Integrating landscape amenities with historic parcelization trends to better target landscape conservation efforts

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FACTORS INFLUENCING LAND PARCELIZATION IN AMENITY RICH RURAL AREAS AND THE POTENTIAL CONSEQUENCES OF PLANNING AND POLICY VARIABLES

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ABSTRACT

As a precursor to land use fragmentation, the process of land title subdivision, or *parcelization*, provides a window of opportunity to planners seeking to preserve large blocks of land for both habitat and farmland preservation. Accurately targeting regulatory or incentive efforts towards parcels most likely to divide is an ongoing challenge. We developed a research approach that entailed mapping historic parcelization patterns and using past trends to better understand future scenarios. Historic land tenure was mapped using GIS for three rural communities in Southern Wisconsin back to 1950. We researched archival plat books and tax assessment rolls and then used a current digital tax parcel layer to work backwards through time and generate accurate historical parcel layers. Historic land use data was also generated by interpreting archived aerial photos and through public consultation. Examining the spatial pattern of parcel creation in each community and its relation to land use variables over time helped us assess the features that appeared to drive parcelization. An exploratory logistic model was employed to see how parcel characteristics influence parcel subdivision. Our results demonstrate the extent to which amenities influence the parcelization process and provide a useful tool for communities looking to better understand factors that drive parcelization.

INTRODUCTION

The division of land into smaller privately owned parcels is a growing concern among planning and natural resource professionals in rural communities (Alig & Butler, 2004; Gobster & Schmidt, 2000). To many, parcelization, which is the process in which large parcels are divided into smaller ones, is considered a crucial step in the transformation of rural landscapes from places that rely on natural resource extraction to areas that package and sell the landscape itself for real estate development. Despite a plethora of research documenting the impacts of parcel and landscape fragmentation (Brown, 2003; Gobster & Schmidt, 2000), researchers have given little attention to the actual process of parcelization. With amenity-rich rural areas experiencing dramatic demographic changes, fueled by in-migration, one would expect that the rates and degree of parcelization to be at an all time high. While people's perceptions of an increased rate of parcelization are common, empirical evidence of such changes in Wisconsin or elsewhere are largely tied to the growing number of land owners or changes in mean parcel size. The process of parcelization has rarely been studied, and what research does exits is limited and the analysis seldom extends further than twenty years back (Drzyzga & Brown, 1999).

The purpose of this research is to quantify the landscape features that may influence rural parcelization. Specifically, we developed a protocol for spatially reconstructing historical parcel patterns in a rural southern Wisconsin county that is experiencing rapid development pressure. An exploratory multiple logistic regression model was employed to see how parcel characteristics (size, proximity to water, elevation, road adjacency, etc) influence parcel subdivision. The remainder of this paper reviews literature on rural community change as it affects parcelization, describes our research region, presents our analytical model, and finally discusses our results and implications.

Rural Community Change

Many rural agricultural and forest-based communities in the United States have experienced population and economic decline in the last century. Modern economic forces and advances in technology have both reduced the demand for workers and manufacturers (Daniels, 1999). The result is a decrease in population especially in rural farming and logging communities. However, recent trends show that not all rural areas are facing these pressures. Nation-wide, areas with abundant natural amenities, such as lakes, rivers, mountains, forests, and public land often outpace other rural areas in terms of population growth, income, and economic activity (Beale & Johnson, 1998). Recent growth in second and seasonal homes in distant remote areas indicates the attractiveness of such amenities.

Amenity driven development is not without its costs. There is potential for conflict when the diverse views and land use objectives of amenity migrants, tourists, and long-time residents clash (Deller, Green, & Marcouiller, 2005). New residents often disapprove of traditional land management practices and complain about dust, odor, and noise related to industrial agricultural and forestry operations (Spain, 1993). In addition, the fragmentation of the landscape can also hinder large resource-based operations, making it difficult for these industries to capitalize on economies of scale (Rickenbach & Gobster, 2003). The parcelization and subsequent development can have irreversible changes to the ecosystem that attracted the new tenants to the amenity in the first place (Odell, Theobald, & Knight, 2003). The environmental impacts become even more important because the natural features that attracted the new resident or tourist – riparian, alpine, and wetland – are often the least resilient to human interaction and exploitation (Hersperger, 1994).

The number of non-industrial private forest landowners in the United States is increasing, and, not surprisingly, the average parcel size is decreasing (Sampson & DeCoster, 2000). Within these forests, scattered second, seasonal, and retirement homes are fragmenting large tracts of land. This type of parcelization and development limits the potential for efficient timber management and places homes in fire prone areas (Daniels, 1999). Furthermore, it can displace wildlife from their habitat and development near riparian areas increases runoff, thus degrading the water quality and threatening aquatic ecosystems (Arnold & Gibbons, 1996).

Low-density residential development in productive agricultural areas also increases the need for and cost of public services. Housing tracts can shift property values and subsequent tax increases reduces the profits from remaining cattle and row crop production, hastening the alarming trend in the declining number of agricultural producers in the country (Shi, Phipps, & Colyer, 1997). As the growth in non-farm homes fragment the countryside, the potential for conflict between long-time residents and their exurban neighbors increase (Daniels, 1999).

The Process of Parcelization

While the consequences of amenity-driven development are well documented, the actual process of rural land use change is not. Unlike urban models, where development is viewed as a consequence of infrastructure, population growth, and job-related migration, rural development is likely driven by open space and second and seasonal homes (Capozza & Helsley, 1989). These building forces changes the productive resource capacity of land that has traditionally played an important role in the location of rural residents. Today, rural newcomers seek terrain and water, giving little attention to the actual productive capacity of the land.

Whether rural amenity growth is motivated by one's familiarity of an area (Stewart & Stynes, 1994) or by the overall popular perception of a region (Butler, 1980), growth in amenity-rich rural areas is externally driven and depends on the well-being of distant urban economies. This is not altogether different from the productive form of rural economic growth, wherein external markets for raw and finished products determine commodity prices enjoyed by rural landowners and laborers. The difference in the post-productive era is that the urban economies are now consuming the land itself rather than just the fruits of that land.

The core process of this phenomenon is parcelization: the division of land into smaller parcels and their subsequent sale on the market. It is through parcelization that the land resources are refined and packaged for wholesale and retail consumption as real estate.

The characteristics of parcels can have significant impacts on the uses available to a parcel owner. Parcel size is often a critical factor: a parcel too small is impractical to manage for farming or forestry, while parcels that are too large may be impractical for housing or other consumptive uses (Gobster & Rickenback 2004). Parcel sizes help determine market values. Land has not only a per-acre value, but also a value that derives from the necessary parceling for purchase, also known as plattage (Chicoine 1981). The premium can be two or more times the agricultural value when subdivided. Thus, parcels too small for one use may be subdivided to smaller parcels for another use.

While the pressure to parcelize seems intense, researchers and planners do not have a very good handle on whether the dynamics and rate of parcelization is greater today than previous years. Very few people have sought to analyze land division through the historic parcel reconstruction. By deciphering past pressures of parcelization we can better understand today's forces. Despite concerns over parcelization, there are few empirical estimates of how quickly rural land is actually being subdivided. Some researchers have measured parcelization by tracking the change in average parcel size or through the number of new landowners in a given region (Brown, 2003; LaPierre & Germain, 2005). Their research is fairly straightforward, where the average parcel size is a function of the total number of landowners. They do not capture rates, spatial configuration, or the geographic variation of new lots over time. It is more challenging to explain the spatial configuration or geographic variation of new parcels and the consequences of these arrangements have on both productive human uses and ecosystem health. The purpose of this research is to better understand the rate and pattern of rural parcelization by analyzing their relationship to landscape variables. Our results demonstrate the extent to which amenities influence the parcelization process and provide a useful tool for communities looking to better understand factors that drive parcelization.

METHODS

Study Area Description

This research focuses on rural townships experiencing growth in rural residential development. We selected Columbia County, Wisconsin for this research based on several criteria: availability of a complete spatial parcel database of the county, adjacency to a metropolitan county, whether the community is actively engaged in planning, and local officials showing favorable relationships with research personnel. Columbia County, located in south central Wisconsin, represents an area experiencing significant growth from both urban fringe development from nearby Madison (state capitol) and rural recreational development due to the scenic nature of the area.

Although Columbia County remains mostly rural in nature with nearly 350,000 acres of active farmland and an overall population density of 70 persons per square mile, its convenient geographic location has resulted in a significant increase in rural residential development (Wisconsin Department of Tourism, 2007). With over 11,000 acres of lakes, 16,000 acres of public hunting and wildlife land, and numerous campgrounds, Columbia County has an abundance of recreational opportunities that attract both seasonal and new full time residents. Interstates 39 and 90/94 make this area also a short drive from Madison (30-40 minutes), Milwaukee (90-100 minutes), and Chicago (180 minutes).

Data Collection

Ideally, all of Columbia County should have been included in our study, but the construction of the database would have consumed years. Consequently, tax parcel reconstruction efforts focused on three rural townships in Columbia County at nearly ten year increments based on data accessibility. To attain a representative sample of the area, we concentrated on townships representing different degrees of current parcelization (high, medium, low). The current 2005 digital parcel data obtained from the county was of high accuracy (i.e. COGO) and therefore, we employed a process of "reverse parcelization" to select and merge parcels into the original large parcel of origin. We visually inspected historic tax records and plat maps to identify dates of parcel subdivision. Working backwards, we were able to spatially reconstruct property boundaries for the years 1953, 1961, 1967, 1972, 1983, 1991, 2000, and 2005. These years represented dates that tax rolls corresponded with published plat books.

We decided to map tax parcels instead of ownership parcels since rural areas are already divided into legal (Alliance) parcels that are at most 40 to 80 acres in size. One owner can own multiple large tax parcels, and an owner can divide his or her land into numerous smaller legal parcels without selling. Therefore, tax parcelization is likely to occur before ownership parcelization. Along with parcel data, we generated historic land use data from archived aerial photos for 1940, 1968, and 2005. Land use data was needed to help us identify past landscape features that seemed to influence the parcelization process.

Parcels that split (parent parcels) were identified by generating a parcel identification tracking number. Columbia County started this process in 1950 with each municipality. However, the numbering protocol varied over the years, making it difficult to track parcel lineage. For each parcel layer, we developed a tracking index which indicated the parcel of origin and a unique parcel identification number for that particular parcel. The unique parcel ID was carried over to the next time period as the parent parcel ID for each parcel. Parcels that split were again given a unique parcel ID, keeping the original prefix sequence (Figure 1). We were then able to select and summarize parcels that split during the next time period, monitoring the number of 'offspring' parcels for any given parent parcel.

[Insert Figure 1]

We then generated current and historic land use patterns using archived aerial photos and public consultation[1] (Figure 2). In each community, particular parcel characteristics (i.e. distance, abundance, and presence/absence measures for various landscape variables) were acquired and defined for each parcel using GIS overlay and zonal statistical procedures. This step helped us assess the features that appeared to drive the parcelization process. (Table 1).

[1] Interpreted land use maps were displayed at the town halls for one month during the November, 2006 election period. Town officials and local citizens commented on and corrected any misinterpreted land use.

[Insert Figure 2]

[Insert Table 1]

Spatially reconstructed parcel maps are illustrated in Figure 3 (a – h) for the Township of Lodi, (the town with the largest number of parcels). One can see that there has been significant parcel subdivision from 1953 through 2005. The pattern of parcelization does not appear to be random, and there seems to be some relationship between landscape features and where splits have occurred.

[Insert Figure 3]

Based on the preliminary review of parcel splits and landscape features, we noticed that land subdivision appeared to be associated with certain landscape features. Pearson's correlation coefficient was used to test the relationship between landscape variables and parcels that split (Table 2). The value of the correlation coefficient ranges from 1 (perfect relationship) to -1 (perfect inverse relationship). A value near 0 indicates that the relationship between the two variables is negligible. Because we are interested in parcels that split, we analyzed the coefficients of the 'split' variable against all other variables. Parcel acres had a strong relationship with splits with a value of 0.374. Parcel sizes were also categorized into classes and their relationship to parcel splits was strong as well at 0.754. Other significant variables found were proximity to water, percent of parcel in agriculture and open space, average parcel elevation, average parcel slope, whether the parcel was adjacent to a waterfront parcel, county highway adjacency, local road adjacency, and parcel frontage.

[Insert Table 2]

Using these variables we set up a fairly primitive multivariate model to explore rural parcel division. Since the dependent variable is binary (split, no split), a multiple logistic regression (MLR) was employed to estimate the probability (with maximum-likelihood) that a parcel will subdivide. The MLR technique is designed to estimate the parameters in explanatory variables where the dependent variable is dichotomous. Variables in Table 2 were used to construct the MLR model to test the hypothesis that landscape features can be used to predict which parcels will subdivide. In this analysis, we considered parcel subdivision to include only those parcels that have split into three or more parcels, essentially eliminating 40s that divided into two 20s. Forward selection procedures of independent variables were used to consider which variables would be included in the model. The model was run on our two most parcelized towns. Our third town has experienced little parcelization since 1950, so it was excluded in this first and exploratory model.

RESULTS

The preliminary logistic regression model results look encouraging and are shown in Table 3. All variables included in the model were statistically significant, probably due to our large sample size, and, among them all had the expected sign. The parcel subdivision model had a fair adjusted r^2 of .551. So, individually most variables in Table 1 had a weak relation with the dependant variable, but collectively, they did an adequate job of predicting potential splits. Positive parameters of the coefficient estimates indicate that larger values of the independent variable will increase the likelihood of a parcel split. Likewise, negative values indicate that larger values of the independent variable will decrease the likelihood of parcel division. That said, as expected, parcel size, frontage, and distance to water had a positive impact on parcel subdivision. Alternatively, as a parcel's elevation and acres decreases, the likelihood of subdivision decreases. The categorical variables, county highway adjacency and zonal distance to water (pseudo adjacent) were both good predictors of parcel splits.

[Insert Table 3]

Joining the calculated probabilities from SPSS to our parcels layers, we were able to visualize our model results (Figure 4). As expected, large parcels near the water and with abundant frontage had high probabilities of splitting. In contrast, parcels away from the water and not adjacent to a road had low probabilities of splitting.

[Insert Figure 4]

When joined with the spatial data, we could visually compare observed and predicted parcel splits. Though the model did not predict parent parcels very well, the parcels it did accurately predict, were "productive" (Table 4). For example, between 1953 and 1961 the model correctly identified 34.4% of the parcels that split. However, of those parcels, they produced 64% of the new lots created during that time period. Over time, our model's accuracy got worse; perhaps due to spatial autocorrelation.

[Insert Table 4]

DISCUSSION AND CONCLUSION

The process of parcelization was analyzed by examining various parcel characteristics. By reconstructing historic parcel patterns we were able to identify key attributes that appeared to be influencing land subdivision. A multiple logistic regression was developed to see how well landscape variables accurately predicted parcelization. Due to the exploratory nature of this work and our use of geographic data, we still need to take into account spatial autocorrelation and multicollinearity. Our next step is to build more sophisticated models that address these issues.

As expected, we were not surprised to find that parcel size strongly influenced parcel splits. Larger parcels are more likely candidates of splitting than are smaller parcels. However, length of water frontage and distance to water variables were also strong drivers of parcelization. It was evident that small parcels along or near the shore with considerable frontage still maintained high probabilities of splitting. This was also expected due to the attractiveness of near-shore development. It is not uncommon even for developed properties with adequate waterfront property to carve out lots with the minimum required frontage, especially given the value placed on that land, where in Wisconsin, the average value of waterfront property can exceed $1,000 per foot, compared to off-shore land valued around $2,000 to $3,000 per acre.

One potential reason for the small percentage (20% - 30%) of correctly identified parcel splits was two lakes at the southern edge of the study area. During the entire time period, very little parcel subdivision had taken place along those lake shores. Perhaps social economics or land use regulations are playing an important part here. Our results will be shared with local officials, who may be able to offer important suggestions.

The pseudo adjacency variable, which is a zonal distance measurement from the shoreline, helped to explain the pattern of land subdivision when waterfront areas have been completely subdivided. This can be thought of as the pattern of second and third tier development along water bodies, where the configuration of subsequent parcelization is a result of the original creation of shoreline lots (Figure 5).

[Insert Figure 5]

An area where our model performed poorly was in locations where parcelization had occurred on ridges or rims with attractive views (Figure 6). In Figure 6a, the model predicted low probabilities for most of the parcels along a steep ridge within the town in 1953. However, later on many smaller parcels were carved out along the ridge (Figure 6b), offering long views to new landowners. A more robust viewshed analysis may perhaps capture this recent trend. Initial observations indicate that views to water appear to be more correlated with parcelization than views some distance from water.

[Insert Figure 6]

Our analysis of parcelization included only parcels that had divided into three or more parcels. We attempted to model all parcel splits with the current set of variables, but the results were mixed. By focusing on subdivisions of three or more lots, we were able to more accurately model parcelization. We also assigned a weighting factor in the model, which essentially weighted the data by the number of "offspring" parcels created by a parent parcel. This helped to give more attention to parcels that created many lots rather than just a few, such as large subdivisions along Lake Wisconsin.

Over time, the model accuracy progressively got worse (Table 4). Though we cannot give a detailed explanation of this, it may be due to the complete parcelization of waterfront land. Because the number of parcel offspring weighted the model, more attention was given to parcels that created many lots (i.e. parent parcels of subdivisions). Most of these subdivisions were platted along the waterfront. When these areas became parcelized, future land division had to take place further away from the water, making water less of influential.

The issue of spatial autocorrelation and multicollinearity are present in the model. Others have used a spatial filtering or a sampling approach to correct for spatial autocorrelation (Brown, 2003; Gobster & Schmidt, 2000). However, due to the relatively small number of parent parcels in the data, we felt that the sample size would not be large enough for an adequate model. Alternative sampling techniques will be examined to deal with local trends.

The paper presents an early step in a larger research project studying the consequences of planning and policy variables on land parcelization. Future research will build off this exploratory work by integrating spatial econometric modeling techniques (Irwin & Bockstael, 2002) to address landscape variables and rural parcelization.

Parcel ID
1325

Parent ID	Parcel ID
1325	1325.001
1325	1325.002
1325	1325.003
1325	1325.004
1325	1325.005

Figure 1. Parent and parcel ID number configuration example from 1953 to 1961.

Table 1. Description of parcel characteristics used for estimating parcel subdivision

Variable	*Description*
ACRES	The size of the parcel
FRONTAGE	Length of shoreline (feet)
DIST_WAT	Distance to water (feet)
PER_AG_OP	Percentage of parcel classified as agriculture
PER_FOREST	Percentage of parcel classified as forest
PER_HYDRIC	Percentage of parcel classified as hydric
AVG_ELEV	Average parcel elevation
SLOPE	Average parcel slope
PUBLC_DIST	Distance to public land (feet)
PSEUDO_ADJ	Equals 1 if adjacent to waterfront parcel that had already split, else 0
ROAD_1	Equals 1 if adjacent to State/U.S. highway, else 0
ROAD_2	Equals 1 if adjacent to County highway, else 0
ROAD_3	Equals 1 if adjacent to town (local) road, else 0
DEV	Equals 1 if non-farm development exists on parcel, else 0
PSEUDO_ADJ	Equals 1 if adjacent to subdivided waterfront parcel, else 0

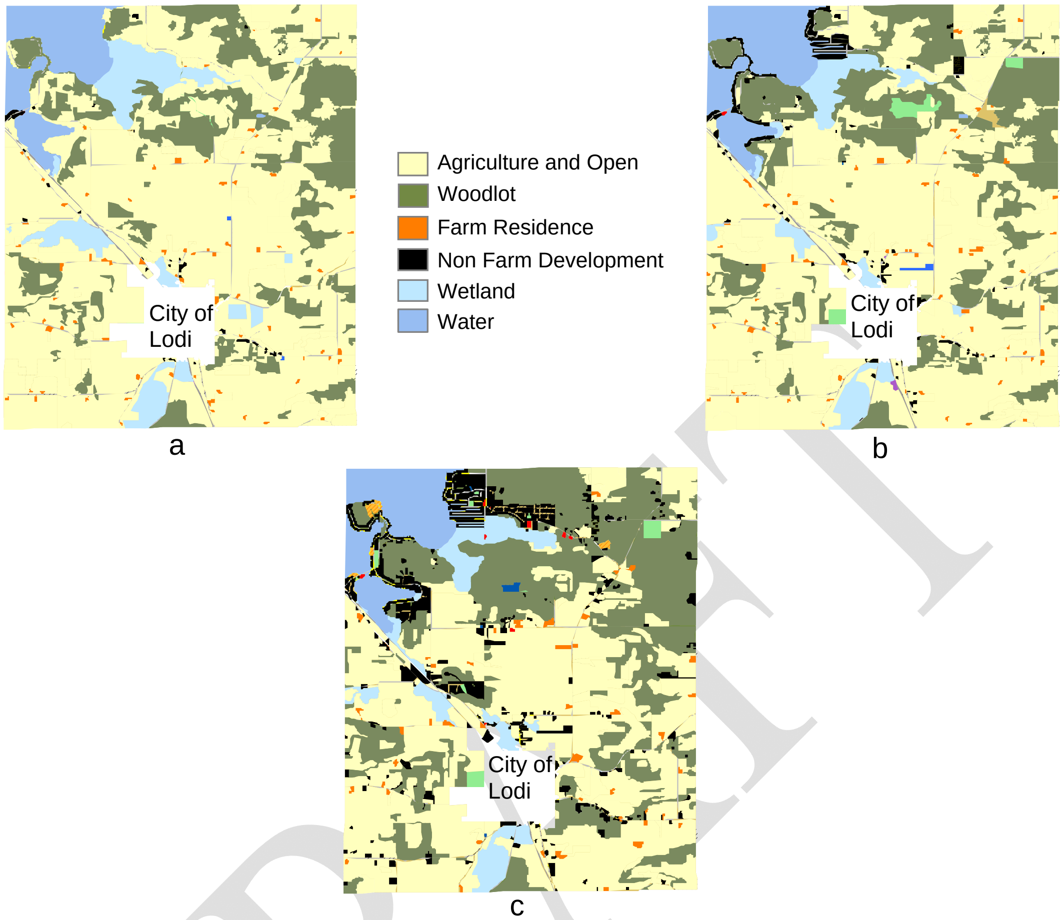


Figure 2. Land use in the Town of Lodi, Wisconsin a) 1940 b) 1968 c) 2005

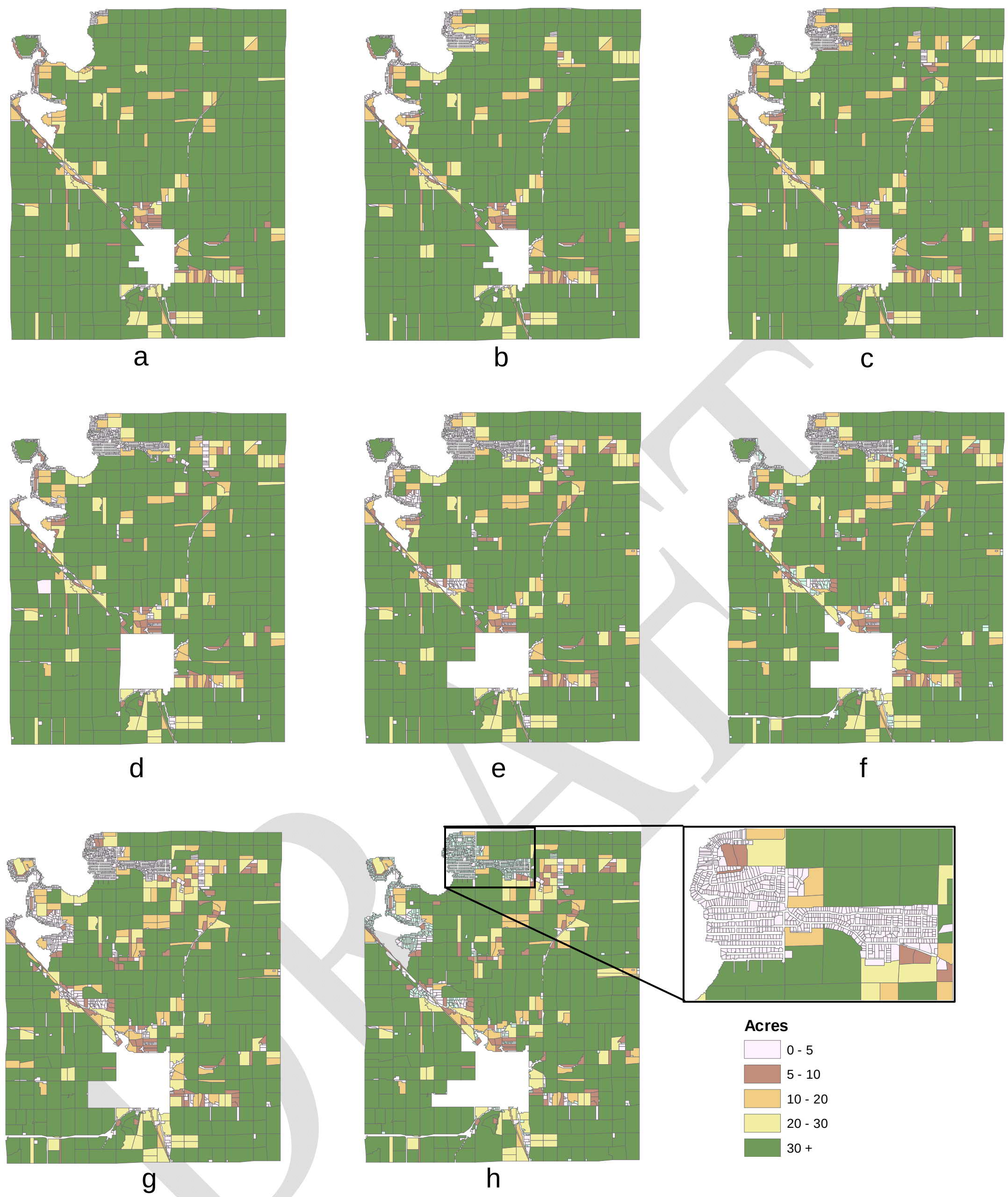


Figure 3. Tax parcels by size class in the Town of Lodi, Wisconsin a) 1953 b) 1961 c) 1967 d) 1972 e)1983 f) 1991 g) 2000 h) 2005

Table 2. Covariance matrix of parcel characteristics included in the model using Pearson's Correlation Coefficient

	ACRES	SIZE CLASS	DIST H2O	% AG-OP	AVG ELEVATION	PSUEDO ADJ	COUNTY HWY	FRONTAGE	SPLIT
ACRES	1								
SIZE CLASS	.754(**)	1							
DIST H2O	.081(**)	.216(**)	1						
% AG - OP	.243(**)	.526(**)	.270(**)	1					
AVG ELEVATION	.148(**)	.376(**)	.552(**)	.237(**)	1				
PSUEDO ADJ	-.247(**)	-.290(**)	-.289(**)	-.267(**)	-.149(**)	1			
COUNTY HWY	.312(**)	.227(**)	.086(**)	.180(**)	-.045(**)	-0.013	1		
FRONTAGE	.612(**)	.234(**)	-.201(**)	-.046(**)	-.231(**)	-.211(**)	.121(**)	1	
SPLIT	.374(**)	.431(**)	-.192(**)	.206(**)	-.123(**)	-0.014	.211(**)	.354(**)	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3. Best predictors of the likelihood for a parcel to split. Logistic regression with forward stepwise results.

Dependent variable = Split (1 if parcel split)

	Coefficient	Standard Error	Wald	Exp(B)
Acres	0.044	0.002***	457.682	1.045
Size Class			1,052.289	
0-2 Acres	-3.420	0.155***	489.739	0.033
10-20 Acres	0.257	0.152*	2.846	1.293
2-5 Acres	-0.681	0.159***	18.394	0.506
20-30 Acres	0.802	0.153***	27.654	2.231
30-40 Acres	0.628	0.136***	21.200	1.874
40+ Acres	0.419	0.139**	9.096	1.520
Water	0.000	0.000***	102.446	1.000
Frontage	0.001	0.001***	113.692	1.001
County Hwy	-0.721	0.084***	73.113	0.486
Ag/Open	0.009	0.001***	87.183	1.009
Elevation	-0.020	0.002***	77.456	0.980
Psuedo_adj	-0.694	0.092***	57.429	0.499
Constant	6.218	0.581	114.456	501.460
r^2	0.396			
Adjusted r^2	0.551			
N	6372			

*p<0.10 **p<0.05 ***p<0.01

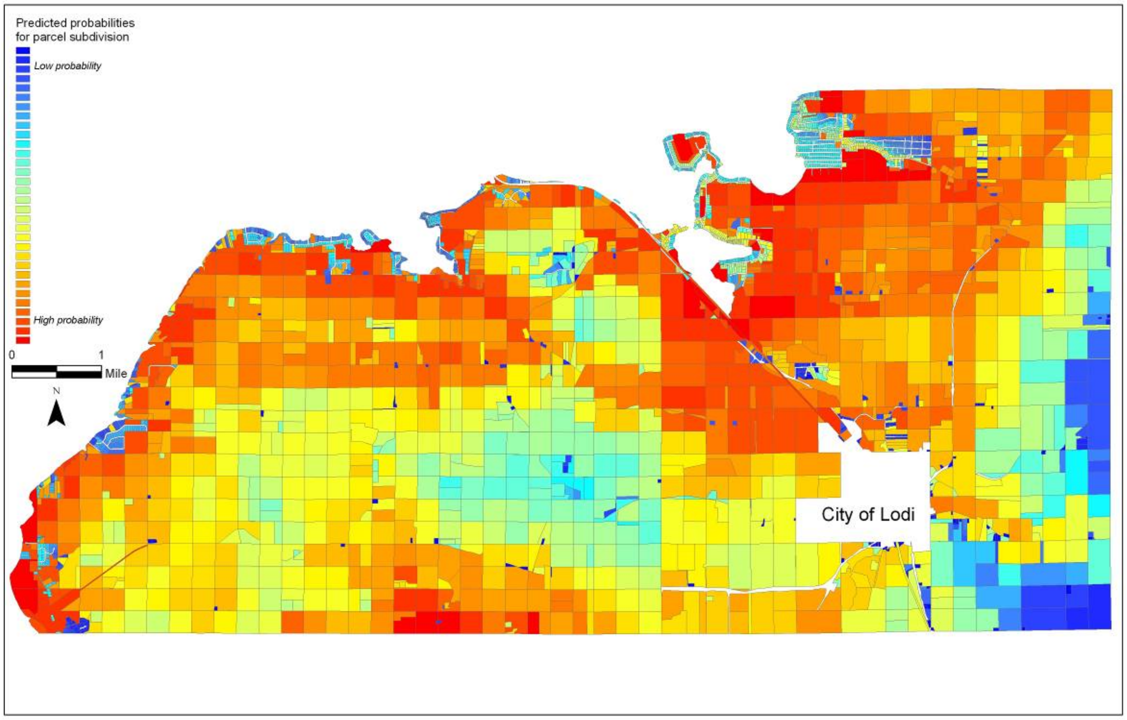


Figure 4. Probability map for parcel subdivision based on the MLR model

Table 4. Model predictions compared to observed parcel splits and total number of new parcels

Year	Observed	Predicted	% Correct	Total parcel offspring	Total predicted offspring	% offspring correctly predicted
1953-1961	32	11	34.4%	445	285	64.0%
1962-1967	26	6	23.1%	201	119	59.2%
1968-1972	26	4	15.4%	349	67	19.2%
1973-1983	56	9	16.1%	404	120	29.7%
1984-1991	28	4	14.3%	139	43	30.9%
1992-2000	48	4	8.3%	337	70	20.8%
2001-2005	38	3	7.9%	266	62	23.3%

Note: Parcel division consisted of 3 or more new lots

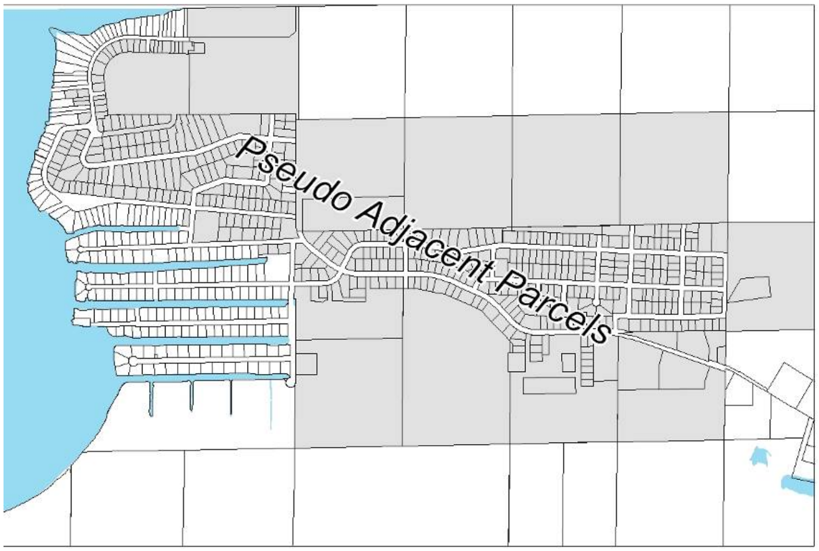
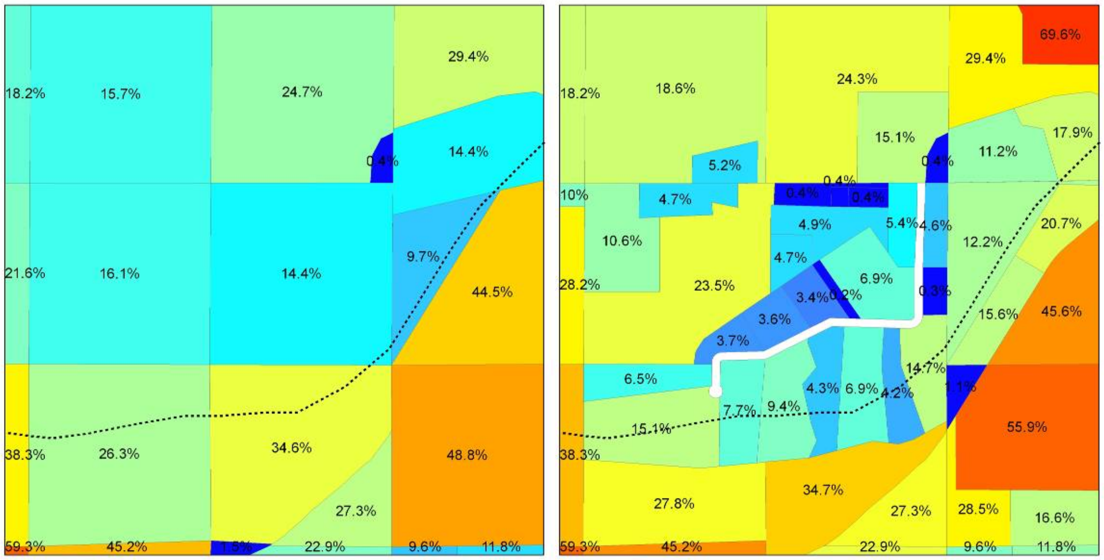


Figure 5. Example of pseudo adjacent parcels. Distinguishing these parcels
Helped explain the configuration of tiered parcelization beyond waterfront areas.



a) b)

Figure 6. Parcel patterns and probabilities of splitting in a) 1953 and b) 2000.

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