gravity) into the growth rules which project future urbanization. Possible parameter coefficient values range between 1 and 100. During calibration every possible combination of these five parameter coefficients (between defined start and stop values and by a defined step size) is applied to the growth rules, in order to find the combination that best matches past urbanization patterns observed in the training data. Once found, the model is run in prediction mode using these parameter values in the growth rules. The model produces one urban growth cycle per year. For each growth cycle, a GIF image is produced showing the probability of urbanization for each pixel.

This project utilized the SLEUTH-3r version of the model taking advantage of added new functionality and substantially increased performance (Jantz et al. 2009) over previous versions.

METHODS

Input Data

The input datasets for SLEUTH-3r were produced using the ESRI ArcGIS suite of geographic information systems software, with the exception of land use, which is optional for the model and was not used in this project. Slope was produced from the National Elevation Dataset (USGS, 2011) using the ESRI ArcGIS Slope tool from the Spatial Analyst Toolbox with the Percent Slope setting and a z-factor of 1. The z-factor is a multiplier used in cases where vertical units differ from horizontal units. Hillshade was produced from the NED raster data, (USGS, 2011), using the ESRI ArcGIS Hillshade tool from the Spatial Analyst Toolbox, with default settings.

The Excluded dataset provides a means for deterring future urbanization through weighted values. Possible exclusion values range from 1 to 100, where higher values indicate greater deterrent. The Excluded dataset was derived from the National Land Cover Dataset (MRLC 2001, Homer et al. 2007) and the Protected Areas Database of the US (PADUS, 2011). Areas classified as water in the 2001 NLCD were excluded from development entirely, as were beach and dune ecological systems in the 2001 Southeast Gap Analysis Project (SEGAP, 2011) land cover data. Wetland classes from 2001 NLCD were assigned a value of 95 because we assumed that only a small portion of wetlands would be developed. Additionally, areas with GAP status of 1-3 (indicating some form of permanent protection status) in PADUS were excluded entirely.

We modified the standard approach for developing urban and transportation input datasets. Prior studies have relied upon air photo interpretation and historical maps for delineation of these inputs (Dietzel, et al, 2004, Herold et al, 2003, NCGIA, 2011, Syphard et al, 2005). However, since this project has such an extensive study area, this approach was not feasible and an alternative was necessary. Line density analysis of roads from US Census Bureau TIGER Line Data (USCB, 2011a) was used to approximate prior urbanization. This approach was chosen due to the frequent and widely available nature of TIGER Line data. Through line density analysis of roads (excluding features such as un-paved roads and private drives), we were able to produce estimates of the urban extent for four input dates (2000, 2006, 2008 and 2009), incorporating exurban areas not classified as urban by regional land cover datasets such as NLCD, but which still impact wildlife habitat and habitat connectivity due to anthropogenic influence.

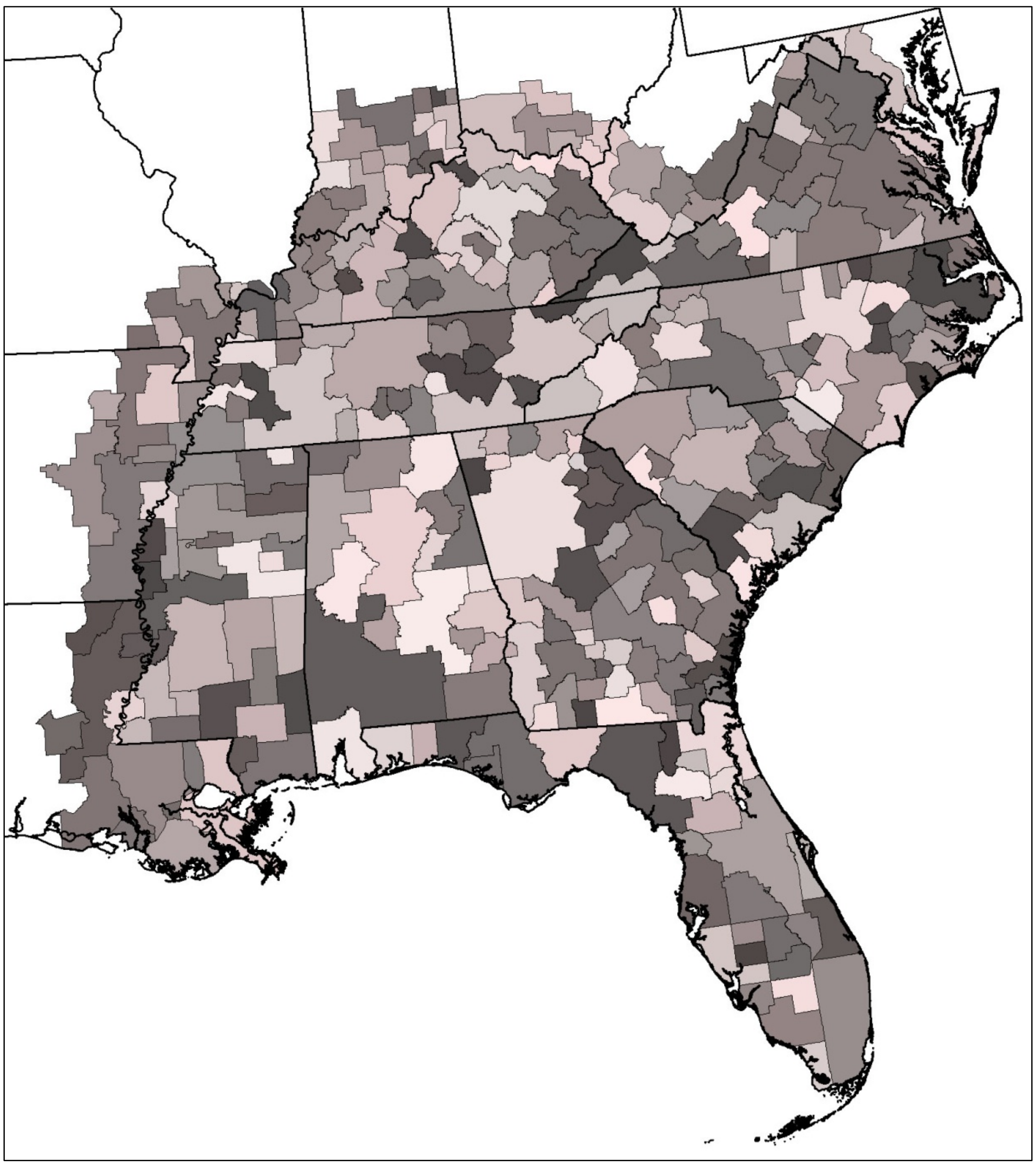
In order to implement this approach careful pre-processing of the roads coverage was necessary. Classification of road features was inconsistent, and in some areas roads such as private driveways and logging roads were classified as “Local, neighborhood, and rural road, city street, unseparated” (USCB, 2011a). As a result, in some areas, the estimations of urbanization for some input years were inflated, resulting in higher growth rates during calibration. Where this issue occurred roads with this classification which are also un-named were removed from consideration during the line density analysis. It was also discovered that in more recent versions of TIGER line data, divided highways were sometimes represented with a single feature per direction of travel where they had previously been represented with a single line feature representing all lanes of travel. Where this was observed, a similar inflation of growth rates in calibration occurred and undeveloped areas along interstates and divided state highways, etc. were more likely to be modeled as urbanized. In order to resolve this issue, major roads were buffered and centerlines were derived from the resulting polygons before line density analysis was performed.

TIGER Line data was also used in producing our transportation datasets. Strong inconsistencies exist within and between early versions of TIGER Line data. Highways and interstates exhibited the greatest thematic accuracy overall, and TIGER versions 2000 and more recent exhibited greatest positional accuracy. Road-Influenced Growth is most likely to occur along intestates and highways, not city or neighborhood streets where new roads and other components of urbanization appear simultaneously. Therefore, only interstates and highways were chosen to represent the transportation network. Because we already had compiled roads for use in developing our urban inputs, we chose to include the first and last dates of our urban inputs for our transportation datasets (2000 and 2009).

Study Area

We developed input data for the entire South Atlantic Migratory Bird Initiative region (SAMBI), but subdivided the region for model calibration and prediction. The computationally demanding nature of SLEUTH3-r and the variability in growth rates and patterns throughout the region required the subdivision. We used the boundaries of US Census Bureau Combined Statistical Areas (CSA) as the basis for subdividing the SAMBI (Figure 1). A CSA is defined as two or more adjacent metropolitan or micropolitan statistical areas (with substantial commuting ties), each with a core area containing a substantial population nucleus and having a high degree of economic and social integration (USCB, 2011b). By conducting simulations across individual CSAs, we are maximizing the likelihood that our simulations occur across regions with uniform drivers of growth. We modified CSA boundaries for our simulations where they crossed state lines, and grouped counties not belonging to any CSA.

Figure 1. Aggregated US Census Bureau Combined Statistical Areas



Code Changes

During testing of the SLEUTH3-r model with these datasets and sub-regions, we found the spreading growth it simulated was excessive and did not reflect prior growth patterns in the Southeast. We determined this was due to a setting in the model's spread.c file, which sets the number of neighboring urban pixels needed by a newly, spontaneously urbanized cell for it to become a new spreading urban center. Therefore, we increased the number of neighbors needed from the default of two to three in an eight cell neighborhood.

During calibration, the scenario file was altered in order to bypass Boom and Bust growth cycles. The Boom and Bust cycle was developed to replicate the tendency of growth to occur at non-linear rates with periods of greater and lesser growth (NCGIA, 2011). Both the upper and lower Boom and Bust values were set to 1 so that growth rate was not further affected when the growth rate fell below the Critical Low or exceeded the Critical High value. The Critical High and Critical Low values are thresholds to which the current cycle's growth rate is compared. If the growth rate falls below the Critical Low, slower growth is initiated by multiplying the growth rate by the Bust parameter (less than 1). If the growth rate exceeds the Critical High, faster growth is initiated by multiplying the growth rate by the Boom parameter (greater than 1).

Calibration

Previous studies have shown that, unlike the other four coefficients, the Road Gravity Coefficient does not exhibit a relationship to any fit statistic (Jantz et al, 2005). Due to its instability, this coefficient was fixed during both calibration and prediction phases of the model. The Road Gravity Coefficient was fixed at 100 principally because we only included interstates and highways in the transportation input datasets and reason that the most permissive coefficient value would best allow this transportation network to influence the mobilization of urbanization along it. Similarly, when modeling areas where slope is not a factor (e.g., the Coastal Plain), the Slope Coefficient was fixed at 25, with 0 being the most permissive coefficient value and 100 being the least permissive.

The first stage in calibration was to determine an initial Auxiliary Diffusion Multiplier (iADM) which, along with the diffusion coefficient and the number of pixels in the urban input image diagonal, determines the number of spontaneous urbanization attempts (Jantz et al, 2009). In order to determine the iADM, the Diffusion coefficient was set to 100 while all the others were set to their least permissive value. Twentyfive Monte Carlo simulations were performed in calibration mode. The area difference and ratio metrics were used to adjust the iADM until area was slightly over-estimated, similar to previous methods (Jantz et al, 2009). Once the iADM was determined, all coefficients were set to their most permissive to determine the maximum growth the model would predict with those coefficient values.

To conduct SLEUTH3-r calibration, metrics describing total area of urbanization, edge growth and number of clusters were compared between the input urbanization datasets and projections made by the model. In order to prevent any one of these three metrics from driving calibration disproportionately, we calculated and totaled the normalized error(s) in the three metrics. We chose the coefficient combinations with the least total error (within a tolerance of +/- 5% of observed to modeled Area) to drive subsequent calibration of the model coefficients until best single values were reached. Additionally, we adjusted the Auxiliary Diffusion Multiplier until the Dispersion coefficient was no longer forced to a minimum to produce least error. Calibration was run with 25 Monte Carlo simulations, using between 1 and 48 processors at the North Carolina State University High Performance Computing Center (NCSU HPC).

Prediction

Once near-optimal values were determined, the scenario file was edited for prediction. Best Fit Coefficient values were set, and Boom and Bust Parameters were each kept at 1 in order to reduce their influence on probability of urbanization projections. The near optimal values and calibration metrics are reported in Appendix A.

The colormap produced for output prediction images was altered in order to capture a 95% confidence interval for urbanization determined by the model. Prediction was run with 200 Monte Carlo simulations, using 48 processors on the NCSU HPC. Resulting output images represented the probability of urbanization at a 60 meter resolution. Where no probability of urbanization was predicted, the input hillshade is present as a backdrop to the image.

Post Processing

Post processing of the output images produced by the model converted them to ESRI grids .The hillshade background was removed in order to keep it from influencing any subsequent neighborhood or multiple-raster analyses. Output for all CSAs in the SAMBI were mosaiced and predicted growth was summarized across the SAMBI for each decadal time step (Table 1). Annual outputs were archived and can be made available upon request to the Biodiversity and Spatial Information Center at NC State University (www.basic.ncsu.edu).

Table 1. Final Urban Growth Datasets (www.basic.ncsu.edu/dsl)

File Name	Dataset Name	Year
sambi_sleuth.zip	sambi_urb2010	2010
sambi_sleuth.zip	sambi_urb2020	2020
sambi_sleuth.zip	sambi_urb2030	2030
sambi_sleuth.zip	sambi_urb2040	2040
sambi_sleuth.zip	sambi_urb2050	2050
sambi_sleuth.zip	sambi_urb2060	2060
sambi_sleuth.zip	sambi_urb2070	2070
sambi_sleuth.zip	sambi_urb2080	2080
sambi_sleuth.zip	sambi_urb2090	2090
sambi_sleuth.zip	sambi_urb2100	2100

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Protected Areas of the United States. http://www.protectedlands.net/padus/

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Appendix A: SLEUTH Near Optimal Values and Calibration Metrics

CSA	DM	run #	diff. coeff	breed coeff	spread coeff	slp resst coeff	road grav coeff	control year	area scl	edge scl	clust scl	scl sum	area diff	area ratio	area fract	edges diff	edges ratio	edges fract	cluster diff	cluster ratio	cluster fract
CSA 5	0.0067	23	1	4	100	25	100	2009	0.001	0.001	0.010	0.047	-681	0.996	-0.004	495	1.018	0.018	858.5	2.520	1.520
CSA 6	0.0040	2	1	1	92	25	100	2009	0.001	0.000	0.008	0.051	119	1.002	0.002	-9	0.999	-0.001	413.7	2.029	1.029
CSA 7	0.0010	19	1	2	83	25	100	2009	0.006	0.006	0.009	0.064	2585	1.012	0.012	1958	1.057	0.057	959.6	2.405	1.405
CSA 8	0.0005	5	1	1	55	25	100	2009	0.000	0.004	0.009	0.055	4	1.000	0.000	129	1.042	0.042	111.9	2.301	1.301
CSA 9	0.0010	4	1	1	34	25	100	2009	0.008	0.005	0.010	0.060	-439	0.977	-0.023	204	1.050	0.050	182.9	2.429	1.429
CSA 10	0.0005	123	1	2	66	96	100	2009	0.001	0.006	0.008	0.053	63	1.001	0.001	594	1.048	0.048	369.0	1.923	0.923
CSA 11	0.0005	45	1	1	89	91	100	2009	0.006	0.005	0.005	0.042	509	1.029	0.029	308	1.068	0.068	131.0	1.856	0.856
CSA 13	0.0005	8	1	1	83	25	100	2009	0.005	0.006	0.009	0.055	232	1.019	0.019	230	1.070	0.070	123.2	2.449	1.449
CSA 14	0.0010	7	1	1	57	25	100	2009	0.004	0.006	0.010	0.068	-729	0.991	-0.009	849	1.059	0.059	515.9	2.573	1.573
CSA 15	0.0010	233	1	1	83	100	100	2009	0.000	0.007	0.007	0.065	167	1.001	0.001	1977	1.096	0.096	702.2	2.481	1.481
CSA 16	0.0010	6	1	1	66	25	100	2009	0.002	0.001	0.008	0.054	125	1.005	0.005	28	1.005	0.005	168.0	1.994	0.994
CSA 17	0.0050	76	1	96	100	25	100	2009	0.004	0.000	0.011	0.080	-1022	0.982	-0.018	-34	0.998	-0.002	552.9	2.365	1.365
CSA 18	0.0010	55	1	4	92	25	100	2009	0.000	0.004	0.006	0.066	4	1.000	0.000	-337	0.955	-0.045	176.1	1.756	0.756
CSA 19	0.0010	23	1	2	92	25	100	2009	0.005	0.004	0.010	0.094	-2788	0.984	-0.016	1252	1.042	0.042	814.2	2.230	1.230
CSA 20	0.0010	19	1	2	68	25	100	2009	0.000	0.007	0.010	0.092	-43	1.000	0.000	2408	1.069	0.069	974.2	2.033	1.033
CSA 23	0.0050	21	1	4	48	25	100	2009	0.000	0.008	0.011	0.058	109	1.000	0.000	7065	1.130	0.130	2254.5	3.143	2.143
CSA 25	0.0020	1	1	1	21	25	100	2009	0.021	0.008	0.013	0.113	-1808	0.960	-0.040	555	1.054	0.054	381.4	2.230	1.230
CSA 26	0.0025	3	1	1	63	25	100	2009	0.000	0.004	0.010	0.061	26	1.001	0.001	228	1.041	0.041	185	2.453	1.453
CSA 27	0.0010	5	1	1	6	25	100	2009	0.013	0.003	0.010	0.072	-1306	0.971	-0.029	190	1.017	0.017	240	1.664	0.664
CSA 29	0.0010	13	1	1	38	25	100	2009	0.001	0.012	0.013	0.090	-220	0.997	-0.003	2277	1.162	0.162	616	2.702	1.702
CSA 30	0.0010	13	1	1	38	25	100	2009	0.001	0.010	0.012	0.087	-255	0.996	-0.004	1617	1.125	0.125	509	2.798	1.798
CSA 31	0.0010	20	1	1	50	25	100	2009	0.001	0.006	0.010	0.089	-132	0.997	-0.003	743	1.085	0.085	315	2.413	1.413
CSA 32	0.0010	650	1	1	45	25	100	2009	0.001	0.008	0.013	0.074	-98	0.998	-0.002	632	1.088	0.088	271	2.497	1.497
CSA 33	0.0010	5	1	1	45	25	100	2009	0.003	0.014	0.013	0.087	278	1.008	0.008	1048	1.158	0.158	288	2.803	1.803
CSA 34	0.0005	8	1	1	18	25	100	2009	0.028	0.005	0.013	0.172	-1068	0.953	-0.047	142	1.026	0.026	158	2.011	1.011
CSA 35	0.0010	2	1	1	52	25	100	2009	0.000	0.011	0.010	0.067	-12	1.000	0.000	1490	1.113	0.113	426	2.434	1.434
CSA 36	0.0014	3	1	1	58	25	100	2009	0.001	0.014	0.026	0.125	82	1.002	0.002	877	1.096	0.096	212	2.572	1.572
CSA 37	0.0050	6	1	1	76	25	100	2009	0.008	0.038	0.042	0.262	248	1.007	0.007	658	1.093	0.093	167	2.518	1.518
CSA 38	0.0020	17	1	2	36	25	100	2009	0.013	0.014	0.021	0.126	-25719	0.951	-0.049	14325	1.179	0.179	3675	3.234	2.234
CSA 39	0.0050	367	1	2	54	25	100	2009	0.001	0.010	0.011	0.068	-270	0.998	-0.002	2349	1.093	0.093	931	2.250	1.250

CSA	DM	run #	diff. coeff	breed coeff	spread coeff	slp resst coeff	road grav coeff	control year	area scl	edge scl	clust scl	scl sum	area diff	area ratio	area fract	edges diff	edges ratio	edges fract	cluster diff	cluster ratio	cluster fract
CSA 40	0.0010	2	1	1	42	25	100	2009	0.000	0.019	0.023	0.133	-196	0.999	-0.001	5641	1.134	0.134	1474	2.897	1.897
CSA 41	0.0050	12	1	1	87	25	100	2009	0.005	0.007	0.013	0.179	-416	0.990	-0.010	409	1.053	0.053	198	2.378	1.378
CSA 42	0.0015	4	1	1	89	25	100	2009	0.001	0.015	0.014	0.090	634	1.004	0.004	4324	1.163	0.163	758	2.901	1.901
CSA 43	0.0010	854	2	1	34	25	100	2009	0.000	0.007	0.014	0.067	26	1.001	0.001	850	1.129	0.129	296	2.896	1.896
CSA 44	0.0010	11	1	1	12	25	100	2009	0.015	0.003	0.012	0.087	-5358	0.951	-0.049	700	1.033	0.033	460	2.145	1.145
CSA 45	0.0050	5	1	1	6	25	100	2009	0.013	0.001	0.011	0.059	-2432	0.970	-0.030	69	1.004	0.004	286	1.822	0.822
CSA 46	0.0010	13	1	1	18	25	100	2009	0.000	0.006	0.010	0.047	37	1.001	0.001	784	1.091	0.091	316	2.611	1.611
CSA 47	0.0035	11	1	1	55	25	100	2009	0.004	0.011	0.026	0.118	-10482	0.986	-0.014	13277	1.120	0.120	4364	3.276	2.276
CSA 48	0.0013	20	1	1	40	25	100	2009	0.009	0.012	0.017	0.122	-9655	0.973	-0.027	8417	1.135	0.135	2561	2.878	1.878
CSA 49	0.0075	6	1	1	21	25	100	2009	0.024	0.006	0.021	0.145	-7329	0.952	-0.048	1139	1.036	0.036	1035	2.531	1.531
CSA 50	0.0050	9	1	1	19	25	100	2009	0.019	0.005	0.018	0.106	-3109	0.961	-0.039	622	1.037	0.037	567	2.359	1.359
CSA 51	0.0075	25	1	2	33	25	100	2009	0.000	0.014	0.020	0.108	-23	1.000	0.000	2774	1.128	0.128	940	2.621	1.621
CSA 52	0.0040	22	1	1	42	25	100	2009	0.013	0.015	0.018	0.187	-1240	0.969	-0.031	1030	1.110	0.110	375	2.387	1.387
CSA 53	0.0035	4	1	1	14	25	100	2009	0.016	0.003	0.012	0.080	-2234	0.954	-0.046	323	1.030	0.030	352	2.089	1.089
CSA 54	0.0025	6	1	1	66	25	100	2009	0.012	0.024	0.019	0.203	-3635	0.978	-0.022	5672	1.204	0.204	950	2.759	1.759
CSA 55	0.0050	9	1	1	49	25	100	2009	0.001	0.014	0.018	0.115	111	1.003	0.003	1579	1.157	0.157	439	2.541	1.541
CSA 56	0.0075	10	1	1	60	25	100	2009	0.001	0.014	0.017	0.108	229	1.003	0.003	2148	1.148	0.148	562	2.501	1.501
CSA 57	0.0050	55	1	2	33	25	100	2009	0.019	0.011	0.017	0.152	-3742	0.952	-0.048	1716	1.088	0.088	797	2.474	1.474
CSA 58	0.0015	15	1	1	100	25	100	2009	0.008	0.014	0.017	0.168	-2992	0.983	-0.017	3288	1.134	0.134	670	2.904	1.904
CSA 59	0.0010	272	1	1	50	25	100	2009	0.008	0.012	0.015	0.179	-1729	0.979	-0.021	1949	1.113	0.113	676	2.602	1.602
CSA 60	0.0010	28	1	2	77	25	100	2009	0.015	0.007	0.010	0.213	-1526	0.964	-0.036	563	1.056	0.056	292	2.057	1.057
CSA 61	0.0010	0	1	1	75	25	100	2009	0.018	0.003	0.009	0.091	-8722	0.950	-0.050	886	1.036	0.036	732	2.644	1.644
CSA 62	0.0010	233	1	2	67	25	100	2009	0.000	0.012	0.010	0.089	62	1.001	0.001	1663	1.121	0.121	456	2.265	1.265
CSA 63	0.0013	80	1	3	87	25	100	2009	0.002	0.021	0.020	0.177	-558	0.996	-0.004	3650	1.159	0.159	656	2.749	1.749
CSA 64	0.0055	533	1	44	100	25	100	2009	0.012	0.004	0.009	0.084	-2116	0.954	-0.046	-520	0.956	-0.044	317	1.932	0.932
CSA 65	0.0013	10	1	1	100	25	100	2009	0.011	0.002	0.011	0.023	-3759	0.979	-0.021	415	1.013	0.013	611	1.962	0.962
CSA 66	0.0010	226	2	1	76	25	100	2009	0.000	0.000	0.006	0.031	2	1.000	0.000	-96	0.997	-0.003	772	1.809	0.809
CSA 67	0.0003	9	1	1	64	25	100	2009	0.002	0.005	0.009	0.063	-204	0.993	-0.007	434	1.064	0.064	237	2.410	1.410
CSA 68	0.0010	7	1	1	62	25	100	2009	0.000	0.002	0.004	0.024	6	1.000	0.000	320	1.045	0.045	227	2.051	1.051
CSA 69	0.0010	6	1	1	71	25	100	2009	0.004	0.001	0.005	0.030	998	1.012	0.012	298	1.016	0.016	437	1.759	0.759
CSA 70	0.0010	6	1	1	61	25	100	2009	0.001	0.002	0.006	0.031	-218	0.993	-0.007	321	1.041	0.041	255	2.052	1.052
CSA 71	0.0009	5	1	1	85	25	100	2009	0.005	0.007	0.011	0.068	992	1.012	0.012	953	1.060	0.060	382	2.044	1.044
CSA 72	0.0010	4	1	1	79	25	100	2009	0.005	0.000	0.004	0.027	651	1.029	0.029	12	1.002	0.002	107	1.636	0.636

CSA	DM	run #	diff. coeff	breed coeff	spread coeff	slp resst coeff	road grav coeff	control year	area scl	edge scl	clust scl	scl sum	area diff	area ratio	area fract	edges diff	edges ratio	edges fract	cluster diff	cluster ratio	cluster fract
CSA 73	0.0035	4	1	1	69	25	100	2009	0.015	0.006	0.009	0.063	1484	1.035	0.035	517	1.058	0.058	258	1.930	0.930
CSA 74	0.0010	35	1	30	100	25	100	2009	0.020	0.004	0.013	0.113	-2953	0.951	-0.049	394	1.033	0.033	295	2.191	1.191
CSA 75	0.0025	14	1	2	68	25	100	2009	0.000	0.001	0.009	0.080	-3	1.000	0.000	59	1.010	0.010	165	1.913	0.913
CSA 76	0.0030	32	1	6	77	25	100	2009	0.000	0.001	0.007	0.040	48	1.001	0.001	-110	0.985	-0.015	208	1.948	0.948
CSA 77	0.0010	4	1	1	44	25	100	2009	0.001	0.012	0.011	0.090	139	1.002	0.002	1217	1.100	0.100	413	2.314	1.314
CSA 78	0.0005	5	1	1	70	25	100	2009	0.015	0.005	0.006	0.076	410	1.040	0.040	124	1.043	0.043	61	1.513	0.513
CSA 79	0.0010	6	1	1	56	25	100	2009	0.001	0.007	0.009	0.068	72	1.003	0.003	448	1.066	0.066	219	2.016	1.016
CSA 80	0.0010	2	1	1	47	25	100	2009	0.001	0.003	0.005	0.028	136	1.007	0.007	476	1.105	0.105	179	2.325	1.325
CSA 81	0.0010	95	1	45	55	25	100	2009	0.017	0.007	0.015	0.128	-1252	0.951	-0.049	427	1.086	0.086	258	3.208	2.208
CSA 82	0.0010	3	1	1	43	25	100	2009	0.001	0.011	0.012	0.088	73	1.003	0.003	546	1.084	0.084	238	2.367	1.367
CSA 83	0.0001	8	1	1	73	25	100	2009	0.001	0.002	0.010	0.199	-384	0.998	-0.002	751	1.015	0.015	1388	2.155	1.155
CSA 84	0.0010	17	1	3	100	25	100	2009	0.006	0.009	0.015	0.138	-5029	0.990	-0.010	4641	1.072	0.072	1404	2.663	1.663
CSA 85	0.0010	17	1	2	81	25	100	2009	0.000	0.002	0.013	0.130	-35	0.999	-0.001	227	1.017	0.017	320	2.105	1.105
CSA 86	0.0010	186	1	7	100	25	100	2009	0.002	0.000	0.008	0.158	-360	0.994	-0.006	-19	0.999	-0.001	361	2.071	1.071
CSA 87	0.0001	1162	8	1	72	25	100	2009	0.001	0.005	0.014	0.114	-256	0.999	-0.001	1660	1.052	0.052	976	2.504	1.504
CSA 108	0.0015	20	1	2	54	25	100	2009	0.004	0.008	0.015	0.088	-3877	0.983	-0.017	4279	1.117	0.117	1461	3.127	2.127
CSA 109	0.0011	8	1	1	48	25	100	2009	0.001	0.013	0.017	0.084	-349	0.998	-0.002	4465	1.162	0.162	1110	2.901	1.901
CSA 110	0.0010	2	1	1	67	25	100	2009	0.000	0.004	0.007	0.057	23	1.001	0.001	184	1.044	0.044	131	1.926	0.926
CSA 114	0.0020	5	1	1	40	25	100	2009	0.000	0.009	0.010	0.072	-6	1.000	0.000	649	1.101	0.101	280	2.706	1.706
CSA 115	0.0050	17	1	2	51	25	100	2009	0.001	0.015	0.017	0.096	633	1.002	0.002	6143	1.166	0.166	1266	3.578	2.578