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A framework for profiling a lake's riparian area development potential

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Abstract

Some of the greatest challenges for managing residential development occur at the interface between the terrestrial and aquatic ecosystems—in a lake's riparian area. Land use planners need a framework they can use to identify development hotspots, areas were the next push for development will most likely occur. Lake riparian development profiles provide a framework for linking ecological and social factors important to development. In a test of this framework in northern Minnesota, researchers identified seven constructs influencing riparian area development: current general development, current housing development, and availability, accessibility, suitability, aesthetics, and proximity to services. Profiles display a lake's value for each construct relative to the range of values for all lakes in the county. Maps, developed using indicators for several constructs, allow us to identify how the factors interact and are dispersed across the landscape. These profiles help policy makers, planners, and managers identify lakes that are potential development hotspots so they can take timely steps to manage development or control the impacts of development.

Keywords: Land use change; Recreational development; Residential development; Riparian development

1. Introduction

The Upper Great Lakes States of Minnesota, Wisconsin, and Michigan are known not only for the large lakes from which they take their names, but also for the thousands of beautiful inland lakes that are scattered across the landscape. While the sky-blue waters provide a host of benefits to people, it is on the land surrounding these lakes where many of the region's land development and land management challenges are found. Each lake is bordered by an area that is the interface between the terrestrial and aquatic ecosystems—the lake's riparian area.

People value riparian areas as source areas for extractive resource use, as destinations for recreation and tourism, as places for reflection and solitude, and as preferred locations for seasonal and permanent residences (Schroeder, 1996; Daulton and Zanski, 1997; Stynes et al., 1997; Anderson et al., 1998; Van Patten, no date). According to regional and national demographic trends, the number of people choosing to live and recreate in riparian areas in the US is increasing (Zinser, 1995). For example, in Minnesota, development along lakeshores rapidly increased between 1967 and 1982 and has continued at a slower, but significant rate since 1982 (Kelly and Stinchfield, 1998). In northern Wisconsin, researchers determined that between 1960 and 1995 shoreline development increased an average of 216%, and that the average amount of lakeshore frontage per dwelling had decreased to accommodate the development pressure (Wisconsin Department of Natural Resources, 1996).

In the Lake States, it generally falls to local units of government to manage development within their jurisdictions. For example, in Wisconsin, the state establishes minimum use and protection standards for floodplains, shorelands, and wetlands, but local governments have the flexibility to plan for and develop their own local ordinances to deal with their unique land use issues and to protect the natural resources that they value most (University of Wisconsin, 2002). Since 1995, Minnesota counties have had the authority to plan for and manage land use. As of July 2002, 71 of Minnesota's 87 counties had adopted comprehensive land use plans (Association of Minnesota Counties, 2002). These plans discuss the current situation in the county as described by governmental, social, economic, cultural, and environmental factors, possible trends in these factors, and establish goals and objectives for how the county can react to and influence these trends.

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Comprehensive land use planning requires that planners and citizens process large amounts of technical information (Susskind, 1981). Models are used in planning to coherently assemble key variables and other technical information (Machlis and McKendry, 1996). Models are also a means to an end—a hypothesis or problem-solving tool to help understand critical land use issues (Starfield, 1997).

The purpose of this study was to develop a model that provides a general framework for understanding a lake's riparian area development potential—the development profile. The profile displays indicators of biophysical and social conditions, or constructs, important in determining whether or not a riparian area is developed. Profiles display indicator values for one lake relative to other lakes in the region. Profiles provide policy makers, planners, and managers with the information they need to identify lakes that are potential development hotspots so they can take timely steps to manage development or control the impacts of that development. The framework may also be applied to other situations where it is useful to compare conditions at one location or entity to a standard set of conditions, such as the development potential at the wildland-urban interface or the potential for different communities to support new services or businesses.

2. Study location

We tested the concept of lake riparian area development profiles using data from Itasca County, Minnesota (Fig. 1). Itasca County has characteristics common to many counties in the Upper Great Lakes States, including a significant area of public land (federal, state, and county land), a retail center (Grand Rapids, Minnesota), and several large lakes.

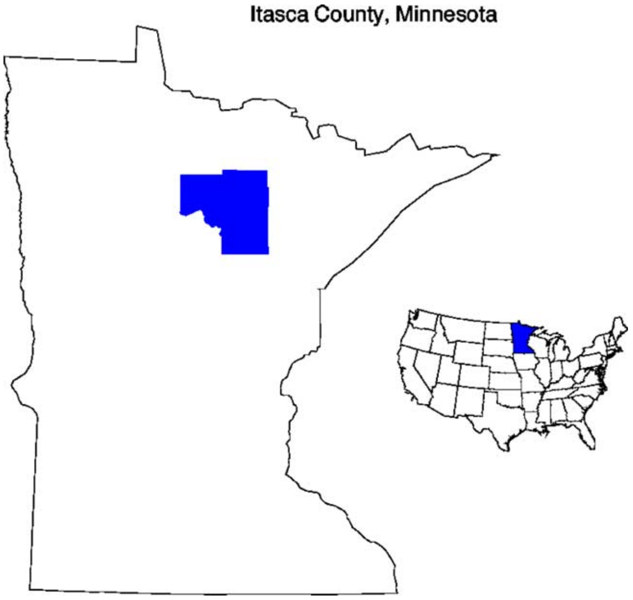

Fig. 1. Location of Itasca County, Minnesota.

Furthermore, Itasca County had several digitized data sets that were valuable in developing profiles.

Itasca County contains approximately 1000 lakes (Biko Associates, Inc. and BRW, Inc., 2000). Since the purpose of the study was to develop a framework to profile potential lake riparian area development, only the lakes most likely to be subjected to development pressure were considered for study. Lakeshore development studies conducted at the University of Minnesota (Borchert et al., 1970) and the Minnesota Department of Natural Resources (Kelly and Stinchfield, 1998) found that lake size affects a person's decision to purchase or build a permanent or seasonal home. Both of the earlier Minnesota studies focused on lakes greater than 145 acres (50 ha) in size as being the most likely for development; therefore, we considered only lakes greater than 145 acres.

There are 164 lakes greater than 145 acres located entirely within Itasca County. The study did not include lakes partially within the county to simplify data collection. Profiles were developed for 44 of these 164 lakes. These 44 lakes were selected because they were included in Itasca County's lake vulnerability study, conducted in 2000 (Itasca Soil and Water Conservation District, personal communication). By selecting lakes identified for study by county officials we enhanced the applicability of this study to land use and natural resource managers and planners in Itasca County.

3. Model

Our goal was to develop profiles to characterize the development potential of a lake's riparian area. Before proceeding, we needed a model for understanding the drivers of riparian area development. There are a number of factors that influence whether or not a particular parcel of land in a riparian area will be developed. In a study conducted for the Minnesota Department of Natural Resources (MDNR), factors such as road access, city proximity, lake size, soil type, and forest cover were found to differentiate the housing desirability of one lake lot from another (Kelly and Stinchfield, 1998). While these characteristics can drive future development, we believe it is important to consider both conditions relevant to future development and the current development level when analyzing development potential because of the interdependence between the two conditions. For example, road access was identified by the MDNR as an important driver of development (Kelly and Stinchfield, 1998). A riparian area with significant current development will already have greater road access than a riparian area that currently has few dwellings or other development. Our lake riparian area development profiles are built to consider both current development and conditions relevant to future development.

The lake riparian area development profiles are based on a model developed by Bengston (1986) to characterize the capacity of research institutions in developing countries. Bengston's approach was to (1) propose a set of constructs that are related to a high level of research capacity; (2) select a corresponding set of indicators used to empirically measure these constructs; and (3) create research capacity profiles displaying the values of the indicators for one institution relative to the values for all institutions. The resulting research capacity profile gauged an institution's strengths and weaknesses not by an absolute standard or optimum, but relative to the norms established by other institutions in countries at a similar level of economic development.

We have adapted Bengston's methodology to create lake riparian area development profiles, highlighting a lake's potential for development relative to other lakes. Adapting Bengston's approach has several advantages. First, this approach encourages us to focus on a few important ecological and social conditions that influence development. When models are developed for a specific use or purpose, such as to aid land use planning, then they should be the simplest and leanest model that will meet that purpose (Starfield, 1997). Using Bengston's concept of profiles also allows us to display values for several important development conditions simultaneously in a graphical format. Graphics are often the most effective way to describe, explore, and summarize the values for a set of variables (Tufte, 1983). Finally, profiles are based on relative values for conditions. Since development will occur first on those lakes with the most favorable conditions for development relative to other lakes, showing relative values for critical development variables helps planners and managers identify lakes with the most development potential—what we will refer to as development hotspots.

Our riparian area development model, including constructs and indicators for profiles, is illustrated in Fig. 2. Current development levels are represented by two constructs: general development and housing development. Riparian area development has historically been defined by human activities that take place in the riparian area. Timber harvesting, mining, livestock grazing, road construction and maintenance, and recreational land uses have been the key human activities found in riparian areas, and have therefore been used to characterize riparian area development (Myers, 1989; Gebhardt et al., 1990; Hanson et al., 1995; Parrish et al., 1996). With our general development construct we account for the historical riparian land uses currently in the area. Because much of the development in northern Minnesota riparian areas is for homes, we also highlight

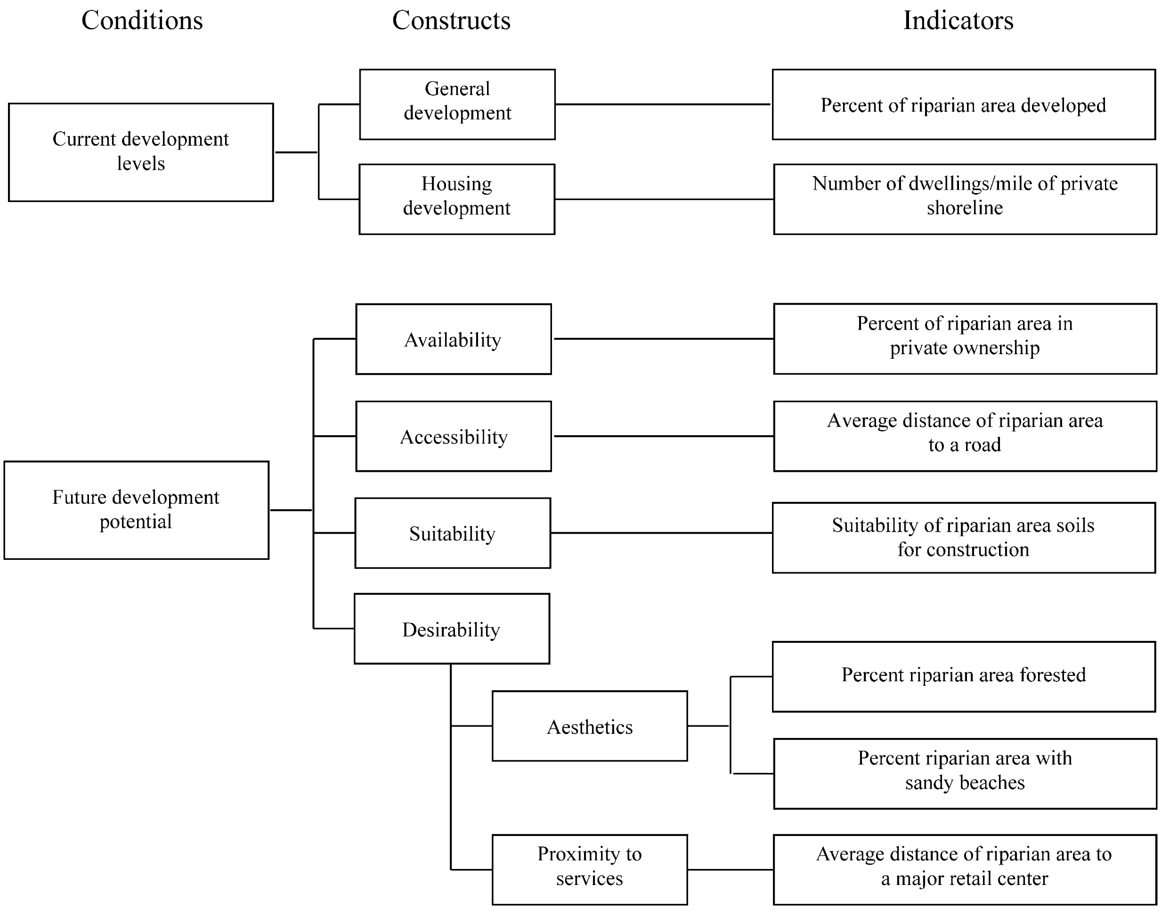

Fig. 2. A model for building lake riparian development profiles linking constructs important to development potential to indicators to measure construct values.

the level of housing currently in the riparian area with a second current development construct, housing development.

Four constructs define future development potential: availability, accessibility, suitability, and desirability. The desirability construct was further broken down into two sub-constructs: aesthetics and proximity to services. These constructs reflect the factors found to be predictors of development in Minnesota (Kelly and Stinchfield, 1998). For example, road access is accounted for in the accessibility construct, soil type in the suitability construct, and forest cover in aesthetics.

Each construct has an indicator—something that can be measured to evaluate a lake's status for that construct. In recent years, criteria and standards for the sustainability of forested lands have received much attention as a result of the 1992 United Nations Conference on Environment and Development and follow-up conferences in Montreal, Canada and Santiago, Chili (Sitarz, 1994; Montreal Process Working Group, 1999). Ellefson et al. (2002) suggest standards that should be used in the development of criteria and indicators of ecological, social, and economic conditions involving forests. These standards guided us in the selection of indicators for the seven constructs. We focused on conditions that are understandable, measurable, and relevant. We also understood that we wanted conditions for which planners would not need to collect new information—conditions where we had secondary data.

4. Defining riparian areas

One of the problems associated with studying riparian areas is defining the area that is riparian. While scientists tend to prefer an ecological-based definition, resource managers try to use a definition that can easily be applied under a variety of field conditions, often a set distance from the high water mark or other point (Hawkins, 1994). Since our study depended on secondary data, much of which would be available and analyzed using geographic information systems (GIS), we used a set distance to define the riparian area to be studied.

The riparian area literature suggests various distances for defining these ecosystems, depending on the characteristic of concern. Stocek (1994) notes that special habitat features for several bird species, coyotes, bobcats, and red fox occur within 100 m of water. He also found that of the 40 species of birds using riparian forests in Iowa, only nine occurred outside of a 90 m buffer from the water. Fitton (1994) defined the riparian zone as the water feature and the adjacent land area extending 200 ft (61 m) from the water feature. He determined that most recreational activities on Crown-land in Canada occurred within this 200 ft riparian zone. Furthermore, Bondrup-Nielsen (1994) summarized the information presented at a riparian zone management symposium and concluded that 'the width of the buffer zones varies among regions and is generally politically determined through legislation' (p. 112).

In Minnesota, various shoreline regulations necessitate the delineation of lake or river riparian areas. A fixed riparian area width is most often used to delineate this area. Itasca County staff (personal communication) suggested that a riparian area boundary width of 300 ft (91 m) would most accurately capture current development and areas most likely to be developed in the future. Because we would be using a 15 m by 15 m grid in ArcView to analyze our data, we assumed that the riparian area extended 90 m beyond the lake boundary.

To determine a lake's riparian area we used digitized data from the Itasca County soil survey. The soil survey data contained the most current and accurate lake boundary delineation. We used ArcView to overlay a 15 m by 15 m grid on the riparian area. We used ARC/INFO (version 7.1) to count the number of cells in the riparian area. We calculated number of acres in the riparian area by multiplying the number of cells by 1/2-acre (0.2 ha).

5. Selecting construct indicators and calculating values

5.1. Current development levels

5.1.1. General development

The MDNR provided data that classify land into five development categories: farmsteads and rural residences, urban/industrial, other rural development, cultivated land, gravel pits and open mines. This data were available in a digitized format for cells 15 m by 15 m. ArcView was used to combine our maps of riparian areas with the MDNR land use data. We calculated the percent of the total riparian area that was developed by dividing the number of cells designated as one of these five land use classes by the total number of riparian area cells.

5.1.2. Housing development

Our indicator of housing development was number of dwellings per mile of privately owned shoreline. In looking at dwelling density we are not interested in how many people occupy these dwellings, just in the density of the existing housing structures.

The first step in calculating lakeshore dwelling density was to determine the total number of seasonal and permanent homes in each lake's riparian area. The Itasca County Land Assessor's Office provided a count of the number of seasonal and permanent dwellings on lakeshore lots for each lake. Second, the digitized Itasca County soil survey and ArcView were used to calculate the total miles of privately owned lakeshore. The total number of homes (seasonal homes plus permanent homes) was divided by the total length of privately owned lakeshore to derive the average number of dwellings per mile of private lakeshore.

5.2. Future development potential

5.2.1. Availability

One of the simplest indicators of whether or not a riparian area lot is available for development is whether the lot is in private ownership. In Minnesota, only one-third of all lakeshore is in private ownership (Minnesota Department of Natural Resources, 1999). According to Minnesota Statutes, most state-owned shoreland areas are not available for sale. However, tax-forfeited parcels can be sold or exchanged. Still, MDNR records show that over the past 150 years the state has retained 90% of tax-forfeited parcels with water frontage (Minnesota Department of Natural Resources, 1999). It is possible that some federal lakeshore could be traded for other parcels deemed more critical to the management of federal lands, however, it would be unusual for such a trade to occur in Itasca County. For these reasons, the indicator used to define availability was the percent of private ownership in the lake's riparian area.

To calculate percent of riparian area in private ownerships, a count was made of 15 m by 15 m cells held in private ownership using ArcView and ownership data from the Minnesota State Planning Agency's Land Management Information Center (LMIC). The percent in private ownership was then calculated by dividing the number of privately owned cells by the total number of cells in the riparian area. Profile values show percent of private ownership.

5.2.2. Accessibility

Accessibility was defined by the average distance of the riparian area to an existing road. The distance to roads rating scheme was based on previous studies conducted by the MDNR (Cohen and Stinchfield, 1984) and the University of Minnesota's Center for Urban and Regional Affairs (Karypis et al., 2000).

For accessibility and several other constructs, we did not directly calculate values to be used in the profiles, but developed scales and assigned point values based on these scales. This method of assigning points assumes that there is a linear relationship between the different construct classes. For example, we assigned cells that are between 1/4 and 1/2 mile of a road four points; twice as many points as we assigned cells between 3/4 and 1 mile (assigned two points). We are assuming that a parcel 1/4 to 1/2 mile distance from a road would be twice as desirable for development as a parcel 3/4 to 1 mile from a road. This assumption could be tested by tracking the sale prices of lots different distances to a road, all other things being equal, but was not done in this study. People with better information on the impacts of different constructs on development potential can assign points that reflect that information.

The accessibility of the riparian area was determined by deriving the average distance from each 15 m by 15 m cell in the riparian area to the nearest road. Each cell was given points (on a scale from 1 to 5) based on how far it is from the nearest road. Cells farther away from existing roads were given fewer points than cells closer to a road. An average distance for the riparian area was calculated by dividing the total distance points by the total number of cells for the riparian area.

5.2.3. Suitability

Soil conditions were used to indicate the suitability of the riparian area for development. ArcView was used to assign points to each cell based on a soil-type rating scheme developed in consultation with a colleague in the Department of Soils, Water and Climate at the University of Minnesota. Each soil survey soil type in Itasca County was assigned points (on a scale from 1 to 4) based on the soil's ability to support the construction of (1) dwellings without basements, (2) septic tank absorption fields, and (3) local roads. Our University of Minnesota soils expert felt that these three types of development would cover most of the concerns associated with residential development in riparian areas. More points were assigned to cells with less severe or no soil limitations than to cells with more severe limitations. Again, we assumed a linear relationship between soil types and impact on development.

5.2.4. Desirability

We defined desirability of an area for development as a function of two sub-constructs: aesthetics and proximity to services, both of which are represented in the profile.

Regarding aesthetics, lakeshore development research reveals that, on average, the highest densities of lakeshore development occur in forested lakeshore areas with sandy shoreline soils (Cohen and Stinchfield, 1984). Our aesthetics construct combines indicators describing vegetation and soils.

The land use data available from the MDNR classifies land by vegetative cover. A 15 m by 15 m cell was counted as forested if the land use classification was mixed forest, coniferous forest, or deciduous forest. The number of forested cells was divided by the total number of cells in the riparian area to determine the percent of the riparian area forested. Riparian areas were awarded points (from 1 to 5) based on the percent of cells classified as forested. More points were given to riparian areas that were more heavily forested.

Each riparian area was also assigned rating points based on the percent of cells with sandy soils. We assumed that riparian areas with sandy soils were most likely to have sandy beaches—a highly valued characteristic for a lake property to have. Our University of Minnesota soils expert suggested that if soil survey data indicated that the first two soil horizons were sandy, then we could assume that there was a high potential for a sandy beach. Riparian areas were awarded points (from 1 to 5) based on the percent of cells that contained sandy soils. More points were given to cells located in riparian areas with a higher percentage of sandy soils.

For the aesthetics points used in the profile, the points for percent riparian area forested and points for percent riparian area with sandy beaches were added together. Aesthetics points ranged between 2 and 10 points. In adding together points for two indicators to describe aesthetics, we are not only assuming linearity for each indicator (as discussed above), but that each indicator is of equal value in defining aesthetics.

Regarding proximity to services, in Itasca County, the growth in permanent housing along lakeshore has been much greater than that for seasonal or vacation housing (Kelly and Stinchfield, 1998). The lake's proximity to a major employment or retail center is a good indicator of the potential demand for that lakeshore for permanent housing. In addition, vacationers seek proximity to retail centers when developing seasonal homes to obtain the goods and services they seek. The major job center in Itasca County is the city of Grand Rapids, Minnesota. Itasca County staff felt that the proximity of a lake to Grand Rapids was an important indicator of future development potential for year round homes.

Grand Rapids is centered around the intersection of US Highway (Hwy) 169 and US Highway 2. The average distance from the riparian area to this intersection was calculated using the same process as that used to calculate the distance to road for accessibility. ArcView was used to calculate the distance from each 15 m by 15 m cell in the riparian area to the intersection of Highway 169 and Highway 2 via the existing road network. The average distance to Grand Rapids was calculated by adding all distances together and then dividing by the total number of 15 m by 15 m cells in each lake's riparian area.

6. Developing profiles

A lake riparian area development profile consists of seven shaded bars, one bar for each of the constructs discussed above. The bars are arranged in two sets—a set of two bars for the two constructs describing the current development level, and a set of five bars describing future development potential constructs. Each bar is displayed within a frame that represents the range of possible values for that construct for all 164 lakes in the study. The frame is divided into quartiles. A quartile is defined by three values that divide the frequency distribution for the indicator into four classes of equal size. Fig. 3 shows the availability construct bar for Balsam Lake in Itasca County. The range of values for availability is from 0 to 100%. The values 45.8, 71.0 and 89.0% define the quartiles. That means that in analyzing the frequency distribution of the values for availability, we found that 25% of the lakes in Itasca County have between 0.0 and 45.8% of their riparian area in private ownership, another 25% have between 45.8 and 71.0% in private ownership, another 25% have between 64.3% and 89.0 in private ownership, and the final 25% have between 89.0 and 100.0% in private ownership. The mean value for availability is 64.3%, and is indicated for each construct by a dashed line. Without knowing actual values, we can quickly see in Fig. 3 that a relatively large percentage of Graves Lake's riparian area is potentially available for development, as defined by the percentage of its riparian area in private ownership. The percent of Balsam Lakes' riparian area in private ownership is greater than more than 75% of all 164 lakes (in value is in the fourth quartile).

For the current development constructs, a tall bar represents a high level of current development. However, when we started working with the future development potential constructs, we were faced with the problem that for some constructs a large value (for example, a high number of suitability points) means that riparian conditions are favorable for development, but for other constructs, a large value (for example a large number representing a far distance from services) means that riparian conditions are less favorable for development. In order to have consistency within a profile, we decided that for all future development potential constructs, the taller the bar, the more positive the conditions for development. So, for some constructs,

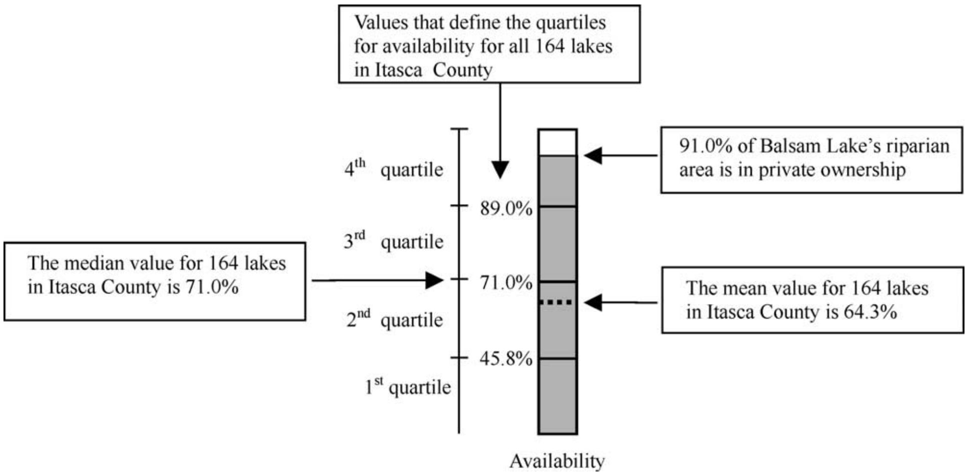

Fig. 3. Interpreting a riparian area development profile, the availability construct for Balsam Lake, Itasca County, Minnesota.

the values represented by the frame in the profile progress from smallest (in the first quartile) to largest (fourth quartile), while for others the values represented by the frame progress from largest (in the first quartile) to smallest (in the fourth quartile). A profile user only needs to know that the taller the shaded bar for a future development potential construct, the greater the potential for development.

7. Findings

We chose two lakes to illustrate information that can be obtained from lake riparian development profiles: Jessie Lake (Fig. 4) and Mud Lake (Fig. 5). These lakes were chosen because their profiles represent a range in values for many constructs.

The two lakes have very different levels of current development within their riparian areas. In Fig. 4 we can see that development in the riparian area around Jessie Lake is relatively high. Jessie Lake has one of the highest levels of current development in the county. Jessie's general development is in the fourth quartile, showing that current general development is greater than more than 75% of the lakes in Itasca County. Jessie Lake also has a significant level of housing development, with one of the highest values for dwellings/mile of private shoreline. The level of current development around Mud Lake is relatively low (Fig. 5). More than half of 164 lakes studied in Itasca County have more general development than Mud Lake, and more than 75% of the lakes have more housing development.

The future development potential Jessie and Mud Lake also differ. Both lakes have a relatively low percentage of their riparian areas in private ownership, which may limit future development (the availability construct). Accessibility of riparian areas does not seem to be a major problem for either lake, relative to other lakes in the county. There is a major difference in other constructs defining future development potential. There appears to be a major problem with the suitability of soils for construction in the riparian area around Jessie Lake (in the first quartile), while soils are very suitable for development around Mud Lake (in the fourth quartile). While the aesthetics in the riparian area around Jessie Lake would appear to be very favorable for development (in the fourth quartile), Mud Lake's aesthetics do not appear to encourage development

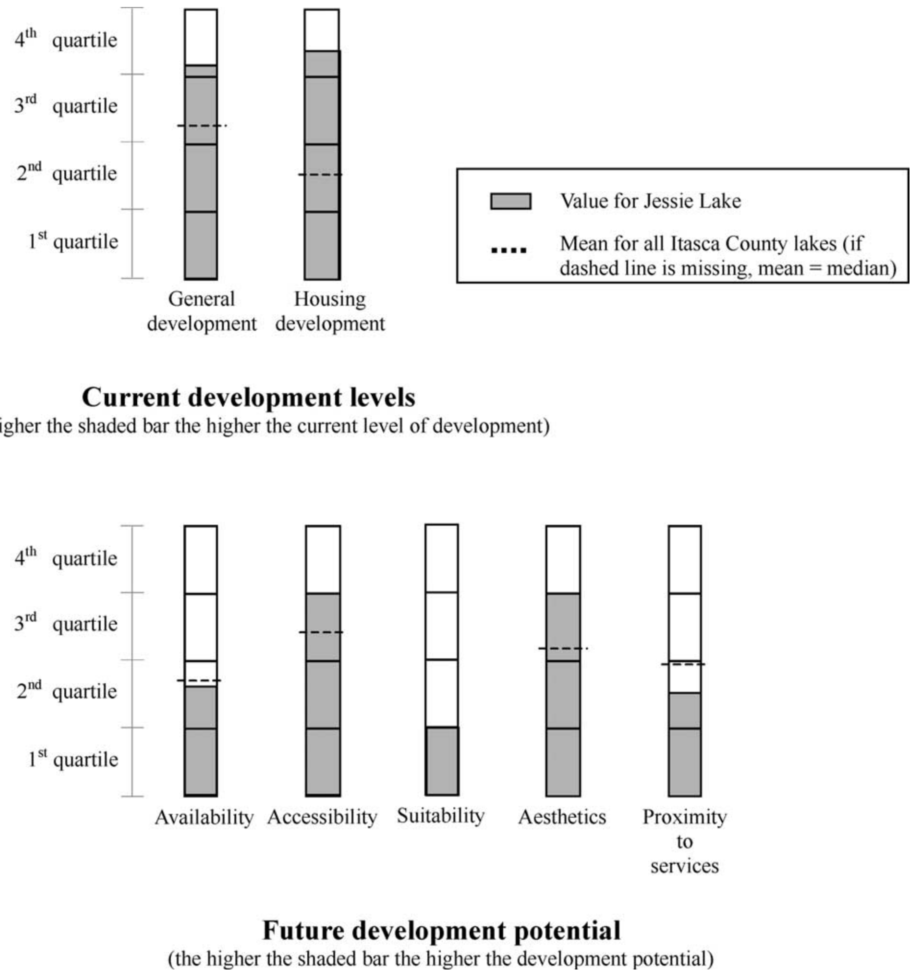

Fig. 4. Lake riparian area development profile for Jessie Lake, Itasca County, Minnesota.

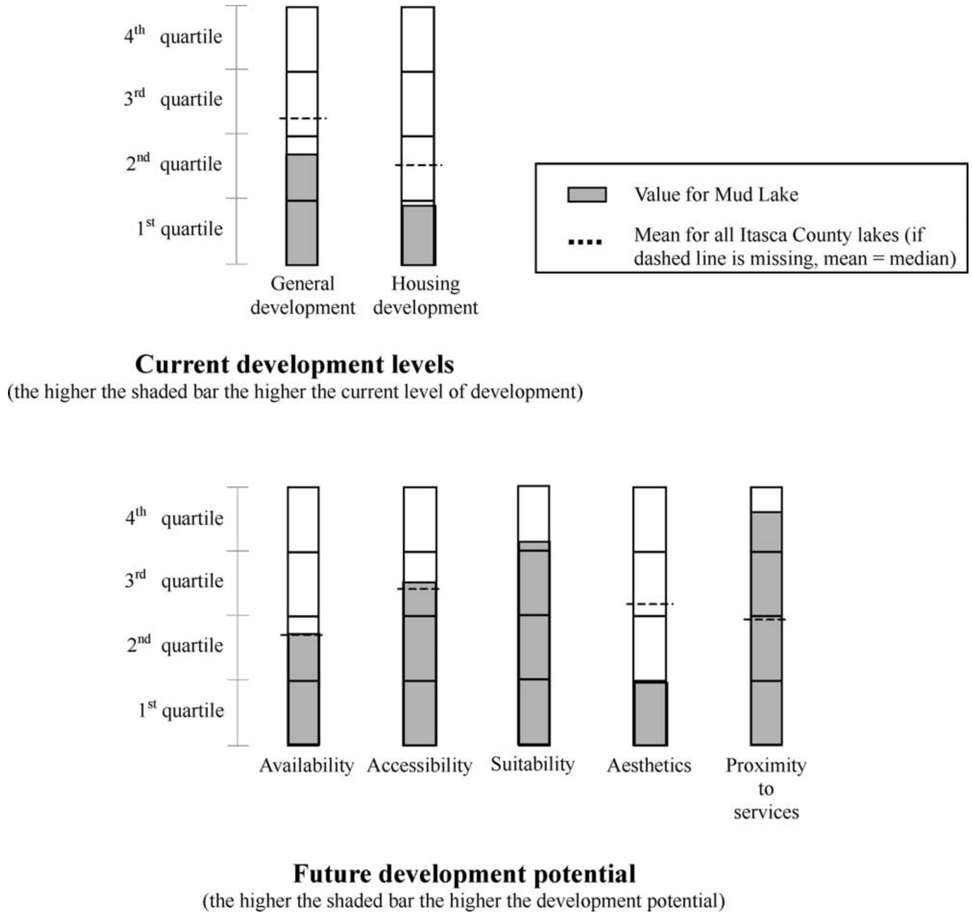

Fig. 5. Lake riparian area development profile for Mud Lake, Itasca County, Minnesota.

(in the first quartile). However, Mud Lake appears to be much closer to the services available in Grand Rapids, MN than Jessie Lake.

These profiles give us a quick snapshot of factors important to development, however, they do not show us how these factors interact or overlap in the landscape. As a supplement to the profiles, we created lake riparian area development potential maps using indicators used in the profile for which we had GIS data. We started with a map of the lake's riparian area (upper left map in Fig. 6). We removed the riparian area in public ownerships, leaving a map showing the location of privately owned land (lower left map in Fig. 6). Next we eliminated cells that are currently developed or classified as wetlands, resulting in a map that shows undeveloped privately owned land (lower right map in Fig. 6). Finally, we take away cells with moderate to severe or severe limitations for development, as defined in the suitability construct (upper right map in Fig. 6). We have created a map that accounts for current development, availability, and suitability. Maps could be further refined depending on the GIS data available. These maps complement the profiles in that they eliminate construct values that limit development and show where in the riparian landscape conditions may be favorable for development.

8. Discussion

The profiling and mapping methods presented in this study allow planners and managers to visually assess several environmental and social variables related to potential riparian area development simultaneously. Obviously a planner would collect far more information than that contained in a profile before making any land use decisions, however, lake riparian development profiles and maps can raise red flags regarding development potential that may be useful in planning. The profiles developed for Itasca County are currently being used in planning efforts by the county and Chippewa National Forest.

Several limitations of using profiles should be addressed. First, concerns about the timeliness and relevance of the data for building lake development profiles need to be assessed. For example, in our study the roads database may not include all of the unpaved roads in Itasca County. This may lead us to assign lower accessibility ratings to a riparian area than actually exist since the distance to the nearest roads would appear greater than it actually is. Our data allowed us to identify as developed only those 15 m by 15 m cells that have a built structure, mown grass, cultivated land (for agricultural purposes), or disturbance from mining activities. A person who owns a 2 ha parcel of land that

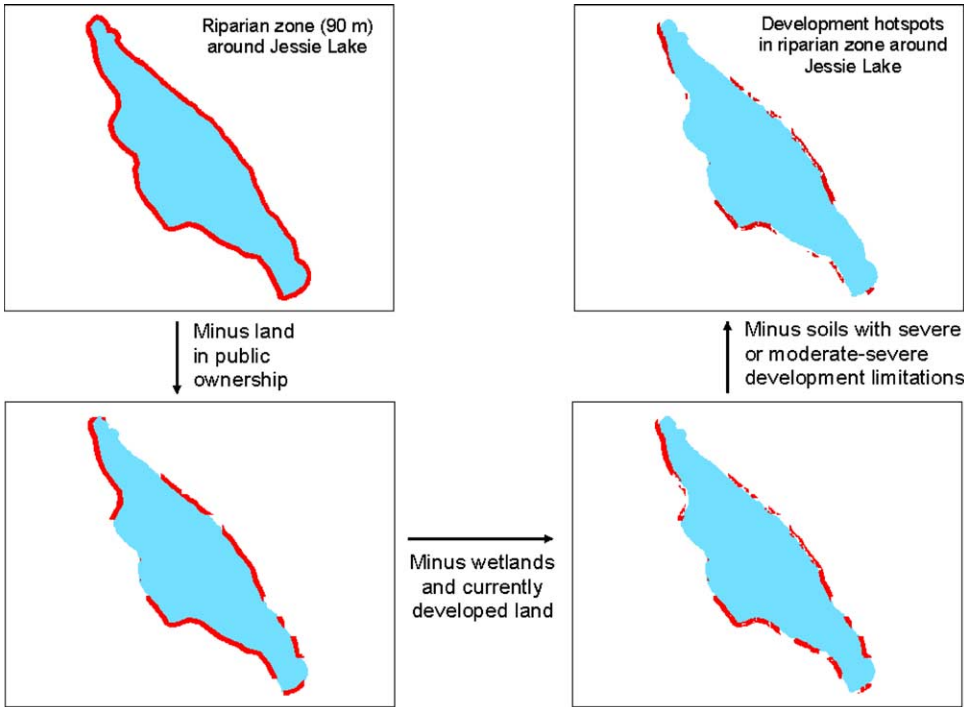

Fig. 6. Mapping riparian area development hot spots using indicators from profiles, Jessie Lake, Itasca County, Minnesota.

contains one dwelling structure may argue that the entire 2 ha parcel is developed and unavailable for future development, but we would classify as developed only that portion of land that meets the criteria mentioned above. Therefore, these development categories may underestimate the current amount of development in a lake's riparian area. Finally, the land use data set we used is 6 years old. However, the age of the data provides other research opportunities—we can return to the region and determine whether lakes we had identify as high potential for development have actually been developed more quickly or to a greater extent than other lakes.

A second limitation is that we may not have captured all of the relevant variables important to lake riparian area development. For example, research shows that water clarity and good fishing are two major reasons people decide to build a seasonal or permanent home on a lake (Kelly and Stinchfield, 1998). Unfortunately, less than half of our study lakes had secchi disk readings that could be used to rate water clarity. Further research could provide alternative measures of water clarity that could be used in profiles. For example, remotely sensed data could prove useful in determining water clarity. In addition, linking water clarity to variables that are readily available for inland lakes, such as lake depth or geologic substrate, would provide another alternative for factors to be included in a lake development profile that indicate lake clarity. Good fishing is a fairly subjective and variable factor, however, water clarity and some nutrient information could serve as indicators of good fishing in a lake development profile.

9. Conclusions

The methods used in this study are aimed at creating planning tools that inform managers, planners, and decision makers about land use and development in lake riparian areas. Having a framework that links current riparian area development with indicators of future development potential is an excellent stepping-stone for addressing the complexities of comprehensive land use planning.

We built our profiles to reflect conditions important to planners and managers in northern Minnesota. If different conditions and factors are important in other regions, the same methodology could be used with new constructs and indicators to illustrate development potential for lakes in those regions. Profiling could also be used to assess situations other than potential riparian area development. For example, profiles could be a useful tool in providing a first look at residential development potential in suburbs or at the urban–wildland interface. They could also be used to display the constructs important to creating a new state park or county campground. Bengston (1986) illustrated how profiles could be used to evaluate research capacity of different institutions, and profiles could be used to evaluate a number of agencies or programs. The most critical consideration in developing profiles is the availability of data for the indicators used to define the constructs.

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