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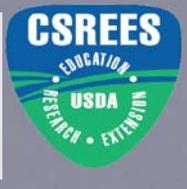
COLDWELL BANKER
 EAST WEST REALTY

LOTS FOR SALE



Identifying Parcelization and Land Use Patterns in Three Rural Northern Wisconsin Towns

Bayfield County Project Summary





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Executive Summary

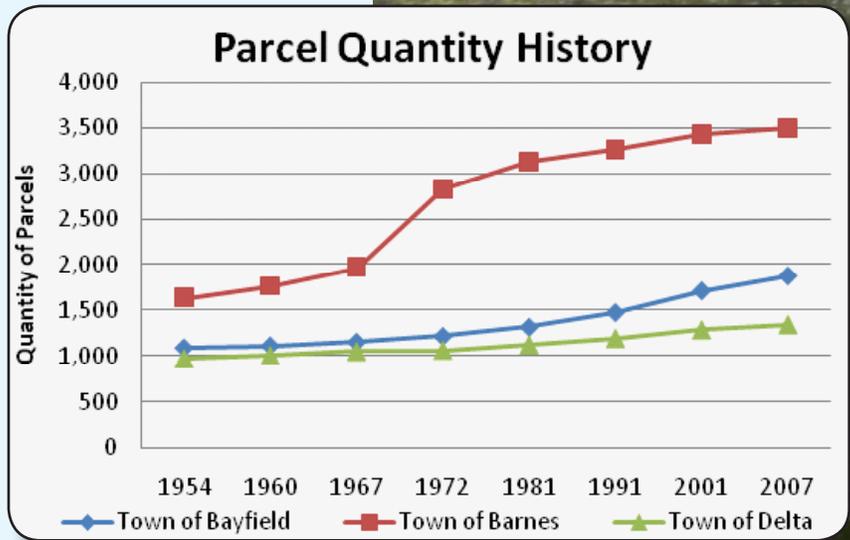
Over the years, rural areas have been considered as places of depopulation and economic decline. However, change is underway in rural America, and communities rich with natural amenities such as abundant lakes, forests, and topography are consistently outpacing other areas in terms of population and economic activity. While the consequences of such development are fairly well understood, the process of rural land use change remains somewhat unclear. Unlike traditional residents, new rural migrants pay little attention to the productive capacity of the land. Instead, it is the accessibility and scale of the amenity itself that drives people to rural areas.

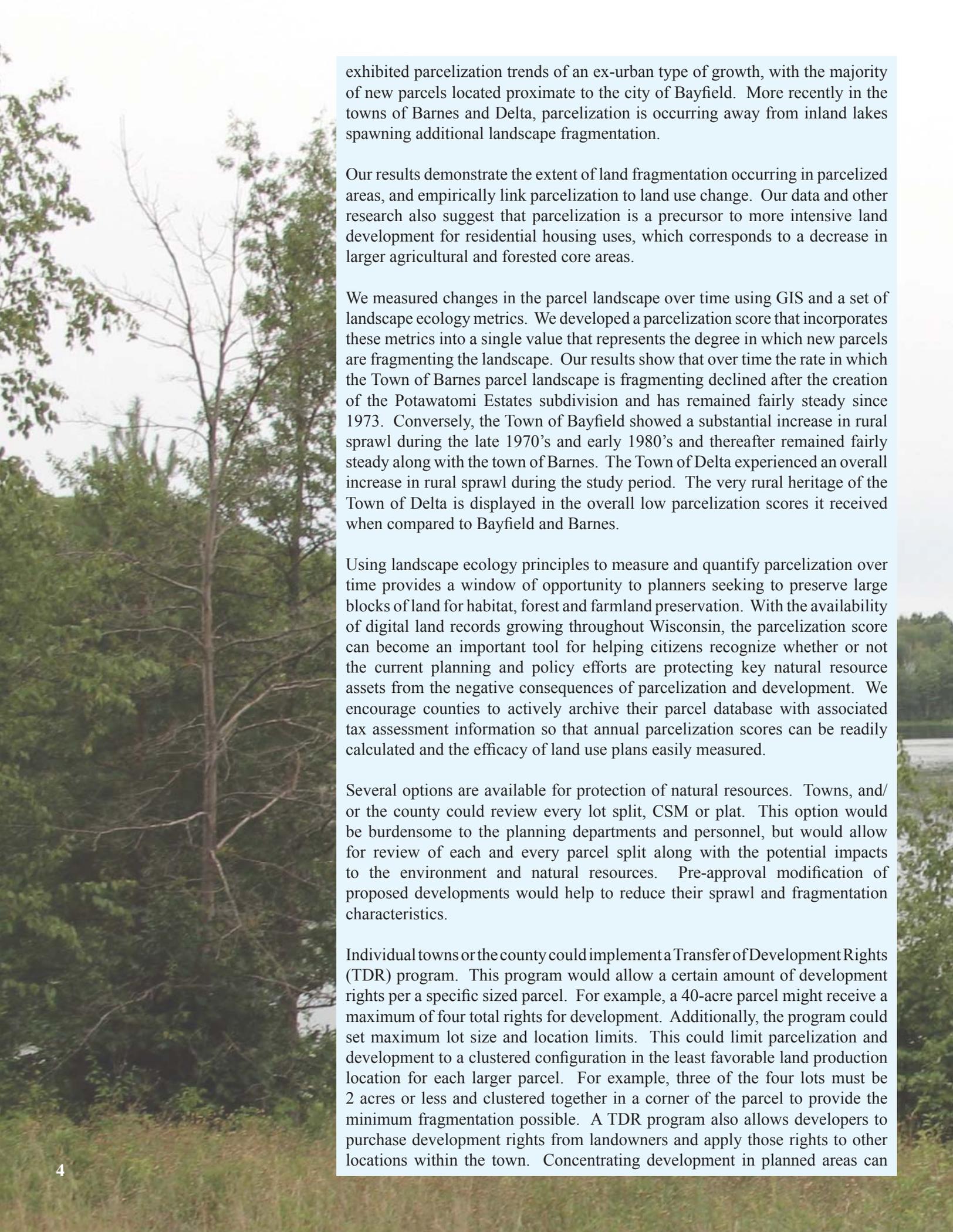
The core process of this change is parcelization – the division of land into progressively smaller tracts. As large parcels encompassing fields, forests, and grasslands become subdivided and developed, rural areas face declining returns on farming and logging activities. At the same time, undeveloped parcels become farther apart and face increasing pressure to further subdivide and develop. New roads and other infrastructure that serve these scattered lots perforate productive agricultural and forested areas. Communities then end up paying more for services than they collect from property taxes. In addition, low-density rural development fragments wildlife habitat. This loss of connectivity in the landscape has profound implications for certain plants and animals and fosters the spread of invasive species.

Though the parcelization process has been occurring in Wisconsin for over 150 years, little attention has been paid to the long-term trends and landscape consequences of land division. In this research, we examined the spatial pattern of parcelization by mapping historical tax parcels and resulting landscape changes using Geographic Information Systems (GIS) in a set of rural communities within Bayfield County, Wisconsin. Paper tax assessment rolls were needed to identify parcel splits back to 1954 in the towns of Bayfield, Barnes, and Delta. Using the current digital tax parcel layer obtained from the Land Information Officer and working backwards, we accurately reconstructed parcel data at five to ten year increments back to 1954 in the towns of Bayfield, Barnes, and Delta.

Analysis of town-level parcelization in a remote forested region shows that the overall rate of parcelization has increased since 1954 in all three towns (Figure 1). The rate of parcelization in Bayfield and Delta has increased at a fairly steady pace during each time period we examined. In contrast, the town of Barnes increased moderately until 1967, thereafter increasing at a greater rate until 1981, where it returned to a similar rate as the towns of Bayfield and Delta. In addition, prior to the 1970s, small parcels were generally limited to the immediate shoreline areas in the town of Barnes. The town of Delta displayed a temporal lag in new parcel creation, as more land became available for splitting during the 1980's and 1990's. The town of Bayfield

Figure 1. Parcel quantity history for all study towns from 1954 to 2007.





exhibited parcelization trends of an ex-urban type of growth, with the majority of new parcels located proximate to the city of Bayfield. More recently in the towns of Barnes and Delta, parcelization is occurring away from inland lakes spawning additional landscape fragmentation.

Our results demonstrate the extent of land fragmentation occurring in parcelized areas, and empirically link parcelization to land use change. Our data and other research also suggest that parcelization is a precursor to more intensive land development for residential housing uses, which corresponds to a decrease in larger agricultural and forested core areas.

We measured changes in the parcel landscape over time using GIS and a set of landscape ecology metrics. We developed a parcelization score that incorporates these metrics into a single value that represents the degree in which new parcels are fragmenting the landscape. Our results show that over time the rate in which the Town of Barnes parcel landscape is fragmenting declined after the creation of the Potawatomi Estates subdivision and has remained fairly steady since 1973. Conversely, the Town of Bayfield showed a substantial increase in rural sprawl during the late 1970's and early 1980's and thereafter remained fairly steady along with the town of Barnes. The Town of Delta experienced an overall increase in rural sprawl during the study period. The very rural heritage of the Town of Delta is displayed in the overall low parcelization scores it received when compared to Bayfield and Barnes.

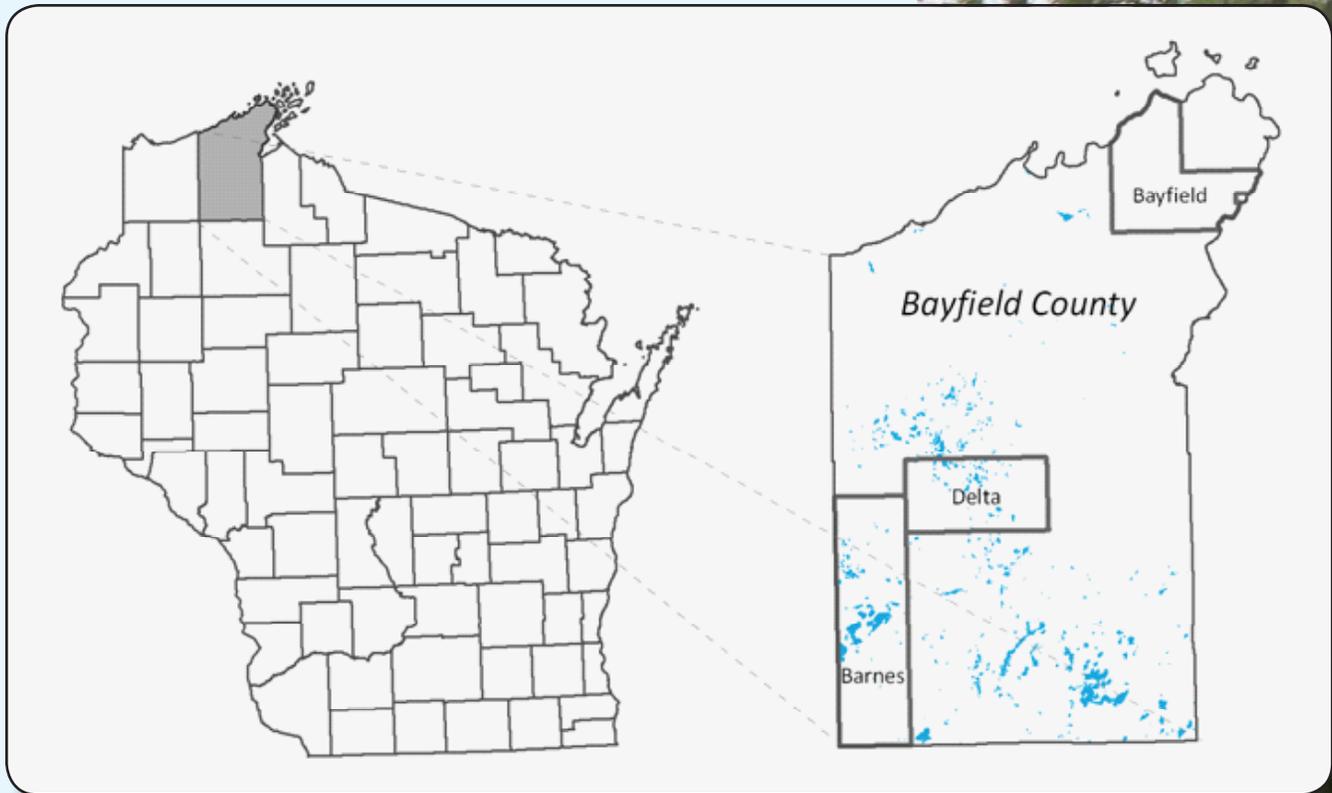
Using landscape ecology principles to measure and quantify parcelization over time provides a window of opportunity to planners seeking to preserve large blocks of land for habitat, forest and farmland preservation. With the availability of digital land records growing throughout Wisconsin, the parcelization score can become an important tool for helping citizens recognize whether or not the current planning and policy efforts are protecting key natural resource assets from the negative consequences of parcelization and development. We encourage counties to actively archive their parcel database with associated tax assessment information so that annual parcelization scores can be readily calculated and the efficacy of land use plans easily measured.

Several options are available for protection of natural resources. Towns, and/or the county could review every lot split, CSM or plat. This option would be burdensome to the planning departments and personnel, but would allow for review of each and every parcel split along with the potential impacts to the environment and natural resources. Pre-approval modification of proposed developments would help to reduce their sprawl and fragmentation characteristics.

Individual towns or the county could implement a Transfer of Development Rights (TDR) program. This program would allow a certain amount of development rights per a specific sized parcel. For example, a 40-acre parcel might receive a maximum of four total rights for development. Additionally, the program could set maximum lot size and location limits. This could limit parcelization and development to a clustered configuration in the least favorable land production location for each larger parcel. For example, three of the four lots must be 2 acres or less and clustered together in a corner of the parcel to provide the minimum fragmentation possible. A TDR program also allows developers to purchase development rights from landowners and apply those rights to other locations within the town. Concentrating development in planned areas can

preserve larger, contiguous tracts of natural resource production land.

Additionally, the implementation of a Purchase of Development Rights (PDR) program can help to preserve critical habitat or natural resources. A PDR program allows landowners to sell development rights to government, land trust, or other public agency. Land is protected from future development or parcelization by the implementation of a conservation easement. Land can still be utilized for agricultural or forestry concerns, however this program will ensure that the land is not fragmented and developed in the future.



Introduction

Many long time residents and visitors of Bayfield County may have noticed changes on the land over the past few decades, mostly in the form of newly created residential developments in the forestland, scattered new homes, low availability of land adjacent to inland water resources, and the successive tiers of new residences and lots away from inland water resources.

Some call these changes wasteful, while others argue that it is merely community growth spurred by market demand. Whatever we call this trend, one of the earliest indicators of this change is parcelization, the creation of new parcels on the landscape. The division of rural land into smaller parcels is a crucial step in the transformation of communities from places that use the land for farming and forestry into places that consume the land itself for housing, recreation, and other forms of development.

Undeveloped rural landscapes such as forests, grasslands, and working farms are important for both city and country residents alike. These areas provide clean water, food, open space, recreation, employment, and wildlife habitat. However, there are concerns among planners and resource managers that increased parcelization and conversion of both productive working

lands and sensitive environments for housing lots may negatively impact the economic viability of farming and forestry (Gobster & Rickenbach, 2003). Scattered development can ultimately degrade water quality and fragment wildlife habitat.

To provide for better understand of the long-term trends, consequences, and factors influencing rural parcelization, the USDA awarded the UWSP UWEX Center for Land Use Education (CLUE) a grant to reconstruct, document, and analyze parcelization and landscape changes over time in a set of Wisconsin communities. The remainder of this report explains in more detail the drivers and consequences of land parcelization in rural communities and includes the results of the long-term study in the Bayfield County towns of Bayfield, Barnes, and Delta.

Drivers of Parcelization

The drivers of parcelization have evolved over time. While most researchers have focused on contemporary causes of land division, it is important to address some of the earliest factors, which happen to be the most significant. One of the first drivers of parcelization in Wisconsin was the disposal of public land to private ownership with the passage of the Federal Land Ordinance of 1785 (Thrower, 1966). At that time, most of the country was in the public domain. The federal government sought to dispose of much of this land because it was viewed as a liability in which it had to watch over and protect. The parcelizing and selling of public lands created a direct revenue source for the young country and it put much of the land into an economic use such as farming, mining, and logging. Selling land to settlers so they could pursue farming also helped to alleviate joblessness that plagued many cities. A quick and efficient method of mapping, describing, and dividing land was needed. The old system, called the Metes and



Bounds, was cumbersome and confusing. Thomas Jefferson led this new effort and proposed the Public Land Survey System (PLSS). The PLSS created a mapped grid across the land. Surveyors systematically divided all the U.S. lands west of the original thirteen colonies into six-square mile towns and one-square mile sections. Further division created quarter-quarter sections, which measured forty acres in size. This method of land subdivision was arguably the most significant parcelization event in the country's history and established the foundation of land policy and ownership today in the regions west of the original thirteen colonies (Figure 2).

Other early drivers of parcelization include the Jeffersonian Vision, the Homestead Act of 1862, and the completion of the transcontinental railroad. Thomas Jefferson's vision that land should be owned by individuals, not the government, yielded a migration of people westward into rural America to farm (Potter & Schamel, 1997). Legislation such as the Homestead Act, made it relatively easy for anyone to claim up to 160 acres of undeveloped land.

Shortly after, the completion of the transcontinental railroad made these lands more accessible as residents and immigrants moved westward to start their new agrarian futures. The establishment of the rectangular PLSS essentially resulted in the development of homesteads at low densities throughout the countryside. Once claimed or purchased, property could not be further subdivided by landowners for at least five years or until the land was entirely paid for. By the end of the 19th century, nearly 270 million acres or roughly 10% of the land in the U.S. had shifted from public property to private ownership.

In the rural Midwest, much of the land exchange occurring in the 1900s until after World War II suffered from a loss of population and from land abandonment. Driven by the economic effects of the Great Depression, private landowners abandoned marginal lands and joined the urban migration in search for work. Bayfield County experienced a 26% decline in population between 1940 and 1970. In Wisconsin, the number of landowners essentially declined, and in turn, state and local governments acquired large amounts of tax delinquent parcels, which currently make up much of the county public land system. Tax forfeit had created once again a government liability in many portions of Wisconsin and the U.S.

After WWII, some rural areas began to rebound as more people returned to rural living, but not to the land-based activities like farming and forestry. Instead, they were seeking solitude and open space characteristic of rural areas. Rural areas endowed with natural amenities, such as lakes, rivers, forests, and public lands, experienced the largest population, economic, and development increases (Beale & Johnson, 1998).

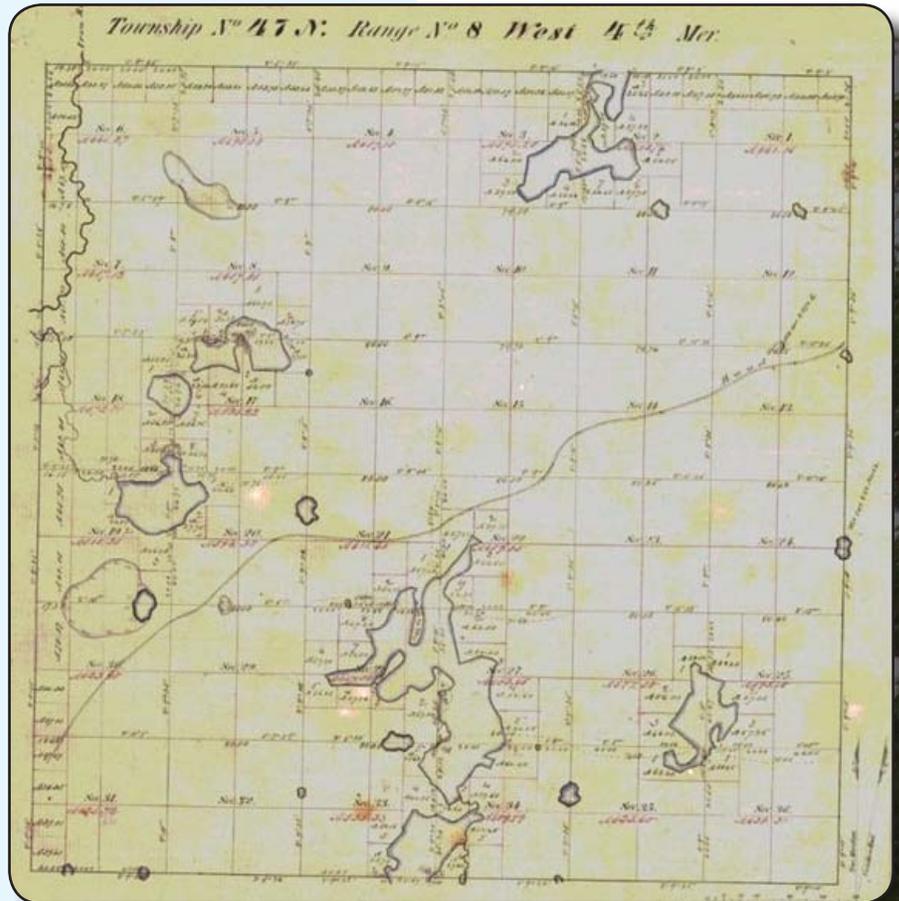


Figure 2. Original survey map from the Town of Delta in 1860.



Amenity-driven parcelization in rural areas continues today, in part, prompted by population growth and the dynamics of nearby urban markets. With the Dot-com explosion and Baby boomers making retirement plans, one can expect the desire for rural property to increase. The demand for such amenities has sparked another driver of parcelization, land speculation. Developers and landowners take advantage of lax land use controls in rural areas and often are able to carve out suburban-style subdivision patterns, making them ideal as second home getaways. As a result, many undeveloped lots invisibly dot the landscape waiting for a new owner and building permit.

A particular concern of parcelization is the increasing landowner age and family dynamics. A large proportion of Wisconsin's farmers and forestland owners are reaching retirement age and much of this land will be passed on to children. Heirs today often have little interest in continuing the farming or forestry operation. Instead, when land is inherited, the property is oftentimes split among multiple heirs. There is also evidence that supports the process in which land is parceled off to pay for inheritance taxes upon a death of a family member (DeCoster, 1998).

The adoption of local land use regulations such as shoreland zoning and subdivision regulations can also influence parcel creation. In the case of shoreland zoning in Wisconsin, land speculators rushed to create near-shore lots prior to ordinance adoption in the late 1960s. A good example of this is the Potawatomi Estates development in the Town of Barnes (Figure 3).

Figure 3. Potawatomi Estates development in the Town of Barnes. The average parcel size is 1.27 acres, a size commonly found in urban areas.

Significance of Rural Parcelization

Over the years, the rural parcelization process has set the stage for thousands of new homes in the countryside. The overarching consequence of rural parcelization is subsequent development which leads to landscape change and fragmentation. This conversion of land signifies the replacement of fields, forests, and pastures with homes, roads, and lawns.

While many acres of private working lands are converted to development, additional lands are being converted to other non-traditional uses, such as land

for recreational value or investment for future land subdivision. This type of trend is putting pressure on Wisconsin's 'bread and butter' farming and forestry lands. Because individual land use decisions are made at the parcel level, these 'breaks' tend to follow parcel boundaries. One of the major concerns regarding productive working lands is fragmentation. This refers to the incremental conversion of land to other uses, essentially creating isolated patches of fields and forests. Both human and natural processes, such as tornadoes or development, can cause fragmentation. However, people deliberately clear vegetation for development or agricultural uses, causing discontinuities in the landscape. Over time, continued land use change and development can generally result in fragmentation. The concept of fragmentation stems from landscape ecology, but can be effectively applied to working lands.

Socioeconomic Impacts

Throughout Wisconsin and many other states, amenity-rich rural areas are outpacing most other rural places in terms of population and economic growth. Such growth is not without its costs. The potential for community conflicts increases between long-time residents and new amenity-migrants due to differing views. This conflict can ultimately create challenges for the effective management of farming and forestry lands. The pattern in which new parcels are created on the landscape can fragment productive working lands so that those industries are no longer sustainable. For example, when the amount of contact between residential areas and farmland increases, we oftentimes find the cost of agriculture operations swell. Therefore, one would expect agricultural parcels with the most edge between conflicting land uses to subdivide.

Though many people assume that land division and development pays for itself in the form of tax revenue from property, studies indicate differently. These cost of services studies show that keeping areas in farms, forests, and open lands generate more tax dollars for a community than what is expended on providing public services to those lands. Isolated homes dispersed throughout the countryside can considerably increase the cost of certain services such as school busing, road maintenance, and utilities. The cost of providing emergency services also increases as new developments are created at further distances from urban areas where these services originate.

The parcelization of larger properties into smaller parcels and their subsequent sale on the market can have significant impacts on the uses available to the new parcel owner. For example, small parcels are impractical to manage for farming or forestry, while larger parcels may be unreasonable for residential development. In addition, 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. When the per-acre value for agriculture or forestland is considerably less than the per-acre value for development potential, parcels oftentimes are subdivided into smaller parcels for residential use. Residents that rely on land production resources can find themselves unable to earn enough income from traditional



land production activities to maintain their lifestyle and lands. These residents may have to retool into available jobs in the service, hospitality or retail professions that accompany rural population growth in natural resource rich areas, or relocate to rural areas not yet affected by the migration of recreational residents.

Ecological impacts

In addition, amenity-led development poses many environmental concerns because the areas that are attracting humans tend to be the most sensitive ecosystem lands and are important for providing environmental services, such as clean water, flood control, and wildlife habitat.

Changes in land ownership, often the result of land subdivision, reshape land management practices which can gradually alter the landscape. People's desire to live in areas with open space increases human densities in rural areas, and, in turn, increases road and building densities. With people come pets, traffic, and invasive species. The cumulative effect is landscape fragmentation and each has the potential to drastically alter local biodiversity. Researchers have shown that parcelization alters the spatial pattern of land cover and can ultimately lead to landscape fragmentation. Whether agricultural or forestry-based, rural parcelization signifies potential changes in the ecological sustainability of remote areas (Daniels, 1999). Although the effects of parcelization may not be apparent at first, smaller parcel sizes may lead to scattered homes near ecologically sensitive areas, fragmenting large forests and wetlands, and degrading water quality (Hersperger, 1994).

The incremental land use changes of the natural and working landscape fragments natural habitats that are essential for the survival of many plants and animals. Fragmentation reduces the ability of the landscape to support healthy populations by decreasing core areas and patch sizes while increasing edge and the distance between patches.

The isolation of particular patches occurs when landscapes become increasingly fragmented through natural or man-made disturbances. As the distance increases between patches of the same type, plants and animals struggle to disperse, mate, and adapt. In turn, genetic diversity and viability is lost ultimately leading to the loss of that particular species.

Institutional impacts

Some of the most immediate consequences of parcelization occur at the local level where records are maintained on landownership. Answering the question "whose land is it?" is easy in areas with only a few large landowners. However, the rapid growth in landowners in amenity-rich rural areas can make this question very difficult. As parcel and ownership patterns go from simple (few landowners, large parcels, and few types of land uses) to complex (many landowners, a range of parcel sizes from large to small, and many land use types), so does the work of the local registrar of deeds, tax assessors, planners,



and elected officials.

Recent extensive land sales have prompted many states and local communities to adopt aggressive control measures to manage the negative impacts of development. Administering a policy response to parcelization adds further to the local workload. Today, all levels of government, non-profit trusts, and local citizen groups are working to create and implement innovative tools and strategies for keeping important working lands intact to avoid over-development and fragmentation. Through regulations, incentives, and voluntary programs these groups seek to minimize the cumulative effects of parcelization. However, these programs require additional record keeping, monitoring, enforcement, and education.

One of the most obvious trends in the last decade is the explosive number of land trusts and the amount of acreage being protected. In 2003, nearly 9.4 million acres have been protected by land trusts in the U.S. This is twice the acreage reported in 1998 (Land Trust Alliance, 2005). Local land trusts are currently the fastest growing and one of the most successful land protection options available. Selling or donating property or development rights to a land trust ensures that future open lands will be maintained and protected.

The main goal of this study was to identify and measure parcelization patterns and resulting land use fragmentation in a set of rural communities within Bayfield County, Wisconsin. We focused on three towns because of the extensive amount of time required to reconstruct and analyze the data. Understanding the links between parcelization and subsequent landscape fragmentation can help planners and policymakers foresee future changes and provide an opportunity to preserve large blocks of land for habitat, forest, and farmland preservation.

Data Sources and Preparation

This research focuses on rural towns experiencing growth in rural residential development. We selected Bayfield County, Wisconsin for this research based on several criteria: availability of a current and complete spatial parcel database of the county, whether the community is actively engaged in planning, and local officials showing favorable relationships with research personnel. Bayfield County, located in the Northern Hardwoods of Wisconsin, represents an area experiencing significant recreational, seasonal and residential growth due to the scenic and bucolic nature of the area and the tourism hub provided by the City of Bayfield.

The process of measuring parcelization began with the digital reconstruction of historic tax parcel layers in a Geographic Information Systems (GIS). We chose to recreate legal tax parcels rather than ownership parcels because of situations where a landowner would subdivide a parcel while still maintaining ownership of each new lot. In cases like this, plat books only show one parcel, while according to tax assessment records, several legal parcels existed. Ideally, all of Bayfield County would have been included in our study, but the construction of the database would have consumed years. Consequently, efforts to reconstruct tax parcels focused on three rural towns in Bayfield County at five to ten year increments based on data accessibility. To obtain a purposive sample of the area we selected towns with a range of contemporary parcel densities (high, medium, low). Having a municipality with a low parcel density allows us to compare against baseline trends of parcelization over time.

Parcel layers were generated for the towns of Bayfield, Barnes, and Delta by utilizing the current digital tax parcel layer obtained from the Land Information Officer. Parcel splits were identified by inspecting the parcel number in consecutive year tax assessment documents where this number was inconsistent. We recorded parcel birth dates by photographing pages in their tax rolls that contained new parcels so that we could view them in the lab. Using GIS, the

current digital tax parcel layer was edited by merging split parcels into their parcel of origin based on the parcel number that was recorded in both the current tax parcel layer and the archived assessment rolls. Using a process of “reverse parcelization” (Figure 4) and working backwards, we created accurate digital parcel layers for the following years: 1954, 1960, 1967, 1972, 1981, 1991, 2001, and 2007.

To identify how parcelization patterns relate to land use change and fragmentation, we mapped land use at various dates for each town as well. Historical aerial photographs were obtained from the University of Wisconsin-Stevens Point Geography Department, the Bayfield County Forestry Department, and the Bayfield County Land Records Department.

Individual photos were scanned into a digital format, geo-rectified to match a projected coordinate system, aligned and stitched together to produce one image covering each town for 1938 and 1972. 2005 aerial photography was obtained from the University of Wisconsin–Stevens Point Online Advanced Spatial Information System. Land use classes were interpreted and digitized on screen. We categorized land use into five classes: developed, agricultural/open space, forest, wetland, and water. Developed/built up areas represent the outer extent of people’s yards and buildings or disturbed area. For small parcels such as within platted subdivisions, the entire parcel boundary was utilized to map the developed area.

Landscape Change

To quantify the effects of parcelization on landscape change, we compared the changes in landscape structure and composition for the towns of Bayfield, Barnes, and Delta. By comparing the different landscape quantification measurements, or indices, over time, we could examine the interaction between parcelization and landscape change.

To measure the cumulative affect new parcels had on the entire landscape, we applied a disturbance zone around residential parcels and calculated the amount of area unaffected by this zone. In general, a small residential parcel has a disturbance zone that extends beyond its boundary. For instance, domestic pets, such as cats, can have a significant impact on the surrounding native bird population. Over time, the combined disturbance zones of all small

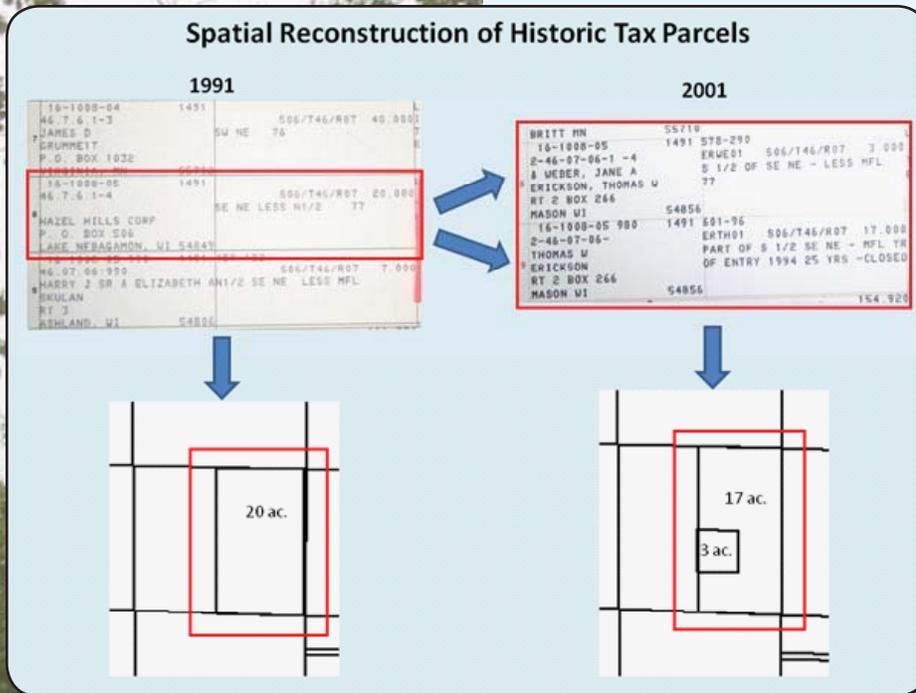
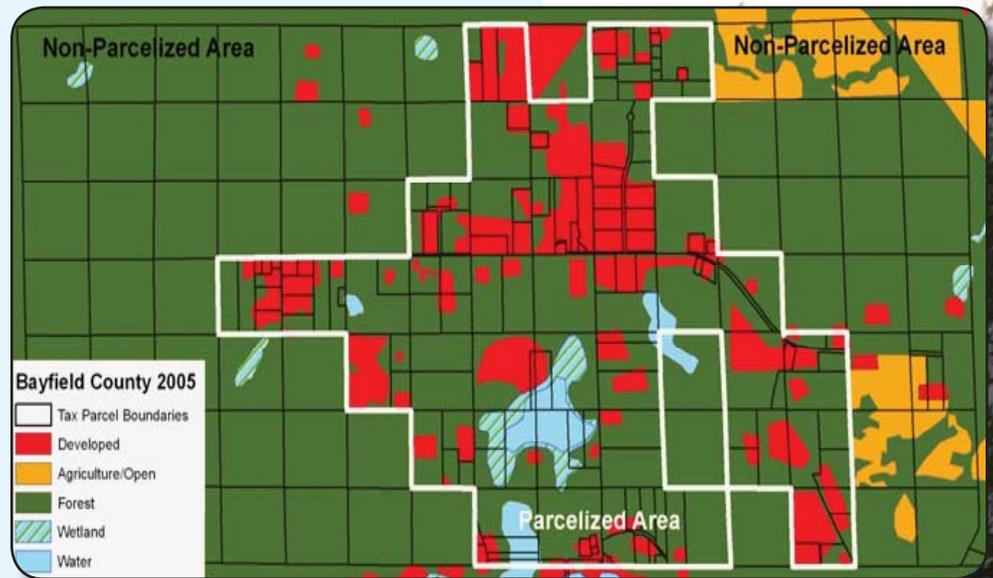


Figure 4. Illustration of reverse parcelization methodology.

parcels, especially developed ones, can substantially decrease the amount of undisturbed land. It is known that clustered development limits the amount of fragmentation due to the overlapping disturbance zones.

Figure 5. Illustration of parcelized and non-parcelized areas.

To determine what affect, if any, parcelization has on land use, we compared the spatial extent of historic and contemporary land use types (i.e. developed, forest, etc.) inside of parcelized areas to the spatial extent of land use types outside of parcelized areas. All parcels that had split during the study period were compiled to create “parcelized windows”, while parcels that never split during the study period were compiled to create the “non-parcelized windows” (Figure 5). Land use change was then calculated and compared inside and outside of these parcelized windows.

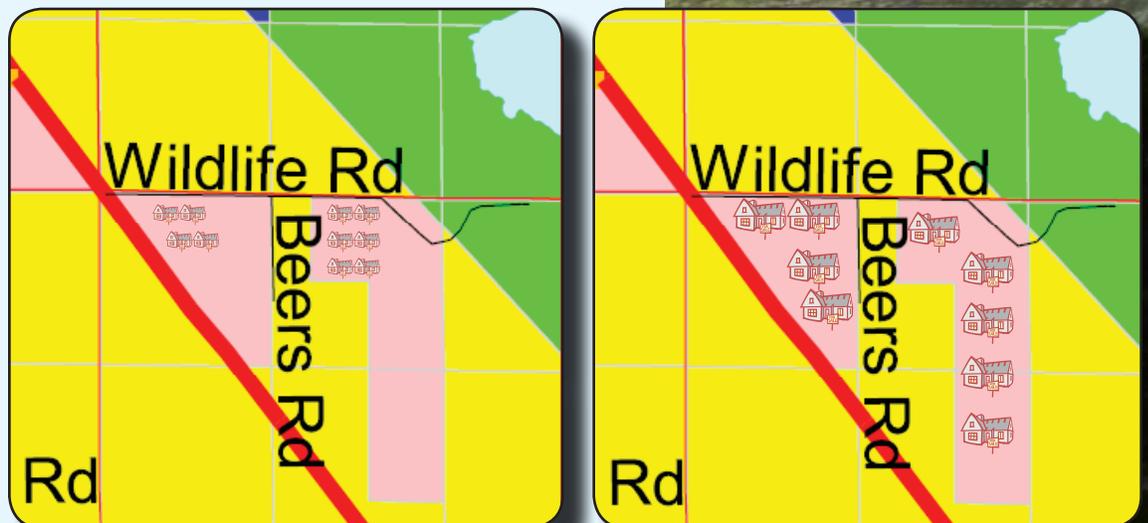


Researchers have found that land use follows parcel lines, and that the change of parcel lines can also instigate a change in land use (Croissant, 2004).

Characterizing Parcelization

Previous research addressing parcelization uses only non-spatial measurements to characterize changes over time such as the number of parcels, size, or density. While these metrics are fairly simple to calculate, they offer no insight into the resulting spatial pattern of land division. Density, for example, is a straightforward calculation in which the number of features is divided by the total area of the area under study. The problem with density however, is that it can remain constant while the actual pattern of features (parcels) can vary significantly (Figure 6).

Figure 6. Example of how density does not capture the spatial configuration of features in a landscape. In both examples, the density of homes within the 60-acre pink remains the same, however, the patch size and dispersion of homes is quite different.



Our approach to quantifying the spatial pattern of parcelization (Appendix A) focuses on the characteristics of landscape fragmentation and sprawl. Specifically, we employed four metrics (Table 1) to quantify the pattern of land division from 1954 to 2007. These metrics were chosen based on their ability to express specific differences in landscape patterns, the lack of correlation among them, and they can be calculated within the ArcGIS environment.

Table 1. Selected landscape metrics used to quantify parcelization.

Metric	Description
Number of Patches	Measures the total number of patches of a particular patch type
Mean Patch Size	Measures the average patch size of a class of patches
Mean Nearest Neighbor	Measure the distance between patches of members of a particular class
Perimeter to Area Ratio	Relates the shape of a patch to its size to express the amount of associated edge

These metrics were computed at each time step for parcels under five acres and separately for new minor land divisions (CSM) parcels and new platted subdivision lots so that the results would not be skewed. For example, it is obvious that platted subdivision lots will be relatively small and clustered, affecting the average parcel size and nearest neighbor metrics. In addition, local officials have expressed concern about landowners trying to slip past the subdivision review process by creating CSM parcels just below the regulatory minimum number of parcels or just above the regulatory lot size. Therefore, the above metrics were measured separately for CSM parcels and platted subdivisions lots.

Comparing metrics

Each spatial metric provides valuable information regarding a particular fragmentation or sprawl characteristic. However, because some metrics are calculated in distances and others are areal measurements, individual measures cannot be compared. Therefore, normalization of each metric through a Z-score calculation results in a value that can be cross-compared between municipalities. Since there is little correlation among the metrics, the Z-scores for all four metrics can be summed to produce a cumulative value representing the parcelization score for each town. This index generalizes the overall parcelization pattern compared to other municipalities and measures historic and contemporary rural sprawl. Positive parcelization index values reflect towns experiencing a more fragmenting pattern of new parcel creation than the three-town average. Conversely, negative parcelization index values reveal towns with a less fragmenting parcel pattern.

Results

While digital tax parcel boundaries are becoming more common, they usually portray the most recent snapshot of land ownership because earlier versions have been written over. It took nearly one year to collect, analyze, and spatially reconstruct these parcel maps for all three towns. Appendix B illustrates the 1954 and 2007 tax parcel reconstruction maps for each town. When reviewing the maps, one can easily see that the trend is near-lakeshore lot development in Barnes and Delta with ex-urban development in Bayfield. Figure 7 demonstrates

Number of Tax Parcels and Distance to Water

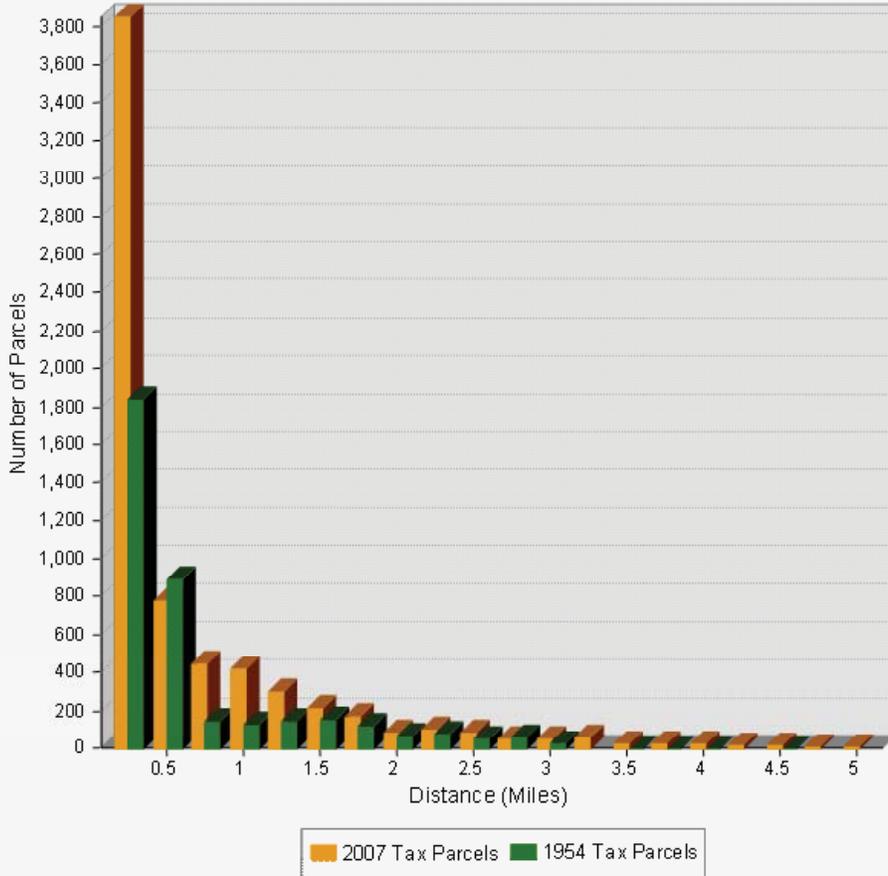


Figure 7. Histogram showing the number of parcels and distance to water in Bayfield County in 1954 and 2007.

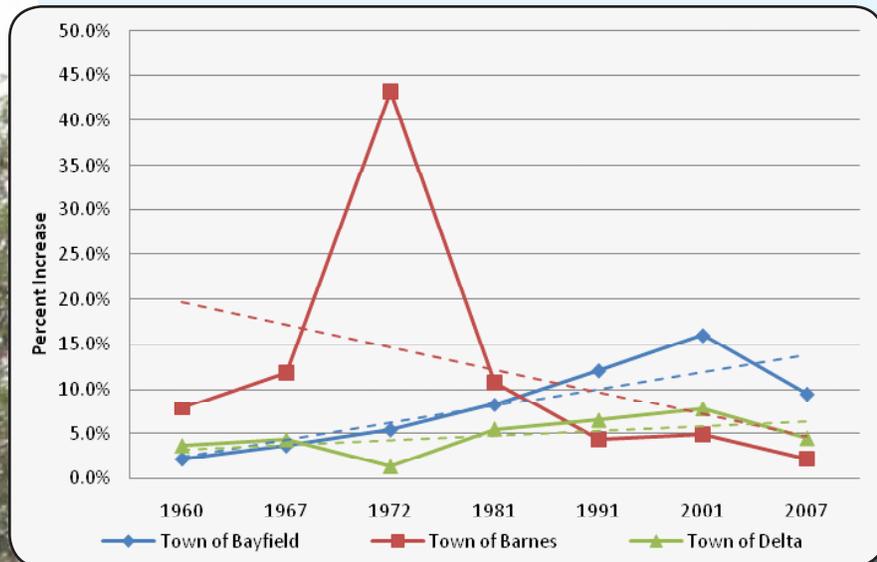
Towns of Bayfield, Barnes and Delta, Bayfield County

this trend by illustrating the number of parcels and their distance to water in Bayfield, Barnes, and Delta. Over 54% of all parcels in the sample towns are within ¼ mile of a lake, while over 66% of all parcels are within ½ mile of a lake. The strong attraction to inland lakes is further demonstrated by comparing the number of parcel splits near lakes. Between 1960 and 2007, 67% of all parcel splits were within ¼ mile of water, while 76% of all parcel splits were within ½ mile of water. It is clear that the location and abundance of natural water resources play an important role in the parcelization of Bayfield County. Table 2 summarizes the number of parcels and average parcel sizes.

Table 2. Total number and average size (acres) of parcels in each town from 1954 to 2007.

Township		1954	1960	1967	1972	1981	1991	2001	2007
Bayfield	Count	1,089	1,112	1,152	1,214	1,314	1,473	1,709	1,871
	Average Size	49.8	48.8	47.1	44.7	41.3	36.8	31.7	29.0
Barnes	Count	1,659	1,787	1,996	2,848	3,152	3,287	3,445	3,520
	Average Size	48.0	44.6	39.9	28.0	25.3	24.2	23.1	22.6
Delta	Count	982	1,017	1,060	1,073	1,134	1,212	1,308	1,364
	Average Size	46.9	45.3	43.4	42.9	40.6	38.0	35.2	33.8

Figure 8. Parcel growth rates for each town with trendlines.



In 1954, Bayfield had 1,089 parcels with an average size of 49.8 acres; Barnes had 1,659 parcels and an average size of 48 acres; and Delta had 982 parcels and an average size of 46.9 acres. The total number of parcels increased in every time step, however, Barnes displayed the highest increase in parcel creation over the entire study period, whereas Delta experienced the least amount of land division. Reconstructed parcel data reveals that the overall rate of land division in Barnes declined since 1954, while the rate of land division increased in Bayfield and Delta since 1954 (Figure 8).

Table 3. Percent change by land use types for each town from 1938 to 2005.

Location	Category	1938	1972		2005		
		Acres	Acres	% Change 1938-1972	Acres	% Change 1972-2005	% Change 1938-2005
Town of Bayfield	Developed	344	214	-37.8%	1,245	481.8%	291.9%
	Agricultural/Open	3,999	3,482	-12.9%	2,050	-41.1%	-48.7%
	Forest	49,461	49,841	0.8%	50,325	1.0%	1.7%
Town of Barnes	Developed	223	513	130.0%	2,436	374.9%	992.4%
	Agricultural/Open	1,540	2,095	36.0%	2,324	10.9%	50.9%
	Forest	72,758	70,642	-2.9%	66,425	-6.0%	-8.7%
Town of Delta	Developed	291	221	-24.1%	637	188.2%	118.9%
	Agricultural/Open	1,551	1,765	13.8%	1,723	-2.4%	11.1%
	Forest	41,592	41,102	-1.2%	41,131	0.1%	-1.1%

Table 4. Landscape ecology metrics used to analyze landscape fragmentation.

Landscape Ecology Metric	Description
NP: Number of Patches	Number of patches of each different land use type
CA: Core Area	Sum of the core area of each different land use type
LPI: Largest Patch Index	Percentage of the landscape comprised by the largest patch
FRAC_DM: Fractal Dimension Index	Measures shape complexity for individual patches

Land fragmentation

We used GIS to record a total of three different snapshot years of land use based on the availability of aerial photography. Appendix C contains the 1938, 1972, and 2005 land use maps for each township. From the maps, it is quite obvious that land use change has occurred in each municipality. Table 3 summarizes both the total amount of land use change and the percent change during each time period. The most apparent change is the increase in the amount of developed land in each township, especially between 1973 and 2005. During the entire study period, the amount of developed land increased 262, 992, and 119 percent in Bayfield, Barnes, and Delta, respectively (Figure 9). The large increase in developed land in Barnes resulted in a decrease in forest cover.

FRAGSTATS, a software package designed to calculate different landscape ecology metrics was utilized to measure the amount of landscape fragmentation that occurred with increased parcelization during the study period. Table 4 explains the four different metrics analyzed to evaluate the effect of parcelization on the landscape.

Except for developed land use in the Town of Barnes from 1938 to 1972, land use change in Bayfield County was relatively benign from 1938 to 1972 (Table 5 on page 18). All four FRAGSTATS landscape ecology metrics for developed land patches increased, while agricultural and forested patches slightly increased or declined from 1973 to 2005.

Increases in the number of developed patches and fractal dimension in the Town of Bayfield from 1973 to 2005 should indicate greater fragmentation. However, the increase in total core area and largest patch index contradict those results. This illustrates that while development is increasing, additional developed patches are proximate to other developed patches. The Town of Bayfield is experiencing new parcel growth in a less fragmenting pattern than Barnes or Delta. This is most likely due to the greater quantity of planned land subdivision developments in the Town of Bayfield.

Between 1973 and 2005, both Barnes and Delta experienced an increase in the developed number of patches, total core area and largest patch index. These results combined with the increase in the forested number of patches, decreased total core

Figure 9. Graphical representation of the amount of change in each land use type for all three towns from 1938 to 2005.

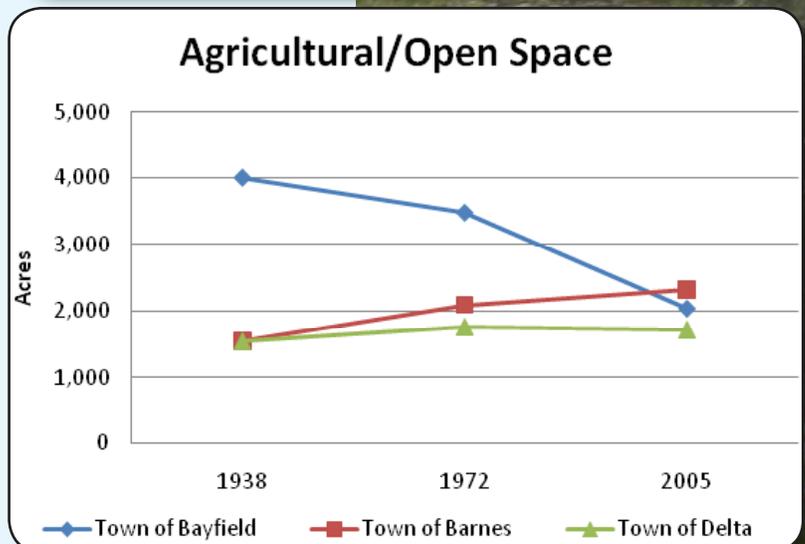
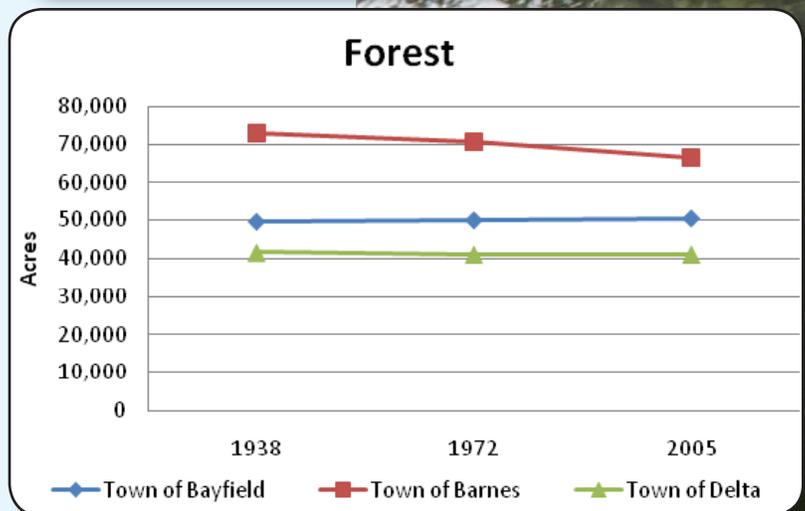
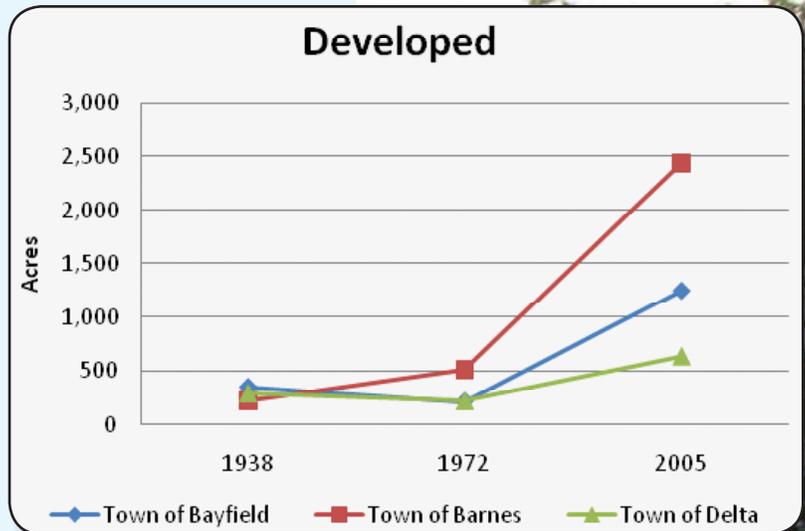


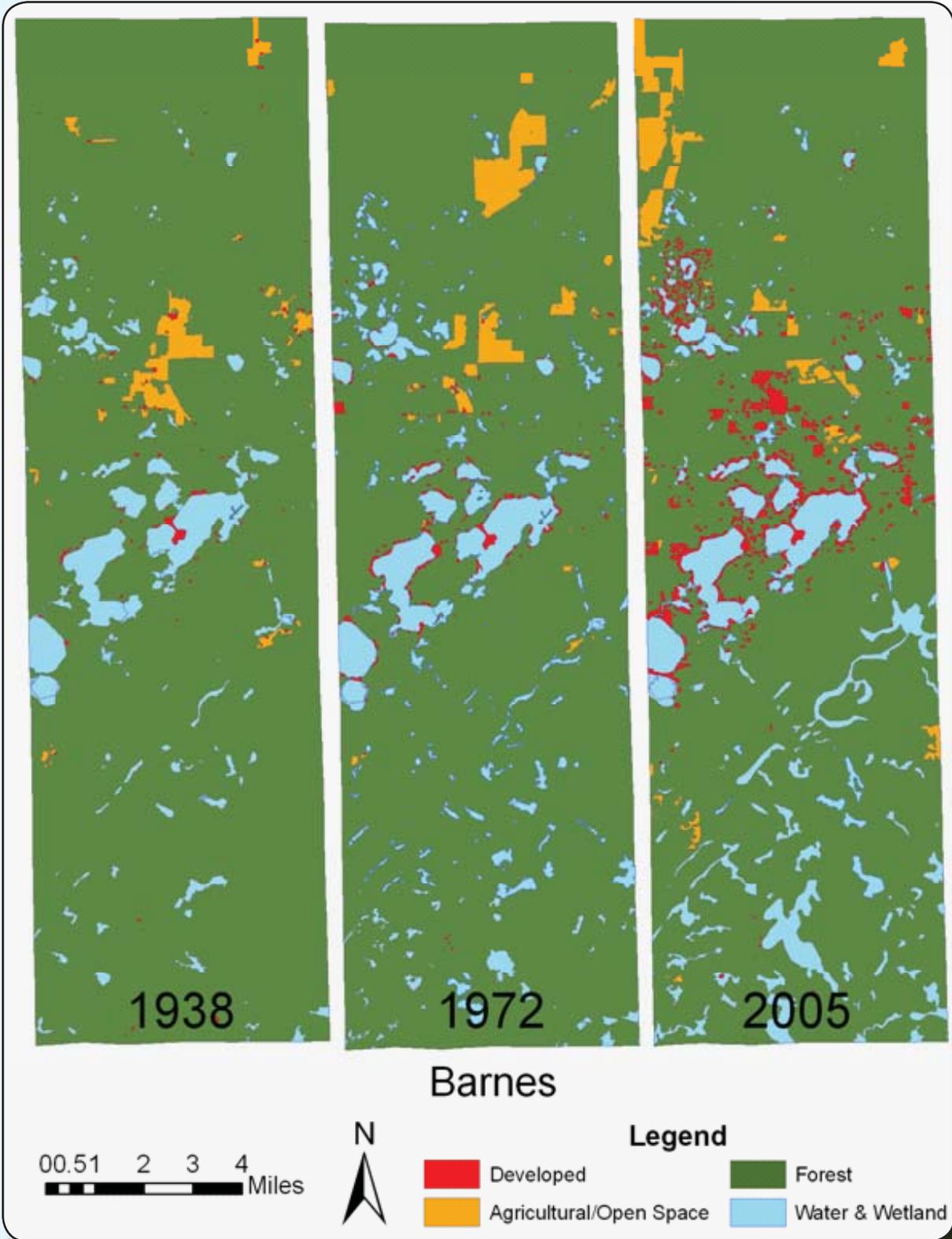
Table 5. Landscape fragmentation results by town for 1938 - 2005.

1938-1972						
Location	Patch Class	Number of Patches (NP)		Total Core Area (acres) (TCA)	Largest Patch Index (LPI)	Fractal Minession (FRAC_DM)
Bayfield	Developed	-45	-28.5%	-41.5%	-82.3%	0.05%
	Agricultural/Open	-17	-13.9%	-12.1%	-2.1%	-0.81%
	Forest	-27	-57.4%	0.8%	0.7%	0.43%
Barnes	Developed	111	91.0%	133.2%	-12.4%	-12.45%
	Agricultural/Open	-6	-16.7%	41.4%	7.1%	7.10%
	Forest	1	10.0%	-3.3%	-2.9%	-2.91%
Delta	Developed	-23	-26.4%	-24.7%	17.6%	17.59%
	Agricultural/Open	-20	-42.6%	19.3%	57.8%	57.78%
	Forest	1	25.0%	-1.2%	-0.5%	-0.52%
1973-2005						
Location	Patch Class	Number of Patches (NP)		Total Core Area (acres) (TCA)	Largest Patch Index (LPI)	Fractal Minession (FRAC_DM)
Bayfield	Developed	226	200.0%	577.6%	934.2%	0.48%
	Agricultural/Open	-45	-42.9%	-39.8%	-16.8%	-0.88%
	Forest	0	0.0%	0.9%	1.1%	1.78%
Barnes	Developed	316	135.6%	425.2%	104.0%	-0.09%
	Agricultural/Open	11	36.7%	7.8%	-11.7%	1.74%
	Forest	16	145.5%	-7.1%	-6.2%	-3.75%
Delta	Developed	123	192.2%	190.5%	112.3%	1.27%
	Agricultural/Open	21	77.8%	-3.9%	-3.6%	0.19%
	Forest	2	40.0%	-0.1%	-0.3%	-4.62%

area and largest patch index, indicates that forest fragmentation is increasing, and could be the result of an increase in developed land uses.

Forest cover in Bayfield County has experienced increased fragmentation throughout the study period. The total core area and largest patch index decreased for both time periods, while patch complexity increased from 1938 to 1972, followed by a slight decrease thereafter. Examining land use change in Figure 10 illustrates this trend. In 1938 and 1972, the majority of developed land use in Barnes was located adjacent to inland water resources. By 2005, that trend had changed with increased development outside the lakeshore zone feeding the fragmentation of forestland. The shortage of land supplies adjacent to inland water resources pushed parcelization into non-adjacent forestland.

Agricultural land use in Bayfield County experienced inverse trends of fragmentation. From 1938 to 1972, all sample towns experienced a decrease in agricultural land use fragmentation. This was the result of a decrease in agricultural/open patches, and in Barnes and Delta increases in total core area and largest patch index. Agricultural/open space patches in Barnes and Delta experienced consolidation and growth in individual patch sizes combined with a loss of smaller agricultural/open patches. From 1973 to 2005, fragmentation



of agricultural/open space increased in Barnes and Delta, and decreased in Bayfield. Bayfield experienced substantial agricultural/open space loss during this time period while Barnes and Delta experienced greater fragmentation. Former agricultural/open space patches have contracted in size and increased in complexity.

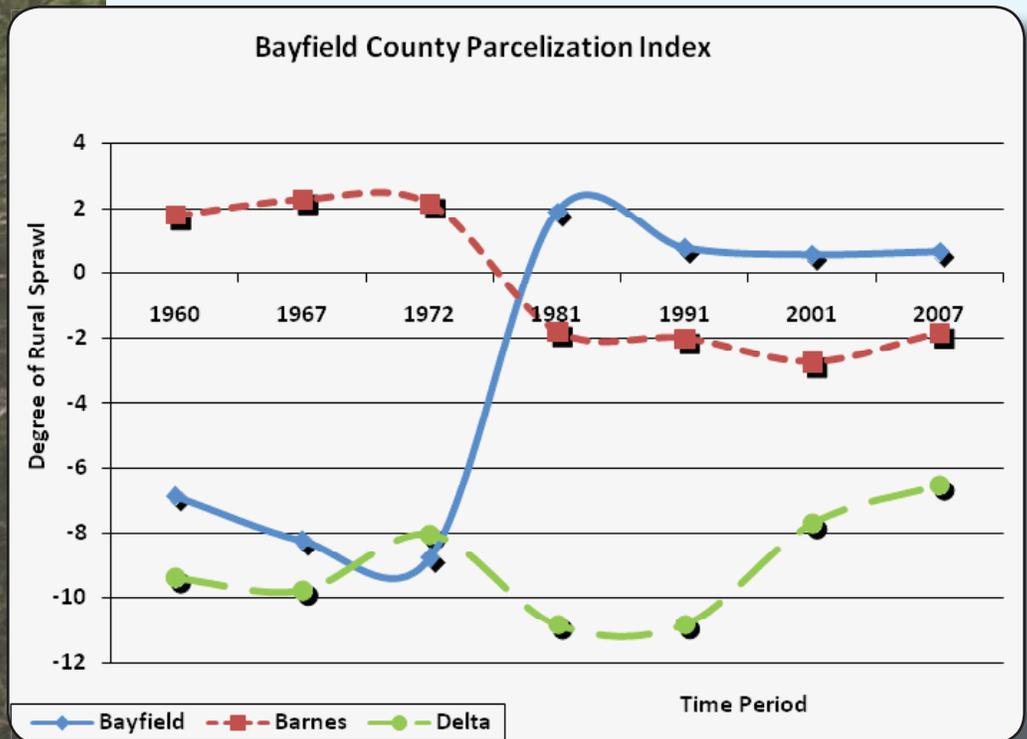
Figure 10. Land use change in the Town of Barnes from 1938 to 2005.

Characterizing Parcelization

Our five individual fragmentation measures revealed varying degrees of fragmentation over time in each town. Appendix D contains the combined town's summary statistics for each time period. Even though the town of Barnes experienced the greatest increase in new parcels, it did not exhibit the highest level of rural sprawl when compared to Bayfield for the latter portion of the study period. The Town of Delta experienced the lowest and most stochastic trend of rural sprawl during the study period.

The average measures for each metric are standardized to allow comparisons and are graphed in Z-scores (standard deviations) from the combined three-town average. The standardized values were summed to produce a single numeric value that represents each community's overall rural sprawl pattern (Figure 11). The range of values for each town demonstrates the different dimensions of parcelization and fragmentation and the resulting rural sprawl. Positive Z-scores indicate towns experiencing a more fragmenting parcel pattern compared to the combined three-town average, whereas negative Z-scores signify a less fragmenting pattern. The greater the absolute Z-score value, the more/less fragmenting the pattern. One important note is that the Z-scores are calculated for each town during each time period separately, therefore the individual town scores for one time period, are relative to the county average for that same time period only.

Figure 11. The parcelization index combines the individual metric scores into a comprehensive evaluation of rural sprawl.



From 1960 to 1972, the Town of Bayfield experienced low rural sprawl when compared to the county average for that time period. In 1981 that changed when the parcelization index score increased to nearly the highest level of all three towns during the study period. The increase in rural sprawl for that period occurred due to the addition of platted subdivision developments during each consecutive time period from 1981 to 2007. From 1960 to 1972, no new

platted subdivision developments were created in the Town of Bayfield which contributed to the low parcelization index score for those time periods. The parcelization index in the Town of Bayfield also remained steady from 1981 to 2007 due to similar quantities of new CSM and platted parcels added during each year analyzed. Unique in the examination of Bayfield County, is the exurban growth surrounding the City of Bayfield (Figure 12). Typically, exurban areas have more land division by platted parcels than unregulated CSM splits, indicating greater land use planning and approval methods. That trend was not exhibited in the towns of Barnes or Delta.

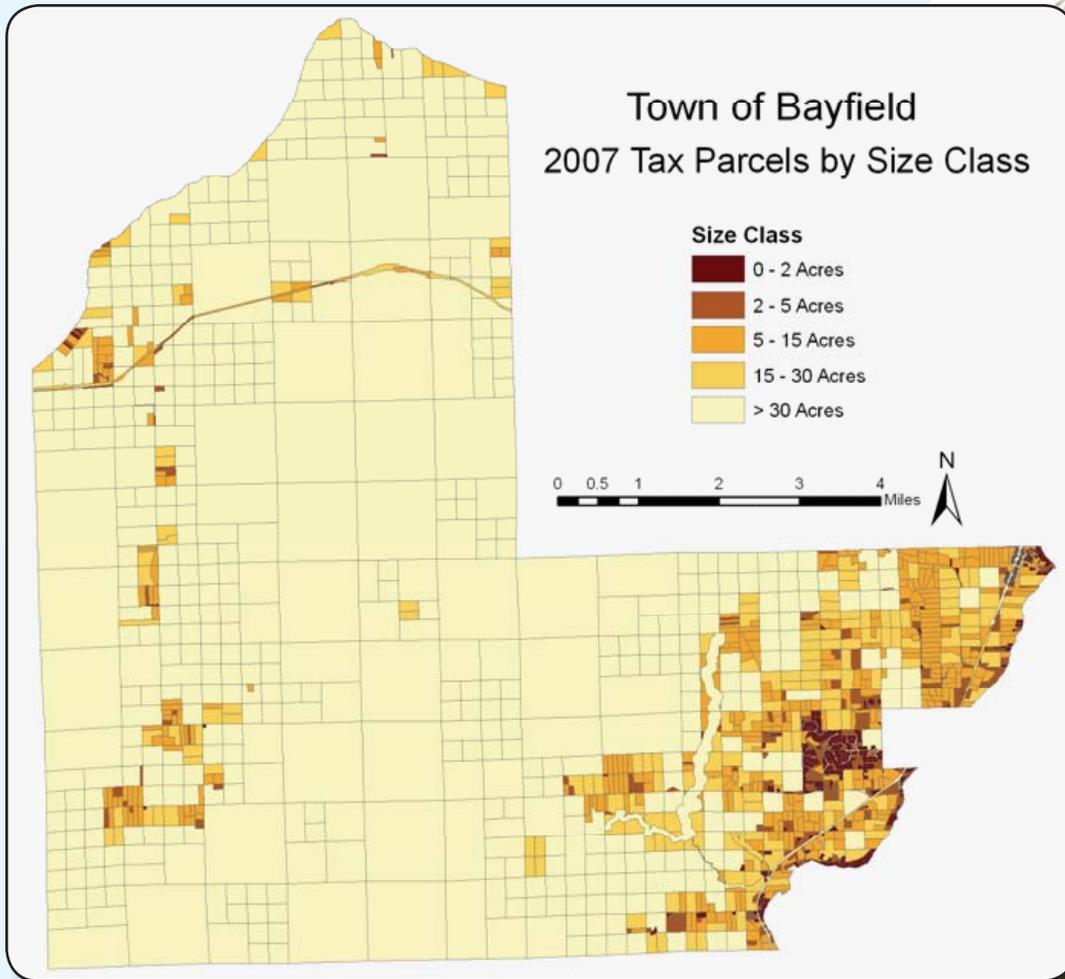
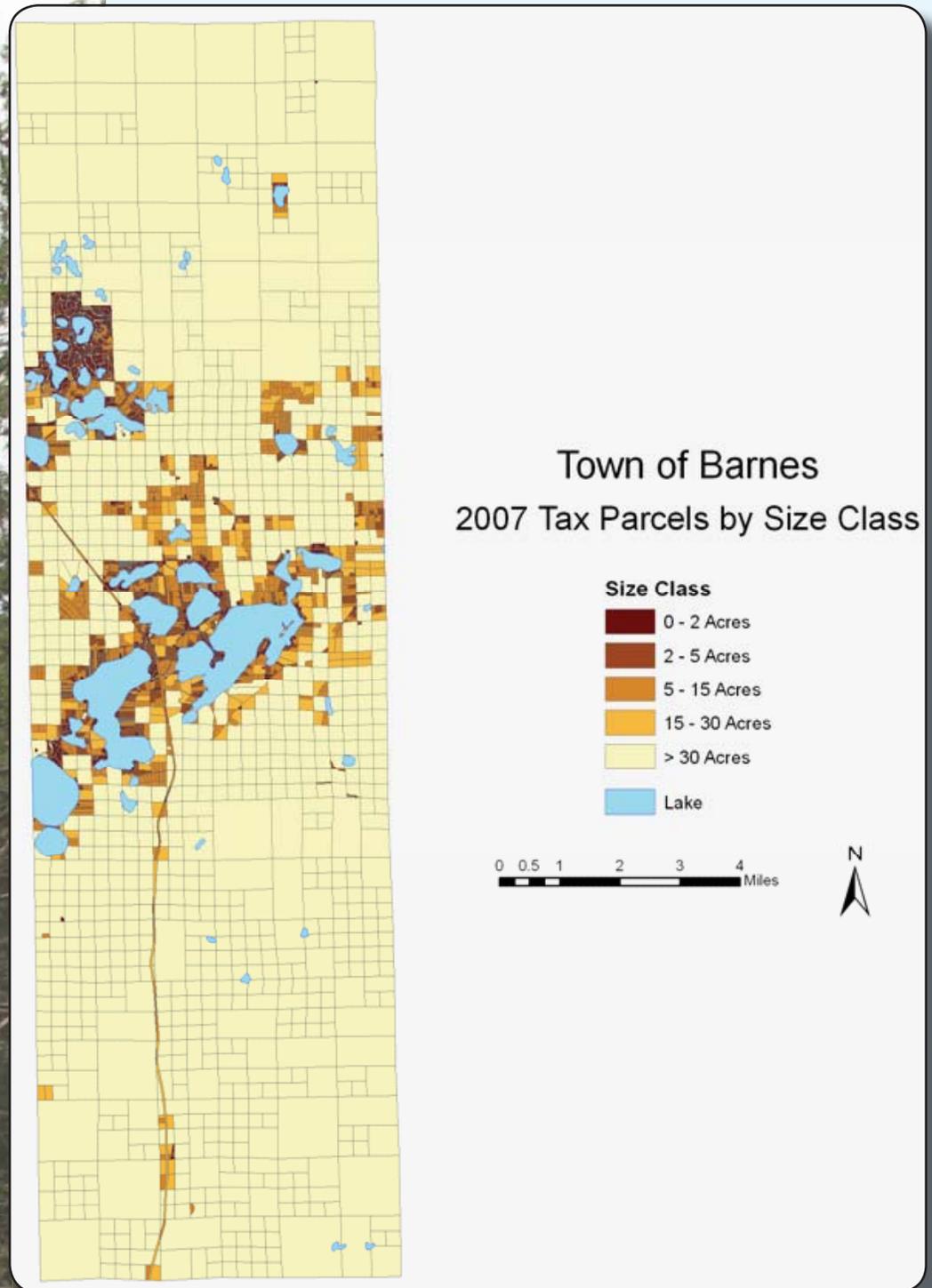


Figure 12. Town of Bayfield tax parcels by size class. Note the prevalence of smaller parcels and the trend of greater parcelization surrounding the City of Bayfield.

Rural sprawl in the Town of Barnes peaked from 1960 to 1972, periods in the history of Bayfield County with reduced shoreland zoning regulations. From 1973 to 2007, rural sprawl slightly declined and remained steady. The parcelization index score began the study period at the highest level for all study towns indicating that Barnes experienced rural sprawl earlier than both Bayfield and Delta during the study period. Greater quantities of new CSM parcels spawned the high level of rural sprawl during those time periods. Additionally, Barnes added nearly 700 new platted parcels between 1968 and 1972 in one single contiguous development. Prior to shoreland zoning, no regulatory structure existed to control land division beyond the state minimum which simply stated is; approval is required for the creation of more than four lots, one and one-half acres or less in size during a single year (Ohm, 1999). Shoreland zoning

introduced a minimum average lot width of 100 feet and 20,000 square feet of area for lots not served by public sanitary sewer (Figure 13) (WDNR, 1967).

Figure 13. Town of Barnes tax parcels by size class. Note the clustering of smaller parcels around inland lakes.



Barnes was the only town to add platted parcels between 1960 and 1972, while also adding 242 more new CSM parcels than both Bayfield and Delta combined. Even though Barnes expanded by nearly 700 new platted parcels from 1968 to 1972, the parcelization index score remained steady through the next time period. It appears from the results that this highly clustered development offset the expected higher parcelization index scores. Rural sprawl is evident by

large parcel sizes in low-density spatial configurations that are greater distances from urban areas (Burchell et al., 1998). Due to the tight clustering of new platted parcels, the parcelization index declined offsetting the addition of 161 new CSM parcels during the same time period. Subsequently, the parcelization index remained steady in Barnes until 2007, where the addition of 36 new platted parcels initiated a slight increase in the score. This result illustrates the effectiveness of cluster developments in reducing rural sprawl, and potentially fragmentation.

It is possible that shoreland zoning, enacted in 1972 had a moderating effect on historic parcelization in Barnes. Because many parcels had previously split around inland water resources prior to shoreland zoning, lower quantities of land were available (Figure 14). By 1973, 56% of all available shoreline land was encompassed in parcels less than 30 acres in size. In the Town of Barnes, not including land in public ownership, only 81 tax parcels greater than 30 acres in size remained with water frontage in 1973.

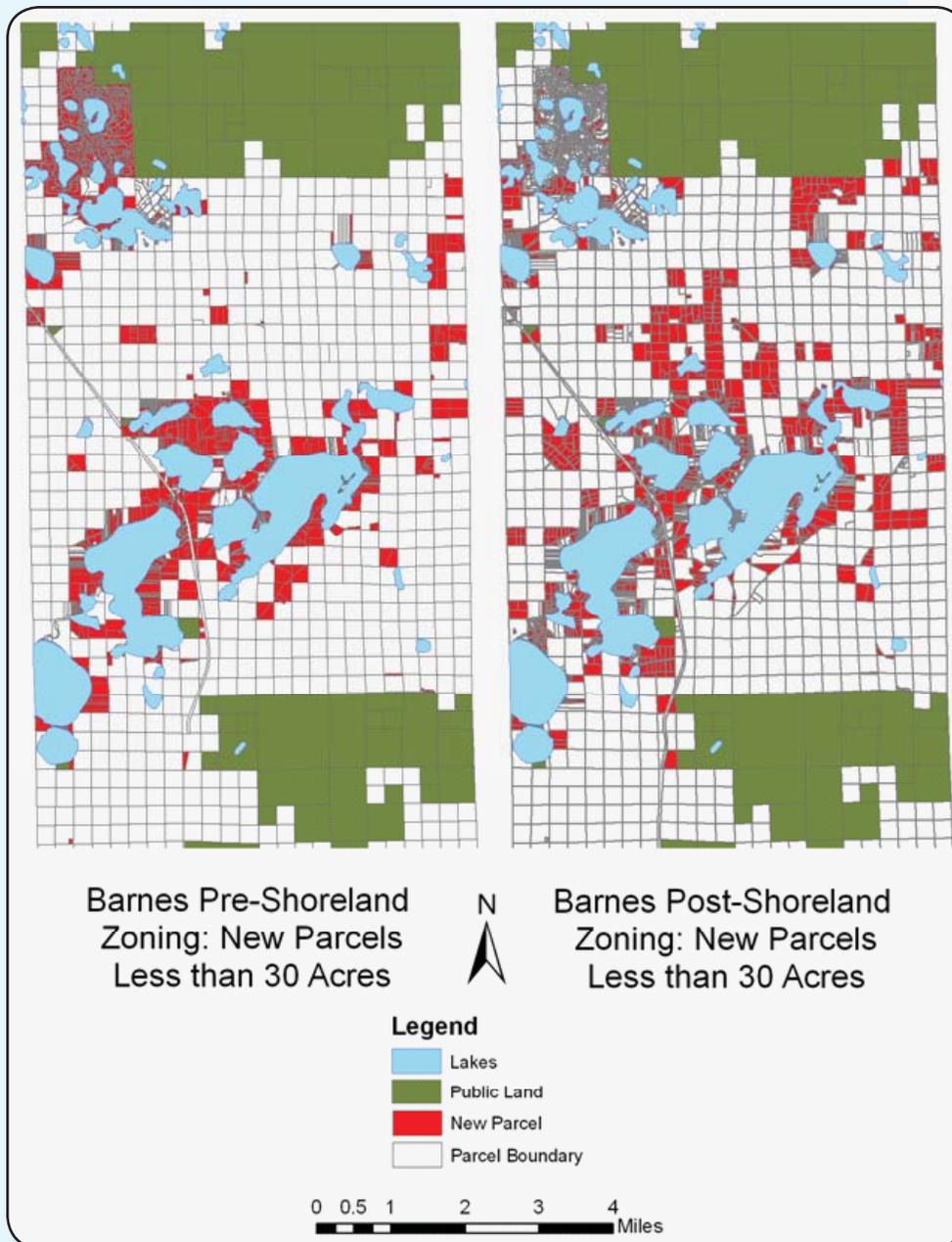
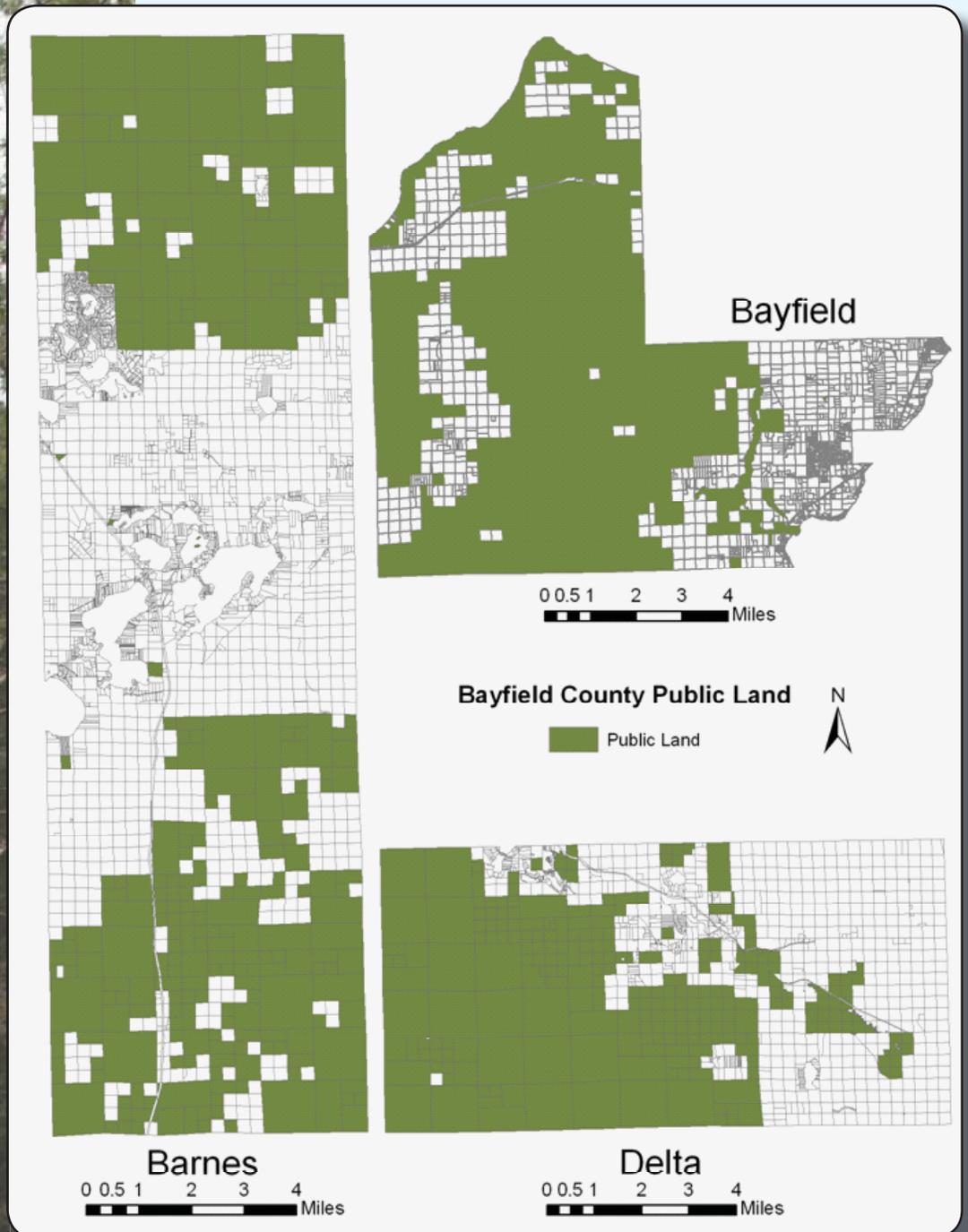


Figure 14. New parcels less than 30 acres in the Town of Barnes pre and post-shoreland zoning enactment.

Any discussion of historic parcelization and land use in Bayfield County would be incomplete without including the large quantities of public land. Spatial aerial size indicates Bayfield is the second largest county in Wisconsin. However, gross spatial area can be misleading when considering the amount of land available for parcelization and settlement. Viewing the quantity of privately held land that may be available for future subdivision, we see that public land (most likely unavailable for future subdivision) funnels parcelization into smaller zones, in effect tightening available land supplies spatially (Figure 15).

Figure 15. Public land unavailable for future land division in the three study towns in Bayfield County.



This funneling effect limits available land supplies and can increase rural sprawl by pushing parcelization into smaller areas. From this same map, we can see

that available privately held land supplies near the City of Bayfield is limited with Lake Superior on its eastern border, and public land on its western border. The quantity of public land, along with privately held forestry land, also had an effect on the historic parcelization of the Town of Delta.

Prior to the 1981 time period, available land supplies in the Town of Delta were constricted to areas not under public or private forestry control. With low quantities of land available, and the inherent remoteness of the town, rural sprawl was relatively benign. That trend changed during the 1980's and 1990's when approximately 9,000 acres of privately held forestland was clear cut and sold, quickly increasing supplies of land that were previously unavailable for splitting and sale. By 2007, only about 1,000 acres of land remained in privately held forestry control. Additionally, the absence of new platted parcels during the entire study period was a primary factor in the low parcelization index scores in the Town of Delta (Figure 16).

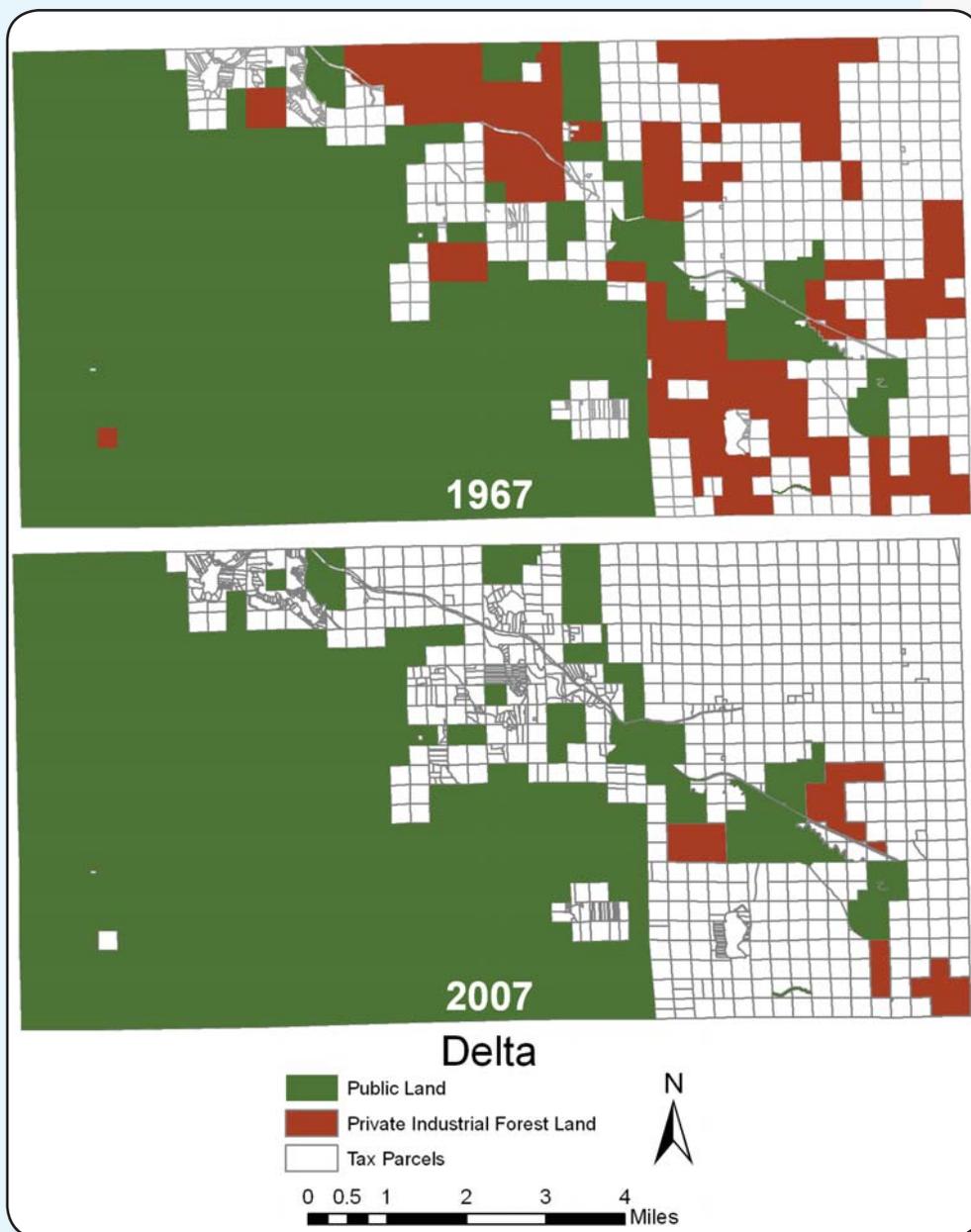


Figure 16. Public and privately held forestry land in the Town of Delta in 1967 and 2007.

The results indicate unexpected historic temporal and parcelization trends between the towns of Bayfield and Barnes. Barnes exhibited rural sprawl earlier in the study period than Bayfield, surprising considering that the Town of Bayfield borders the city of Bayfield, a prominent tourism hub and access point for the Apostle Island National Lakeshore.

Parcelization causes land use change

As Table 6 illustrates, developed land use increased substantially greater inside parcelized windows vs. outside of parcelized windows. Developed land use in the study towns increased by 872% inside parcelized windows, vs. 90% increase outside parcelized windows (Table 6). This indicates that parcelization is a direct link to landscape change. We know from other research that parcelization leads to development, and development causes fragmentation. Therefore, we have a direct link that parcelization leads to land use change, and potentially fragmentation of the landscape. Parcelization is a just cause of concern for planners, non-governmental organizations, land production interests, and residents alike.

Table 6. Land use change results inside and outside of parcelized areas for the three study towns in Bayfield County.

BAYFIELD COUNTY			
Parcelized Areas	1938 (acres)	2005 (acres)	% Change
Developed land use	344	3,343	872%
Agricultural land use	2,509	1,145	-54%
Forest land cover	20,576	18,895	-8%
Non-Parcelized Areas	1938 (acres)	2005 (acres)	% Change
Developed land use	514	975	90%
Agricultural land use	4,188	2,259	-46%
Forest land cover	143,199	138,971	-3%

Discussion and Conclusions

With this research, we set out to explore the long-term trends and consequences of rural land parcelization in three towns within Bayfield County, Wisconsin. We focused on a set of landscape metrics with intuitive explanatory power for planners and citizens looking for something more spatially sophisticated than density or change in the number of parcels to quantify parcelization. We developed a detailed, process-based approach to apply landscape ecology metrics to quantify and measure the spatial dimension of parcelization. Our results demonstrate that the amount and spatial pattern of parcelization has had a distinct influence on the resulting landscape.

The first process of digital parcel reconstruction proved complicated. We were surprised to learn that there lacked a consistent protocol for numbering parcels in the tax assessment rolls, i.e. parcel identification number (PIN). Not only did this make it difficult to recognize parcel splits in the tax assessment rolls, it was complicated to track specific parcels over time.

All three towns displayed evidence that fragmentation caused by developed land uses has increased, causing landscape fragmentation to forests and agricultural/open areas. The results also indicate that most of the fragmentation

and landscape change is due to an increase in development that has occurred since 1973 in the three towns in Bayfield County. Some of the agricultural loss and reforestation followed a trend in the mid 20th century when poor soils not conducive to agricultural production led to the abandonment of farms in northern Wisconsin.

Water resources played a critical role in historic parcelization in the towns of Barnes and Delta. During a five year time period we examined, nearly 700 new platted parcels were created surrounding the Island Lake area in the Town of Barnes. Speculative land development played a key role in the early parcelization in Barnes. We estimate that only about 35% of the parcels in the Potawatomi Estates subdivision have been developed, leaving the town and county with service burdens minus the appropriate tax revenue that would come from a development with greater occupancy. This attests to the detrimental effects of speculative land development. Speculative land development not based on actual demand for parcels, places an unneeded burden on communities to provide infrastructure, emergency and health services, and planning services while important tax revenue is not realized due to lower human settlement and occupancy.

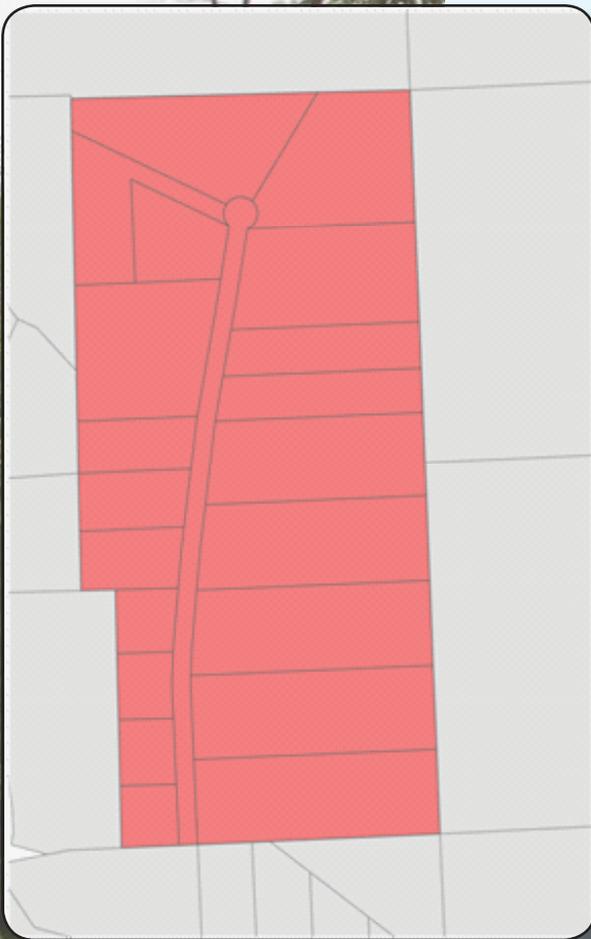
Even though the parcelization score provides a convenient single number measurement for characterizing parcel development in municipalities, it should be interpreted carefully. Parcelization is dynamic over both time and space, and may be more complex than what a single number can convey. Additionally, parcelization is not a single-dimensional phenomenon, but includes social, economic, political, and spatial factors. Our study primarily investigated the spatial dimension of parcelization. However, the parcelization score encompasses several landscape ecology metrics that are characteristic of fragmentation and provides a new approach to summarizing new parcel creation and potential future changes. Calculating standard deviations from the combined town average allows one to compare towns to each other against larger averages such as the county, region, and state.

The parcelization score we developed in this work can become an important tool for communities to use when evaluating and implementing land use plans. It is in everyone's interest to know if the resources, time, and cost expended during the comprehensive planning process are worthwhile. To evaluate a plan, communities have several questions to address; have these plans successfully preserved working lands? What policies are efficient for promoting smart growth? Many rural communities lack a standard approach to answering such questions. With the availability of digital land records growing throughout Wisconsin, the parcelization score can become an important tool for helping citizens recognize whether or not the current planning and policy efforts are protecting key natural resource assets from the negative consequences of parcelization and development. We encourage counties to actively archive their parcel database with associated tax assessment information so that annual parcelization scores can be readily calculated. If communities do not have enough digital storage space, the Center for Land Use Education at the University of Wisconsin – Stevens Point will readily archive digital data for you.

The results of our study shed light on some contemporary planning debates in Wisconsin. People throughout the state appear to be looking for a balance between growth and natural resource protection. The continued parcelization of rural lands can weaken a community's goal for protecting productive forest

and farmlands. Therefore, we recommend strict enforcement of CSM creation (perhaps reviewing all lot splits). Many landowners choose to create lots under the statutory minimum size or below the required number of parcels, so that they may avoid a lengthy regulatory review process. It has long been recognized that non-platted (CSM) division of parcels is cheaper and easier than succumbing to the formal review process to create a platted subdivision (Melli, 1953). In effect, CSM parcel splits are a type of “poor man’s” subdivision. As Figure 17 illustrates, owners and developers have found creative ways to circumvent the regulatory review process. A good example of this is a 20-lot subdivision in Columbia County, Wisconsin, which was created by bypassing the platted subdivision review process. The developer split the parcels during multiple calendar years staying under the radar, and under the state minimum requirements for parcel split review. The access road was constructed without municipal review and inspection.

Figure 17. A subdivision development in Columbia County, Wisconsin, created “under the radar,” without any formal review process.



The CSM method of parcel splits is especially prevalent in the Town of Delta where all 328 new parcels during the entire 53-year study period, were created by CSM splits. This act can create numerous environmental and infrastructure problems in the future, paid for not by the owners of the new lots, but by everyone in the community.

Whether your community’s goal is forest, farmland, or open space preservation, sliding scale zoning that allows a certain amount of development rights may fragment the working landscape. This approach essentially allows larger property owners (usually farmers) to split off more parcels than smaller property owners. In Bayfield County, this means creating isolated clusters of parcels throughout large forested areas, distant from existing development and public services. Instead, the clustering of parcelization near existing development is encouraged. However, a Transfer of Development Right (TDR) program internal to the county or town used in conjunction with a sliding scale zoning approach can affectively preserve forest and farmland while shifting development to designated areas with existing public services.

Appendix A

Parcelization Metrics

Number of Patches

The number of patches (NP) in a landscape provides a measure of the number of subdivision or fragmentation of parcels. We measured the number of patches separately for platted subdivision lots and CSM lots. Parcel fragmentation is considered to increase with an increase in the number of new parcels.

$$NP_{\text{csm/plat}} = \text{ParcelsTime2} - \text{ParcelsTime1}$$

where $NP_{\text{csm/plat}}$ is the number of new CSM or platted parcels in each town for a given time period, ParcelsTime2 is the number of either CSM or platted parcels at Time 2, and ParcelsTime1 is the number of either CSM or platted parcels at Time 1.

Average New Parcel Size

The average parcel size (AC) component of parcelization measures how much land the average new parcel is consuming. This component provides information on the impact or effectiveness of minimum lot size policies. The average parcel size was calculated by selecting new parcels and summarizing the area. We removed residual or non residential parcels from the selection, such as if a forty acre parcel split into a 2 acre and 38 acre parcel. In this case, the larger parcel was removed. Larger average new parcel sizes would indicate that new lots are consuming more land.

$$AC_{\text{csm/plat}} = (\sum \text{Pac}) / NP$$

where $AC_{\text{csm/plat}}$ is the average new parcel size (acres) index for new CSM or platted parcels in each town for a given time period, Pac is the new parcel size, and NP is the total number of parcels in a given municipality.

Distance to Existing High Density Development

New parcels that are created at a large distance from previous urban areas are indicators of future land use change and potential development, commonly known as leapfrogging. Dispersed development like this can be considered rural sprawl and have many negative implications including higher service costs, low density residential development, and perforated working lands. High density development was defined as previously existing platted subdivisions or city/village boundaries. A straight line distance was measured in a GIS for each new parcel and summarized by every town. As the distance between new parcels and existing high density development increases, the pattern can be considered more fragmenting and sprawling.

$$UD_{\text{csm/plat}} = (\sum \text{Pud}) / NP$$

where $UD_{\text{csm/plat}}$ is the leapfrog index for new parcels, Pud is the distance from each new parcel to an urban or high density developed patch, NP is the number of new parcels in a given town.

Average Nearest Neighbor Distance Between New Parcels

The fourth metric used to characterize parcelization is the average nearest neighbor. The average nearest neighbor metric gives an indication of the dispersion of new parcels over the landscape. It was measured similar to the urban distance measure, except straight-line distances were measured between new CSM parcels of the same year. The nearest neighbor was not measured between new subdivision parcels because parcels here are obviously clustered. Larger average nearest neighbor values indicates increased dispersion and potentially more fragmentation.

$$NN_{\text{csm}} = (\sum P_{\text{nn}}) / NP$$

where NN_{csm} is the nearest neighbor index for new CSM parcels, P_{nn} is the distance between each new CSM parcel, and NP is the number of new CSM parcels in a given town.

Perimeter to Area Ratio

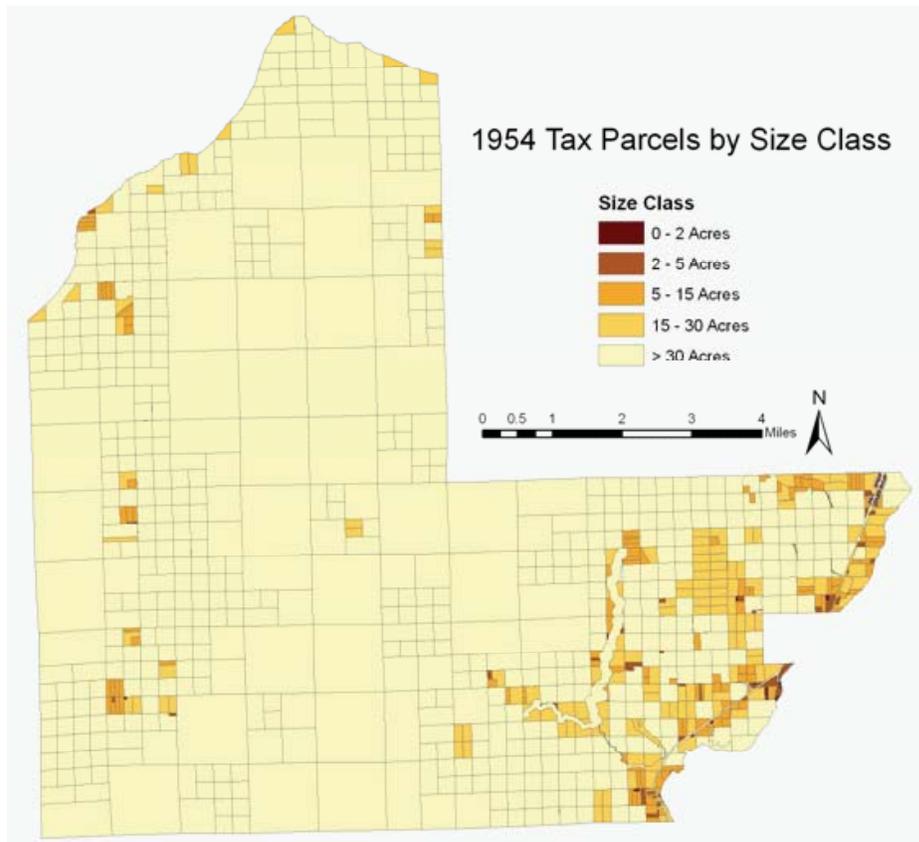
Finally, parcel shape can have significant implications on the sustainability of ecological habitats and farming operations. For example, complex shapes increase the amount of edge between the interfaces of neighboring parcels potentially creating more contact between differing land uses. The perimeter to area ratio metric was calculated for each new parcel. This metric is the ratio of the parcel perimeter length to parcel area. It is an indicator of patch shape in which larger values represent parcels with a more complex shape.

$$PAR_{\text{csm/plat}} = (\sum P_{\text{perim}} / \sum P_{\text{area}}) / NP$$

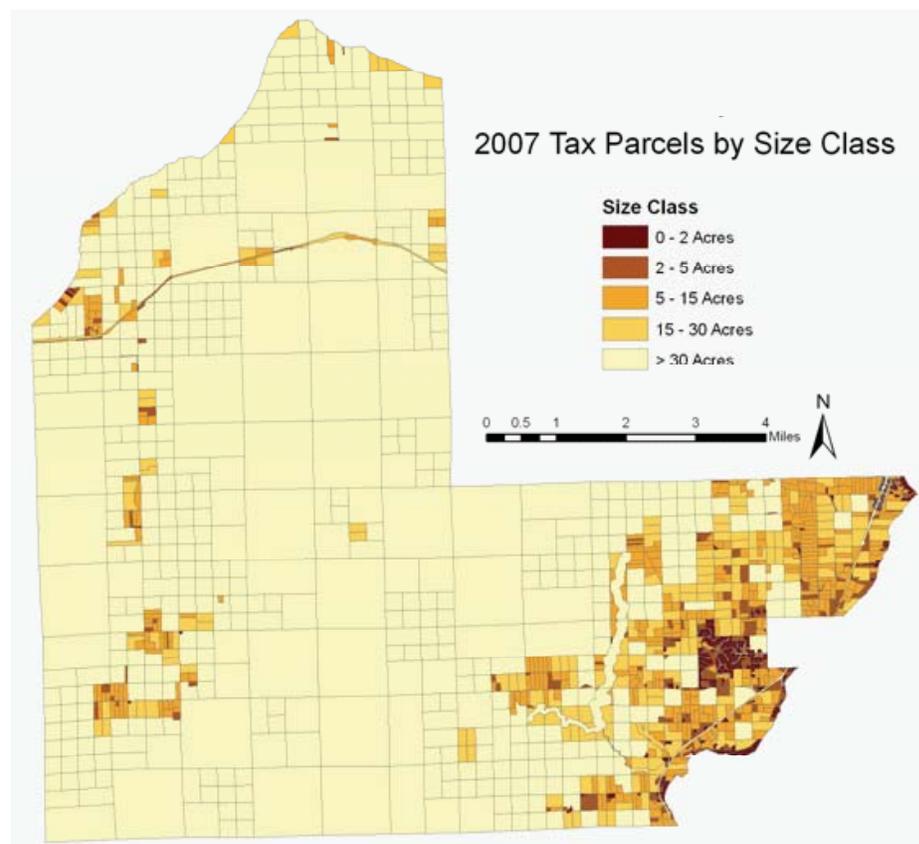
where $PAR_{\text{csm/plat}}$ is the perimeter to area ratio index for new parcels, P_{perim} is the perimeter of each new parcel, P_{area} is the area of each new parcel, and NP is the number of new parcels in a given town.

Appendix B Parcel Maps

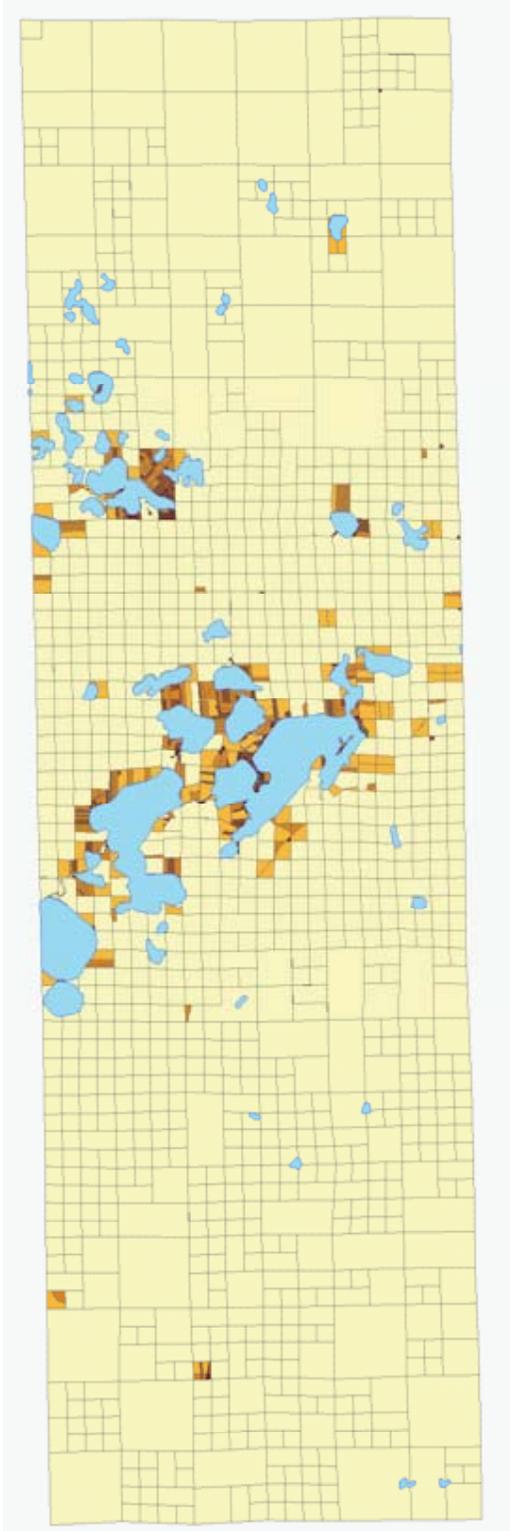
Town of Bayfield 1954



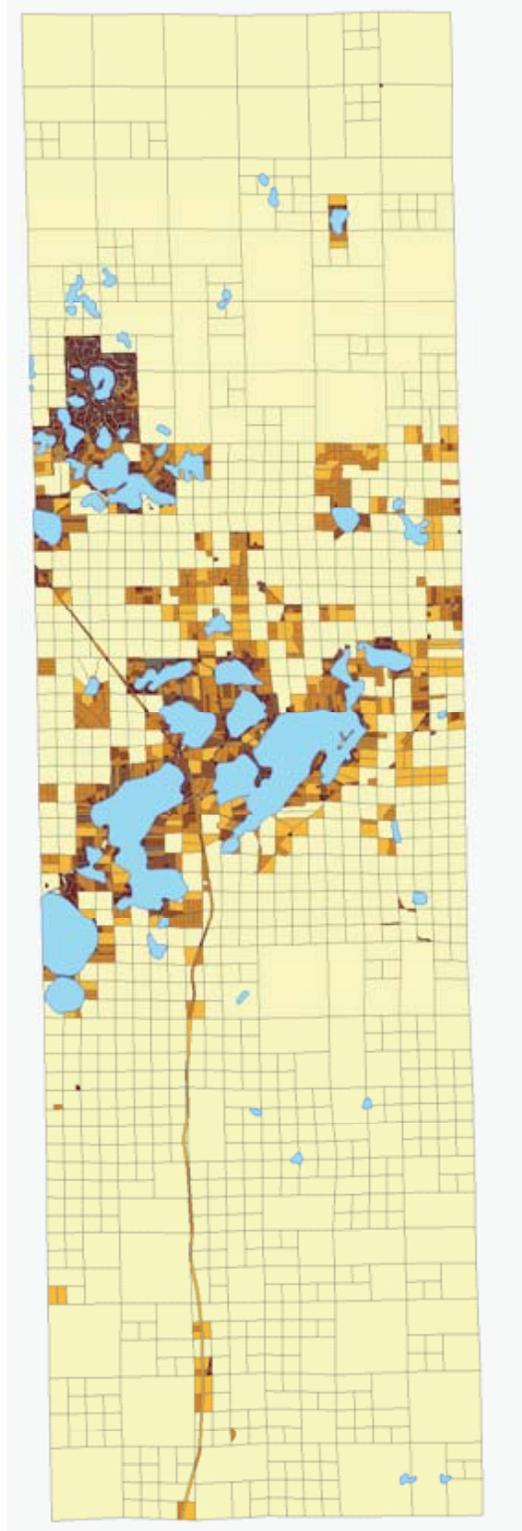
Town of Bayfield 2007



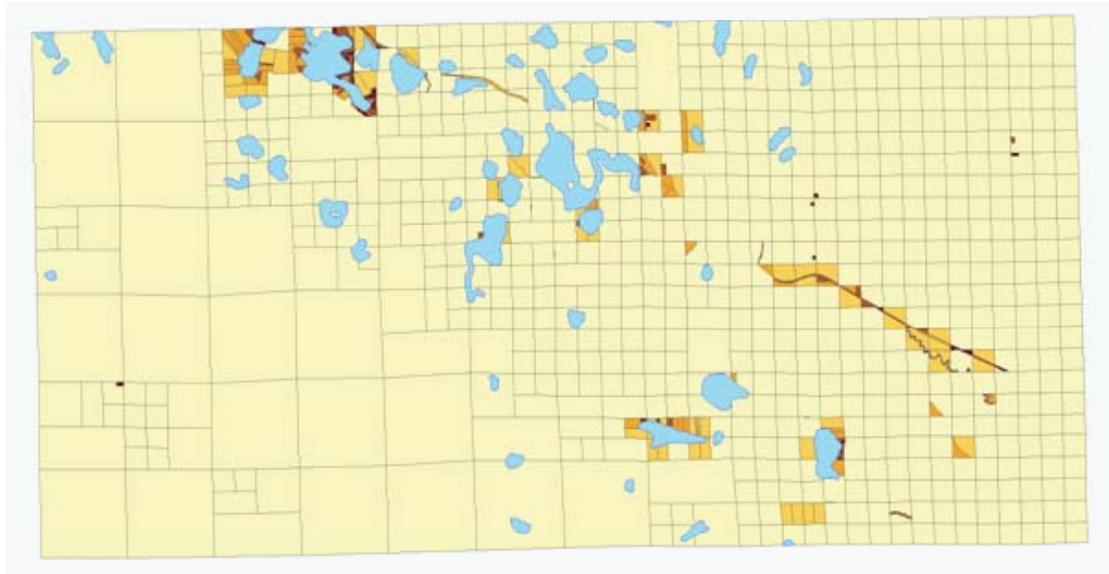
Town of Barnes 1954



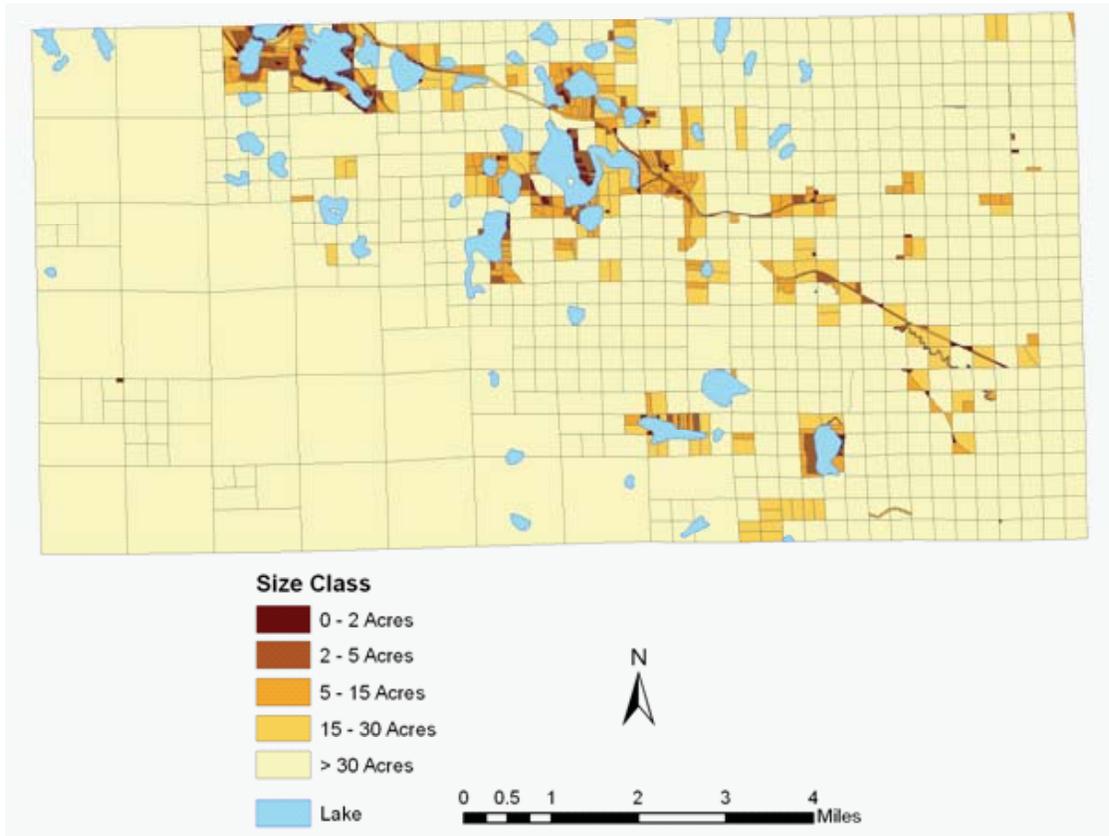
Town of Barnes 2007



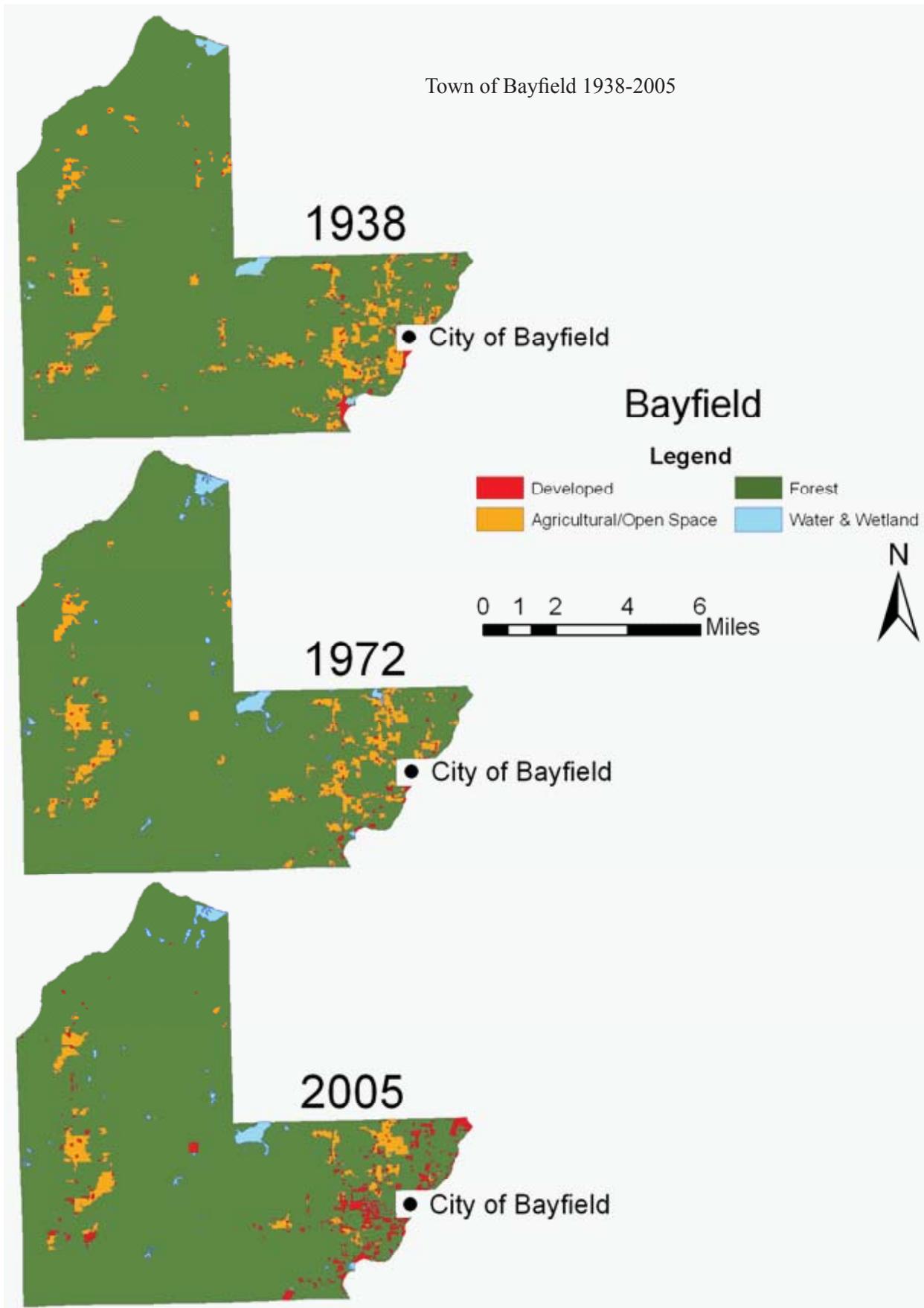
Town of Delta 1954



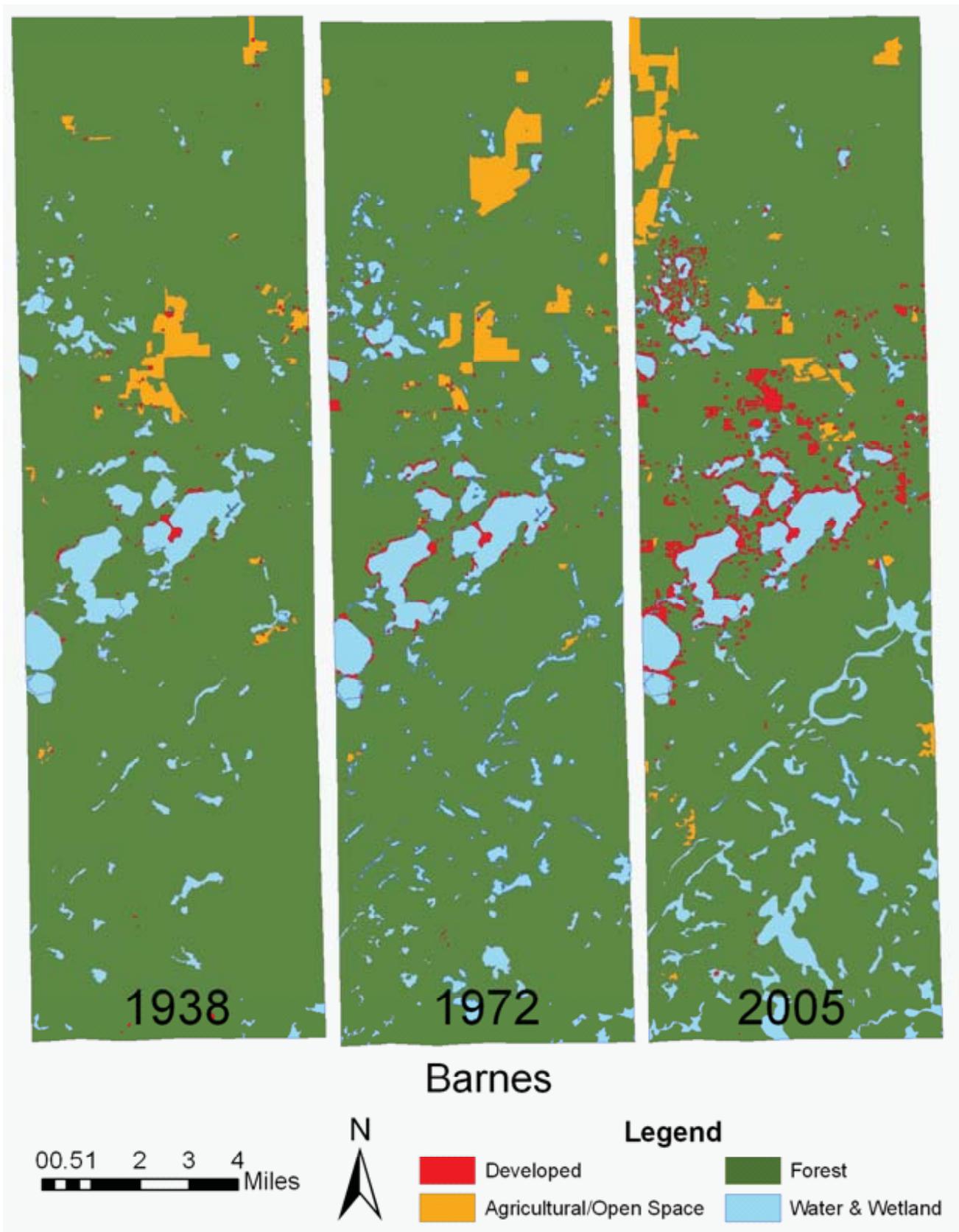
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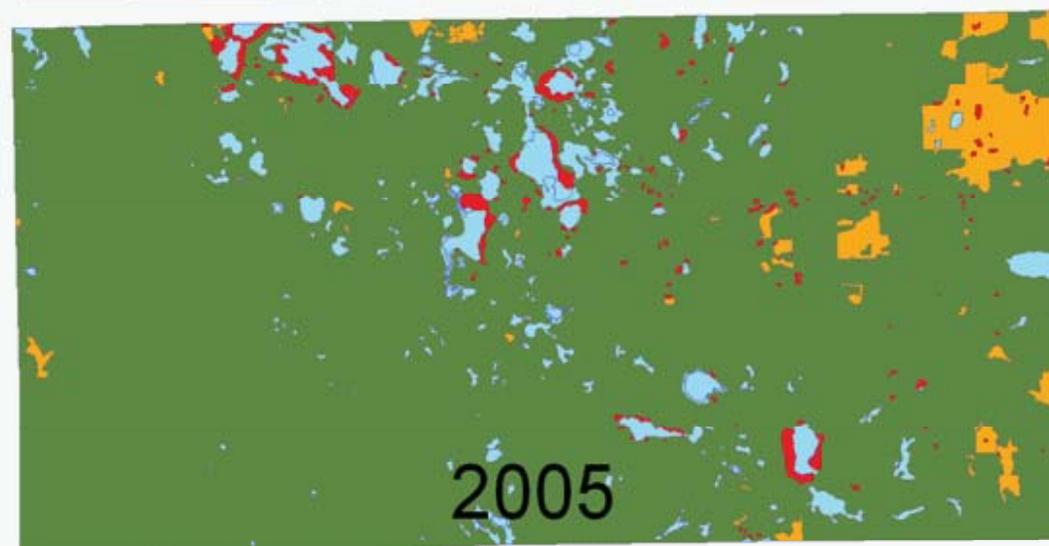
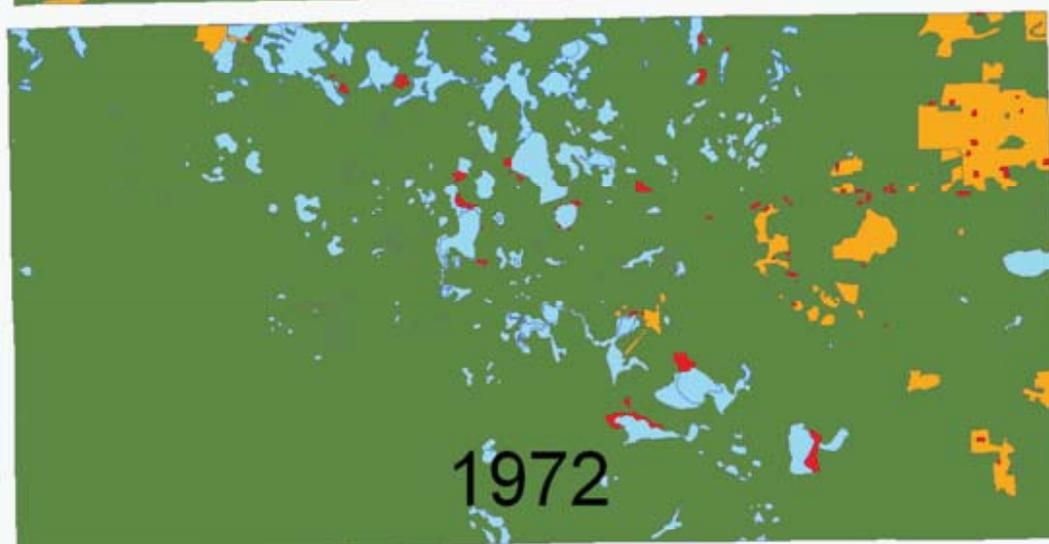
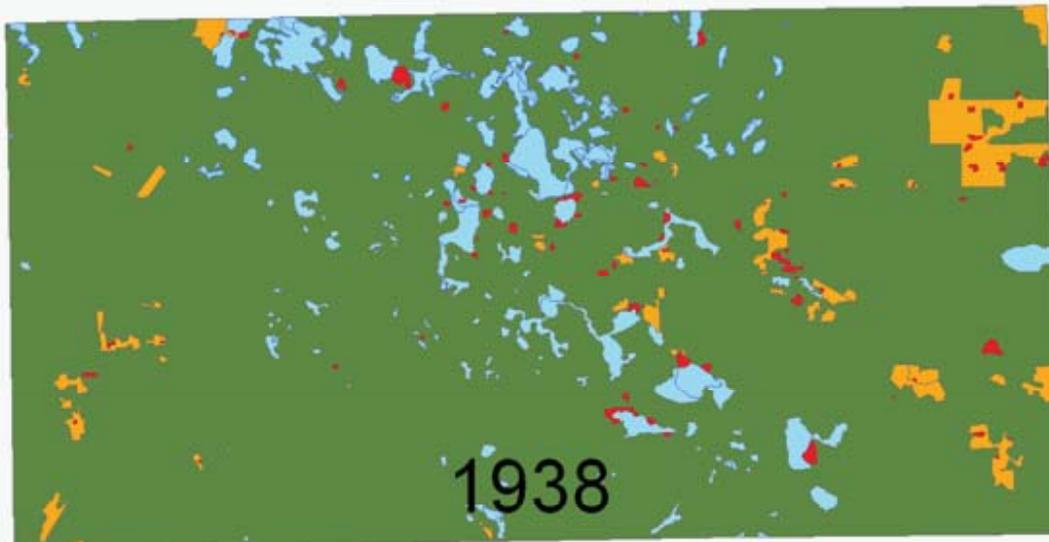
Appendix C Land Use Maps



Town of Barnes 1938-2005



Town of Delta
1938-2005



Delta



Legend

- | | |
|---|---|
|  Developed |  Forest |
|  Agricultural/Open Space |  Water & Wetland |

Appendix D

Township Level Metrics

1954-1960											Parcelization Score
Town	N	NP _{cs} m	AC _{cs} m	UD _{cs} m	NN _{cs} m	PAR _{cs} m	NP _{pl} at	AC _{pl} at	UD _{pl} at	PAR _{pl} at	
Bayfield	10	10	1.82	19,680	4,928	0.031	0	0.00	0	0.000	-6.880
		-1.542	-0.125	1.044	1.776	0.528	-2.049	-1.152	-2.594	-2.767	
Barnes	125	119	2.02	8,106	712	0.023	6	.069	80	0.040	1.781
		0.729	0.027	-0.154	-0.127	-0.066	1.464	0.000	-0.092	0.000	
Delta	37	37	1.92	11,641	834	0.025	0	0.00	0	0.000	-9.384
		-0.979	-0.052	0.212	-0.072	0.069	-2.049	-1.152	-2.594	-2.767	
1961-1967											Parcelization Score
Town	N	NP _{cs} m	AC _{cs} m	UD _{cs} m	NN _{cs} m	PAR _{cs} m	NP _{pl} at	AC _{pl} at	UD _{pl} at	PAR _{pl} at	
Bayfield	24	24	1.43	12,255	2,848	0.039	0	0.00	0	0.000	-8.252
		-1.438	-0.192	0.457	0.909	0.455	-1.775	-1.208	-2.374	-3.086	
Barnes	233	214	1.78	7,548	557	0.029	19	0.59	96	0.042	2.284
		0.938	0.100	-0.104	-0.090	-0.070	1.437	0.025	0.061	-0.012	
Delta	39	39	1.16	10,968	662	0.032	0	0.00	0	0.000	-9.759
		-1.250	-0.429	0.303	-0.044	0.103	-1.775	-1.208	-2.374	-3.086	
1968-1972											Parcelization Score
Town	N	NP _{cs} m	AC _{cs} m	UD _{cs} m	NN _{cs} m	PAR _{cs} m	NP _{pl} at	AC _{pl} at	UD _{pl} at	PAR _{pl} at	
Bayfield	47	47	1.50	6,847	1,488	0.029	0	0.00	0	0.000	-8.776
		-1.014	0.017	-0.177	0.344	0.275	-1.733	-1.493	-2.643	-2.351	
Barnes	855	161	1.49	7,854	539	0.023	694	1.02	5,232	0.024	2.150
		0.737	0.014	-0.037	-0.146	-0.150	1.728	-0.001	0.004	0.000	
Delta	17	17	1.28	13,393	1,653	0.035	0	0.00	0	0.000	-8.047
		-1.475	-0.174	0.734	0.429	0.659	-1.733	-1.493	-2.643	-2.351	
1973-1981											Parcelization Score
Town	N	NP _{cs} m	AC _{cs} m	UD _{cs} m	NN _{cs} m	PAR _{cs} m	NP _{pl} at	AC _{pl} at	UD _{pl} at	PAR _{pl} at	
Bayfield	72	34	2.46	9,033	2,702	0.027	38	1.84	1,558	0.016	1.875
		-1.384	0.350	0.012	1.138	0.523	1.080	0.099	0.283	-0.226	
Barnes	257	250	1.94	8,411	367	0.020	7	1.60	250	0.019	-1.803
		0.847	-0.051	-0.063	-0.168	-0.100	-1.229	-0.251	-1.318	0.531	
Delta	51	51	2.04	11,448	781	0.023	0	0.00	0	0.000	-10.829
		-1.208	0.020	0.302	0.064	0.140	-1.751	-2.643	-1.624	-4.129	

NP = Number of new parcels
 AC = Size of new parcels in acres
 UD = Distance to nearest high-density/urban area in feet
 NN = Distance to nearest new parcel in feet
 PAR = Perimeter to area ratio for new parcels

1982-1991											
Town	N	NPcsm	ACcsm	UDcsm	NNcsm	PARcsm	NPplat	ACplat	UDplat	PARplat	Parcelization Score
Bayfield	133	68	2.49	6,235	1,321	0.018	65	1.79	916	0.016	0.756
		-0.542	-0.022	-0.249	0.098	-0.004	1.496	-0.132	0.017	0.094	
Barnes	87	83	2.49	5,562	823	0.017	4	3.66	471	0.012	-2.018
		-0.303	-0.017	-0.336	-0.057	-0.057	-1.545	2.144	-0.325	-1.521	
Delta	66	66	2.58	13,434	910	0.018	0	0.00	0	0.000	-10.824
		-0.573	0.045	0.680	-0.030	0.076	-1.745	-2.301	-0.687	-6.289	
1992-2001											
Town	N	NPcsm	ACcsm	UDcsm	NNcsm	PARcsm	NPplat	ACplat	UDplat	PARplat	Parcelization Score
Bayfield	186	87	2.34	5,373	602	0.020	99	1.60	916	0.019	0.548
		-0.722	0.024	-0.230	-0.024	0.000	1.421	0.179	0.123	-0.222	
Barnes	151	142	2.33	4,463	568	0.020	9	0.28	76	0.045	-2.753
		-0.082	0.017	-0.318	-0.050	0.010	-1.453	-1.972	-1.351	2.444	
Delta	68	68	2.22	17,692	814	0.020	0	0.00	0	0.000	-7.715
		-0.943	-0.066	0.959	0.133	-0.020	-1.740	-2.427	-1.484	-2.126	
2002-2007											
Town	N	NPcsm	ACcsm	UDcsm	NNcsm	PARcsm	NPplat	ACplat	UDplat	PARplat	Parcelization Score
Bayfield	165	107	2.94	9,262	621	0.018	58	0.88	173	0.032	0.638
		-0.279	0.319	0.206	-0.009	-0.180	0.363	-0.275	0.242	0.253	
Barnes	133	97	2.10	2,786	478	0.023	36	1.60	111	0.019	-1.856
		-0.415	-0.225	-0.390	-0.114	0.125	-0.435	0.471	-0.372	-0.502	
Delta	50	50	2.07	10,460	956	0.023	0	0.00	0	0.000	-6.518
		-1.055	-0.246	0.316	0.238	0.143	-1.741	-1.174	-1.472	-1.527	

NP = Number of new parcels
AC = Size of new parcels in acres
UD = Distance to nearest high-density/urban area in feet
NN = Distance to nearest new parcel in feet
PAR = Perimeter to area ratio for new parcels

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