

AN ALTERNATIVE FUTURES ANALYSIS OF FLATHEAD COUNTY,  
MONTANA: EVALUATING TRADEOFFS AMONG ECONOMIC  
GROWTH, LAND USE POLICY AND LAND USE CHANGE

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Doctor of Philosophy

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by  
ANTHONY S. CLARK

Dr. Tony Prato, Dissertation Supervisor

December 2007

The undersigned, appointed by the Dean of the Graduate School, have examined the dissertation entitled

AN ALTERNATIVE FUTURES ANALYSIS OF FLATHEAD COUNTY,  
MONTANA: EVALUATING TRADEOFFS AMONG ECONOMIC GROWTH,  
LAND USE POLICY AND LAND USE CHANGE

Presented by Anthony S. Clark

A candidate for the degree of Doctor of Philosophy

And hereby certify that in their opinion it is worthy of acceptance.

Anthony A. Prato, PhD

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Thomas G. Johnson, PhD

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Christopher L. Fulcher, PhD

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Georgeanne M. Artz, PhD

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Hong S. He, PhD

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Dr. Tony Prato, Dissertation Supervisor

**ABSTRACT**

Growth in total output and jobs and land use change in Flathead County, MT are simulated for nine alternative futures and two study periods using the RECID (Residential and Commercial-Institutional-Industrial Development) model. The alternative futures involve different assumptions regarding future economic growth and land use policy. RECID consists of an economic module and a land use policy module. In the economic module, IMPLAN multipliers and ratios are used to translate low, moderate, and high growth output growth in 11 different economic sectors into job growth, which is then used to project future acreage requirements for residential and commercial-institutional-industrial (CI&I) development.

In the land use policy module, each developable parcel is assigned a development attractiveness score (DAS) based on the parcel's distance from various amenities (e.g., lakes, forests, ski resorts) and disamenities (e.g. railroad tracks, trailer parks, and airports). Current, moderately restrictive, and highly restrictive land use policies are simulated. The DASs are adjusted using transition probabilities, which take into account historical changes in land use cover. Parcels are developed for residential housing units and CI&I units based on the adjusted DASs. The RECID model is employed in conjunction with a Geographic Information System (GIS) to spatially simulate future

land use changes for the nine alternative futures. Results of the study are reported as tabular land use data and GIS-based maps of land use change, and are being incorporated into a web-based decision support tool that will allow stakeholders in the study area to examine tradeoffs associated with the alternative futures. The study has numerous potential applications. In particular, the results can be used to examine water quality, wildlife habitat, housing affordability, and the cost of public services in the county for alternative futures.

# CHAPTER 1. INTRODUCTION

## 1.1. General Issue

Sprawl is becoming an increasing concern for communities across the United States and elsewhere. Results from a March 2001 Gallup poll indicate that 69 percent of American adults are concerned about urban sprawl and the loss of open spaces (PollingReport.com 2006).<sup>1</sup> According to Burchell et al. (2005), “Land in the United States is being consumed at triple the rate of household formation, automobile use is growing twice as fast as the population, and prime agricultural land, forests, and fragile lands encompassing natural habitats are decreasing at comparable reciprocal rates.” Fulton et al. (2001) state that, “[b]etween 1982 and 1997, the amount of urbanized land in the United States increased by 47 percent, from approximately 51 million acres in 1982 to approximately 76 million acres in 1997. During this same period, the nation’s population grew by only 17 percent.”

Many U.S. cities and counties have enacted policies to keep sprawl in check while other communities are only beginning to grapple with the tradeoffs associated with sprawling development. Rapid outward expansion of a given community is typically accompanied by economic growth, and job growth in particular. Although some might argue that sprawl is merely a market outcome that reflects the preferences and incomes of consumers (e.g., Gordon and Richardson 2000), the negative aspects of unchecked

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<sup>1</sup> 35 percent of the survey respondents indicated that they were worried a great deal about urban sprawl and the loss of open spaces while 34 percent said they were worried a fair amount.

development are becoming increasingly apparent to policymakers and citizens alike. The costs of sprawl include both direct costs generated by the creation of the public infrastructure necessary to support sprawling development and indirect costs that take the form of negative environmental/natural resource externalities, along with other consequences that negatively impact quality of life. To cite an example of the latter, a 2003 study by Ewing et al. (2003) found that people in counties with a higher degree of sprawl tend to have a higher body mass index than low-sprawl counties. The study also found higher rates of obesity and hypertension associated with sprawling counties, even when controlling for the amount of walking people do for exercise (Ewing et al. 2003). Similar results were reported in a study of Atlanta, GA by Frank, Andersen and Schmid (2004), which showed that “each additional hour spent in a car per day was associated with a 6 percent increase in the odds of being obese, while each additional kilometer walked per day was associated with a 4.8 percent reduction in the odds of being obese.”

Regarding the environmental consequences of sprawl, Burchell et al. (2005) report that “Each year between 1997 and 2001, more than a million acres of forestland were converted to developed uses...Each year, development disrupts wildlife habitat by claiming millions of acres of wetlands and forests. This loss often results in habitat fragmentation, in which animals are forced to live in smaller areas isolated from other members of their own species and sometimes unable to forage or migrate effectively. Habitat destruction is the main factor threatening 80 percent or more of the species listed under the Endangered Species Act.” In addition to loss of habitat, evidence exists suggesting that sprawl negatively impacts air quality. Frank et al. (2000) found a positive correlation between per capita vehicle miles of travel—which tend to be greater in

sprawling areas—and per capita emissions of oxides of nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOCs). Similarly, a report by Ewing et al. (n.d.) found that ozone pollution levels are as much as 41 parts per billion higher in the most sprawling areas. The study's authors point out that such a discrepancy can mean the difference between meeting federal health standards and violating them. In fact, Ewing et al. (n.d.) contend that the degree of sprawl is more strongly related to the maximum ozone days than it is per capita income or employment levels.

The occurrence of sprawl in a given locality may reflect market realities (e.g., homeowners seeking more desirable housing than what is available closer to the urban core), but evidence also exists suggesting that sprawl may occur at least in part due to government failure. For example, studies have been conducted providing evidence that the local tax structure affects a locality's rate of sprawl, as does the type of infrastructure provided by the local government and the degree of political fragmentation in a given area. Pendall (1999) found that localities whose local governments rely on ad valorem property taxes to fund services and infrastructure tend towards higher rates of sprawl than those that rely on a broader tax base. The rationale for this is that a reliance upon property taxes creates an incentive on government's part to develop lower density, higher value properties than higher density properties that yield a lower per capita tax revenue. Fulton et al. (2001) found that the rate of sprawl is influenced by infrastructure endowments and finance, and specifically that the rate of sprawl is negatively correlated with the endowment of public sewer systems and positively correlated with the endowment of public water systems. Fulton et al. (2001) also verified the work of previous researchers in their finding that the more politically fragmented a region is the greater its rate of

sprawl. In a study indirectly related to sprawl, Galloway and Landis (1986) found that cities are more likely to undertake annexations “when state law places annexation decisions exclusively in the hands of local governments,” and less likely to undertake annexations when state law requires popular approval of annexation proposals.

The question of whether sprawl is a result of government failure or a mere expression of homeowner and developer preferences will not be answered here. Although concern about the potential consequences of sprawl is one of the primary motivations for the current study, sprawl is only one aspect of a broader subject: the study of land use and its change. Over the past few decades increasing attention has been placed on land use change and the substantial role humankind plays in shaping that change (Jobin 2003; Turner et al. 2003). Certain linkages between the way humans use land and the overall state of the biosphere have been well understood since the early 20<sup>th</sup> century. Although those linkages are still being explored, many believe that human actions rather than natural forces are the greatest source of contemporary change in the biosphere (Turner and Meyer 1994; Pickett et al. 2004). Land use change—of the sprawling variety and otherwise—is gaining recognition as one of the major drivers of environmental change (Riebsame and Parton 1994; Petit and Lambin 2002). Land use patterns result in land-cover changes that affect “biodiversity, water and radiation budgets, trace-gas emissions, and other factors that, cumulatively, alter the global climate and biosphere” (Riebsame and Parton 1994). Land use patterns also affect wildland fire spread and other ecological phenomena (Saura and Martinez-Millan 2000). A clearer knowledge of the tradeoffs among various economic growth and land use policies vis-à-vis key environmental

factors would thus be highly beneficial in helping policymakers shape appropriate public policy.

## **1.2. Problem Statement**

Flathead County, located in Northwest Montana, and the Flathead Valley in particular, is an area where residents are beginning to experience some of the tradeoffs associated with rapid growth. Policymakers and concerned citizens have already started to contemplate the county's future. Foremost on the minds of many stakeholders is the question of whether or not the county can support the kind of growth it experienced during the 1990s without incurring serious negative consequences.

Flathead County is an area rich in environmental amenities. The county contains the portion of Glacier National Park west of the continental divide, several ski resorts, and an abundance of lakes and rivers, including Flathead Lake, which is the largest freshwater lake west of the Mississippi River (Flathead County Economic Development Authority). Flathead County has three incorporated cities and several smaller communities. The county grew substantially throughout the decade of the 90s: population in the county increased by 24 percent from 1990 to 2000, compared to 12.9 percent for the state of Montana and 13.1 percent for the nation as a whole (Flathead County Economic Development Authority and U.S. Census Bureau 2000).

The fast pace of economic growth in the Rocky Mountain West, including Flathead County, has created opportunities, but also some problems and potential concerns. According to Citizens for a Better Flathead (2001), 75 percent of the privately owned land in the county is vulnerable to uncontrolled development due to the lack of



adequate guidelines or regulations that: (1) preserve farmland and open space; (2) control development in buffer areas around Glacier National Park; or (3) protect wildlife and riparian corridors along the rivers, streams and lakes.

Prato (2004) notes, “Local residents have expressed concern that Flathead Valley, where most of the growth is occurring, is losing the amenity values that make it an attractive place to live, work, and play. As a result of development, most old growth forests that once existed outside of protected park and wilderness areas have been harvested, rivers have been altered by hydroelectric power development, significant farm and forest acreage has been converted to residential and commercial development, lakes and streams have become polluted by agricultural and urban runoff, fish and wildlife habitat has been degraded, large areas have been invaded by non-native species, and air quality has diminished.”

Different stakeholder groups have different preferences regarding the county’s future, ranging from those with pro-growth, anti-government sentiments who would like to see growth unchecked, to those with pro-environment attitudes who would prefer to see more managed growth. It is unlikely that these various groups would reach consensus on one best overall growth strategy without adequate information regarding the tradeoffs associated with various potential growth policies.

### **1.3. Research Objectives**

This study’s primary objective is to develop an alternative futures analysis (AFA) for Flathead County, MT. Another study is incorporating the results of this study into a web-based decision support tool that stakeholders can use to examine tradeoffs among

various economic growth scenarios and land use policies. The AFA covers two study periods, one focusing on the intermediate term (2004-2014) and one focusing on the longer term (2004-2024). The study has the following objectives:

1. Develop an economic model based on IMPLAN that translates output growth in the county into required acreage for residential and commercial-institutional-industrial (CI&I) development;
2. Identify developable parcels in the county using GIS data and county zoning regulations;
3. Develop a GIS-based land use change model that converts available parcels in the county to developed parcels based on various land use policy assumptions and development attractiveness scores for parcels; and,
4. Interpret the tabular and spatial results in a way that provides direction to users of the web-based decision support tool.

Chapter 2 provides more detail about the study area. Chapter 3 includes a review of the relevant literature on alternative futures analysis and land use change. Chapter 4, the methodology chapter, explains how the alternative futures were developed, including a detailed description of the Residential and Commercial-Institutional-Industrial Development or RECID model. The chapter also discusses the data that were used in the analysis and the sources of the data. Chapter 5 provides a summary of the tabular results of the analysis (map output are included in Appendices D and E). Chapter 6 includes a discussion of the tabular results and the GIS-generated map results. The contribution of

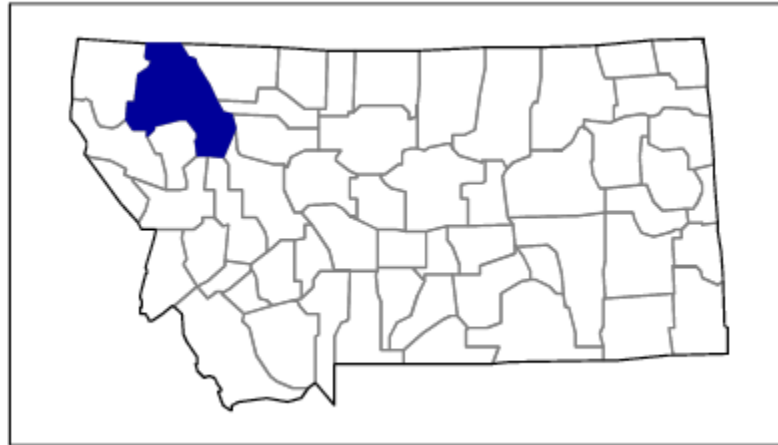
the study, the limitations of the modeling framework, and directions for future research are also discussed in Chapter 6.

## **CHAPTER 2. STUDY AREA**

### **2.1. Land Characteristics**

Located in Montana's northwest corner (see Figure 1), Flathead County is the third largest county in the state, with a landmass encompassing 3,361,230 acres or 5,252 square miles (Montana Natural Resource Information System). Approximately 79 percent of the total land in Flathead County is managed by the federal government, with 59 percent of the county's acreage consisting of national forestland, including portions of four national forests, along with two federal wilderness areas (Montana Natural Resource Information System). The county also contains a portion of Glacier National Park, whose lands comprise 19 percent of county's total area. Other federally managed lands in the county include two national wildlife refuges and five waterfowl production areas (Flathead County Planning and Zoning Office Online 2007a).

The State of Montana owns and manages 129,670 acres in Flathead County. These state-managed areas consist of lands that were granted to the state by the federal government at the time Montana received statehood "for the sole purpose of generating income for support of the common schools and other public institutions" (Montana Department of Natural Resources and Conservation). Under the act which granted the lands, known as the Enabling Act, the state is prohibited from disposing of these lands unless full market value is received for them. In addition to the lands granted the state under the Enabling Act, Montana Fish, Wildlife and Parks manages another 3,208 acres in Flathead County (Flathead County Planning and Zoning Office Online 2007a).



**Figure 1: Location of Flathead County, MT**

The Confederated Salish and Kootenai tribes own approximately 24,315 acres in the county, which comprise a large majority of the Flathead Indian Reservation. Tribal lands in the county are not subject to the jurisdiction of Flathead County Planning and Zoning (Montana Natural Resource Information System).

Together approximately 82.5 percent of Flathead County's total acres are managed by federal, state, or tribal interests and are not subject to the policies of Flathead County Planning and Zoning. Private landowners manage the remaining area, consisting of approximately 587,431 acres. Of these private lands, a considerable portion is used for timber production. Plum Creek Timber Company, F.H. Stoltze Land and Lumber, and Montana Forest Products together account for 310,000 acres, or approximately 52.7 percent of the county's privately owned land. In addition to the three largest timber landowners, many smaller timber companies operate throughout the county, indicating that well over half of the total private land in Flathead County is used for timber production. Although these lands are privately owned, many timber companies in the

county allow public access to their lands (Flathead County Planning and Zoning Office Online 2007a).

Of the remaining private land the largest share is used for agriculture. According to 2002 data, 234,861 acres, or approximately 40 percent of Flathead County's private land, was being utilized for agricultural purposes at that time, with 1,075 individual farms operating throughout the county (USDA 2002). The vast majority of these farms are small hobby farms, with 78 percent being less than 179 acres in size, and more than half of them recording annual sales under \$2,500. Only 98 of the farms were over 500 acres in size, and only 115 farms recorded annual sales over \$50,000. Major crops grown in Flathead County include wheat, barley, flax, alfalfa, grain hays, and silage. Livestock is also a major agricultural commodity in the county. In addition to these major products, several specialty crops are grown in the county, including seed potatoes, mint, lawn sod, canola, mustard, raspberries, strawberries, cherries, grapes and vegetables. As is the case with other fast-growing rural areas, much of the land being converted to residential uses in Flathead County is agricultural (Flathead County Planning and Zoning Office Online 2007a).

Of all of Flathead County's private lands, 392,771 acres are currently unzoned. Most of the 194,660 acres that are zoned are located around or between the county's business centers. An estimated 1,749 acres of these zoned lands are currently zoned for commercial and industrial uses. Since the definition of commercial uses varies among zoning districts, it is difficult to account for the exact number of acres currently devoted to commercial uses (Flathead County Planning and Zoning Office Online 2007a). It should be noted that not all privately owned lands in the county are suitable for

development. In particular, areas that lie within the 100-year floodplain, lands for which the average slope exceeds 30 percent, land under conservation easement, and wetland areas are not considered suitable for development. For the purposes of this study these areas have been identified and removed from the stock of parcels that are considered available for development (see Chapter 4, Section 4.3).

In describing the land that comprises Flathead County, it is important to discuss not just the quantity but also the quality of the land, e.g., the environmental amenities provided by the land. The mountains surrounding the Flathead Valley consist primarily of forestlands managed by the federal and state government. The county features over 40 lakes and three major rivers either wholly surrounded by or adjacent to public lands. The county contains a portion of Flathead Lake, which is the largest freshwater lake west of the Mississippi River (Flathead County Economic Development Authority). Flathead County also features many smaller rivers and streams in addition to many wetlands and riparian corridors. These wetland/riparian areas are vitally important to the county from an ecological standpoint because more than 40 percent of Montana's wild animal population depends on riparian habitats (Flathead County Planning and Zoning Office Online 2007a). According to the Comprehensive Fish and Wildlife Conservation Strategy (2005) prepared by Montana Fish, Wildlife & Parks, roughly one-third of the most threatened species require riparian habitats. In addition to providing vital habitat, wetlands reduce flood and erosion damage by serving as retention areas for overflowing rivers, lakes, and streams. Wetlands also perform the important function of filtering pollutants and removing nutrients from surface runoff before it enters the water bodies.

The mountain forests and meadows, rivers, lakes, valleys, wetland and riparian areas of Flathead County provide habitat for a wide range of mammals, birds, reptiles, amphibians, and fish. Important mammal species in the county include the grizzly and black bear, mountain lion, marten, wolverine, moose, elk, white-tailed and mule deer, gray wolf, lynx, and mountain goat. Two of these—the grizzly bear and the Canada lynx—are threatened species and the gray wolf is currently listed as endangered. The county provides habitat for 310 species of birds, including the bald eagle and the endangered whooping crane; 27 species of fish, three of which (the bull trout, the water howellia, and Spalding's Catchfly) are listed as threatened; 9 species of reptiles; and 9 species of amphibians (Flathead County Planning and Zoning Office Online 2007a). All in all Flathead County's unique combination of environmental attributes, including its rich biodiversity, makes it ideally suited as a study area for an alternate futures analysis, particularly in light of the rapidly changing demographic and economic conditions in the county.

## **2.2. Demographic and Economic Characteristics**

Flathead County, and in particular the Flathead Valley, is one of the fastest growing areas in the Rocky Mountain West. The county's population increased by 25.8 percent from 1990 to 2000, compared to 12.9 percent for the state of Montana and 13.1 percent for the nation as a whole (Flathead County Economic Development Authority and U.S. Census Bureau 2000). Interestingly, the county experienced even greater population growth during the 1970s, with a 32 percent increase in population over that decade; population growth then declined to only a 14 percent increase over the 1980s. It



also bears noting that since 1980 the population of individuals in the 65 and older age group in Flathead County has increased by almost 89 percent (U.S. Census Bureau 2000).

The county's primary population centers are its three incorporated cities: Kalispell, Whitefish, and Columbia Falls. Over the decade of the 1990s, Kalispell grew by 19.4 percent, Whitefish by 15.2 percent, and Columbia Falls by 24.8 percent. Overall, throughout the 1990s, population grew by 19.2 percent in the county's three incorporated cities and by 28.9 percent in the unincorporated areas (U.S. Census Bureau 2000).

Approximately 69 percent of the county's population resides in the unincorporated areas, with 16.1 percent residing in areas identified as Census Designated Places (CDPs). CDPs are unincorporated communities delineated to provide data for settled concentrations of population. Seven communities in Flathead County have been designated as CDPs: Bigfork, Evergreen, Lakeside, Somers, Hungry Horse, Martin City, and Coram. Between 1990 and 2000 Evergreen's population increased by 51.1 percent, Somers' by 75 percent, Lakeside's by 77 percent, and Bigfork's by 83 percent. Several other communities throughout the county not designated CDPs are also experiencing growth. These communities, in which residents are self-reliant with regards to water and sewer facilities, include Marion, Creston, Ferndale, Kila, and West Glacier. Some of the more remote communities, such as Essex, Olney, and Polebridge, are not experiencing the same rapid growth as the rest of the county (U.S. Census Bureau 2000).

As a result of Flathead County's rapid growth, native residents of the county are greatly outnumbered by non-native residents. Approximately 18 percent of the population growth between 2000 and 2004 can be attributed to natural change (the difference between births and deaths), and the remaining 82 percent is due to net migration. Many

of the county's new residents are retirees and middle-aged professionals. The county also experiences a large seasonal fluctuation in population. There is no precise method of calculating seasonal population, but county officials estimate that the county's population increases by 40 percent during the months of June, July and August (Flathead County Planning and Zoning Office Online 2007a).

Flathead County's population growth through the 1990s led to a concomitant increase in employment of nearly 50 percent over the same time period. Employment rose by 57 percent in the service and retail trade sectors, which include occupations such as health care, engineering, and business services. Between 1997 and 2002 alone, the number of employees in health care and social assistance increased by 257 percent (U.S. Census Bureau 1997, 2002). Flathead County's per capita personal income for the year 2000 was \$24,001—80 percent of the national average per capita income (U.S. Department of Commerce 2004). In 2000, Flathead County's total civilian labor force was 37,713, indicating an unemployment rate for that year of 6 percent. Since 2000 the county's unemployment rate has declined; in fact, businesses in the service and retail trade sectors are currently experiencing difficulty finding and retaining dependable employees (Flathead County Planning and Zoning Office Online 2007a). Much of this is likely due to the fact that the average wage per job in Flathead County is significantly below the national average, as well as the fact that only 51 percent of private businesses in the county offer their employees medical benefits. This latter issue undoubtedly stems from the fact that a majority of the county's firms are small businesses, employing four or few workers, and they lack the bargaining power necessary to negotiate suitable premiums with insurance providers.

In the 2005 *State of the Rockies Report Card*, Flathead County was cited as having the most diverse economy of any county in the Rocky Mountain West (Hecox et al. 2005). The economic composition of the county has changed dramatically over the past 20 years as the county has shifted from a natural resource based economy, with logging, mining, and commodities as the key industries, to an economy based much more on the services and retail trade sectors. According to the Flathead County Growth Policy (Flathead County Planning and Zoning Office Online 2007a), “The natural amenities contributing to the character of Flathead County have attracted many small businesses and technology companies that are becoming more prevalent in light of the new knowledge-based, globalized economy...In the service sector, growth during the 90’s has been particularly strong in the sub-sectors that typically offer high-quality jobs: health care, engineering and management services, and business services such as computer programming, data processing, advertising, credit reporting, and printing.”

In 2004, there were 3,986 individual private business firms operating in Flathead County. Of all categories of businesses, construction firms were the most numerous and retail trade firms the second most numerous (Flathead County Planning and Zoning Office Online 2007a). Table 2.1<sup>2</sup> provides a breakdown of the number of firms operating in each economic sector in 2004.

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<sup>2</sup> Source: Flathead County Planning and Zoning Online, 2007a.

**Table 1. Number of Firms per Sector - 2004**

<b>Industry</b>	<b># of establishments</b>
Construction	743
Retail trade	534
Professional and technical services	358
Accommodation and food services	324
Other services	317
Healthcare and social assistance	304
Administrative and waste services	207
Real estate and rental and leasing	205
Finance and Insurance	200
Manufacturing	186
Transportation and warehousing	130
Wholesale trade	121
Arts, entertainment, and recreation	115
Agriculture, forestry, fishing, and hunting	101
Information	76
Educational services	29
Mining	18
Management of companies and enterprises	11
Utilities	9
Total private businesses	<b><u>3,986</u></b>

Of all these firms, 91 percent were very small businesses, employing only 1 to 19 workers. In fact, according to year 2000 data, only 24 firms in Flathead County employed between 100 and 499 workers, and only 3 firms employed 500 or more workers. Some of the county's biggest private employers include Century Tel, Glacier Bank, Plum Creek

Timber Company, Schellinger Construction, and Wal-Mart. The largest single employer in the county is the Kalispell Regional Medical Center, with approximately 1,600 employees (Flathead County Planning and Zoning Office Online 2007a).

In Flathead County, during the 1990s, almost 1,000 new businesses were founded and more than 15,700 new jobs were created (Flathead County Planning and Zoning Office Online 2007a). Clearly the rapid pace of economic growth is the primary driver of land use change in the county. The county's economic growth is certainly related to—and highly correlated with—its population growth, but there is another aspect of the growing Flathead County economy that is driving land use change: that is the burgeoning demand in the county for second homes as well as seasonal, recreational, occasional use and vacation housing. The number of housing units in these aforementioned categories increased by 42 percent during the 1990s, while the number of overall housing units increased by only 29.2 percent in the county. Consequently, during the 1990s the median housing price in Flathead County rose by 116 percent (U.S. Census Bureau 2000). With the number of retirees increasing—particularly the number of affluent retirees seeking major changes in lifestyle and living environment—Flathead County's popularity as a recreational/seasonal destination will only continue to grow. Demand for second or seasonal homes may surge as greater numbers of baby boomers retire. As a result, demand for housing units in the county will increase at a faster rate than the county's population. For this reason population projections alone may not suffice in estimating future housing needs in the county. The particular methodology used in this study to arrive at estimates of future housing is described in Chapter 4, Section 4.4.

The following chapter, Chapter 3, includes a comprehensive survey of previous alternative futures analysis studies, as well as a review of literature related to land use change theory and modeling.

## CHAPTER 3. LITERATURE REVIEW

### 3.1. Alternative Futures Analysis Literature

It could be argued that Thomas Malthus in his famous and widely criticized work *An Essay on the Principle of Population* was the first social scientist to engage in what is today commonly called Alternative Futures Analysis (AFA). AFA, sometimes known as scenario planning, is designed to evaluate several different possible outcomes against one another (Peterson et al. 2003b). AFA is not the same as forecasting, but rather AFA takes into account the fact that there is significant uncertainty regarding the future, particularly when decisions are being made that involve multiple parameters and there is no unique optimal outcome. Also underlying AFA is the viewpoint that no single vision of the future is likely to be accurate or superior to all others, and impacts of future development need to be evaluated for a range of conditions (Steinitz et al. 2003). An EPA summary (Environmental Protection Agency 2002) of a study conducted of the Willamette River Basin in Oregon aptly characterizes AFA as follows:

“Alternative futures analysis is an environmental assessment approach for helping communities make decisions about land and water use. The process helps community members articulate and understand their different viewpoints and priorities. The product is a suite of alternative ‘visions’ for the future that reflects the likely outcomes of the options being advocated. The visions are expressed as maps of land use and land cover. Potential effects of these alternative futures are then evaluated for a wide range of ecological and socio-economic endpoints (i.e., things people care about). By capturing the essential elements of a complex debate in a fairly small number of alternative futures, combined with an

objective evaluation of the consequences of each choice, the alternative futures process can help groups move toward common understanding and possible resolution and collective action.”

The study of the Willamette River Basin is a prototypical AFA. The authors of the study used input from local stakeholders to design three future landscapes, each intended to illustrate the impact of a major policy decision regarding the basin. The three scenarios were: (1) Plan Trend 2050; (2) Development 2050; and (3) Conservation 2050. The first scenario was designed to represent the expected future landscape if current policies were maintained and recent trends continued. The second scenario, Development 2050, was intended to represent the expected future landscape if current policies were relaxed to allow “freer rein to market forces across all components of the landscape, but still within the range of what stakeholders considered plausible” (Environmental Protection Agency 2002). The third scenario, Conservation 2050, was designed to reflect the expected future landscape if local policymakers adopt policies that emphasize ecosystem protection and restoration but that are still considered plausible by stakeholders. Each scenario was projected at 10-year intervals through 2050. Results were used by stakeholders in developing a vision for the basin’s future and a basin-wide restoration strategy (Hulse et al. 2000; Baker et al. 2004).

Steinitz et al. (2003) conducted an AFA of the Upper San Pedro River Basin in Arizona and Sonora, Mexico. Three main scenarios were identified in this study: (1) the Plans scenario, which was based on current plans in Arizona and current population forecasts; (2) the Constrained scenario, which directed future development into currently developed areas and reduced the population forecasts; and (3) the Open scenario, which



removed most constraints on land development and assumed a faster rate of population growth than the forecasts. By further modifying select policies, the authors developed ten different scenarios from the basic three. For the Mexican portion of the study area, two scenarios were created by varying assumptions about population growth and the establishment of a conservation area along the San Pedro River. Land allocation in the various scenarios was accomplished using the development model, a simple Lowry-type model designed to “generate estimates of retail employment, residential population, and land use for sub-acres of a bounded region” (Lowry 1964). In the Steinitz et al. study one commercial/industrial land use category was used along with four residential land use categories. The development model allocated land to the various residential land use categories based on each plot’s relative attractiveness for residential development. The Steinitz et al. development model used 98.5 sq. ft. grid cells as the land unit. Plots of land were scored based on their distance from various amenities and disamenities that were identified as either attractive or unattractive attributes, respectively, by land developers in the area. “For each type of residential development, allocation [was] made to the most attractive locations for that type, with the areas where that type [was] allowed by the zoning pattern and other constraints selected in each scenario” (Steinitz et al. 2003). Demand for land in the commercial/industrial land use category was determined in a fairly simplistic manner: by merely extrapolating the current ratio of commercial/industrial land to all developed land to 2020. A 20-year study period was used in developing the alternative future scenarios, and the land allocation process was repeated for each five-year time period.

Limitations of the Steinitz et al. development model included the fact that future road and infrastructure development in the study area was ignored, as was the impact of growth in areas immediately adjacent to the study area. Also, allocation of residential demand for land among various residential land use categories was determined outside the model, implying that insufficient supply of land in a given residential land use category would result in unmet excess demand. Steinitz conducted studies very similar to the Upper San Pedro River Basin/Sonora study in Pennsylvania (1993) and in California (1997).

Peterson et al. (2003a) conducted an AFA of the Northern Heights Lake District of Wisconsin. This study used two key, though weakly controllable drivers—migration patterns and ecological vulnerability—to define three alternative scenarios to the year 2025. Ecological services differed substantially among the three scenarios. The authors of the study make an excellent point regarding AFA when they state that they do not think any of their scenarios are likely to occur, but that aspects of each may occur (Peterson et al. 2003a).

The Maryland Department of Planning completed an AFA of Maryland's Worcester County and the Coastal Bays, the results of which were published in 2001. The Maryland Coastal Bays study used a growth simulation model to project the "existing landscape into a series of possible future landscapes, each a function of different land use management scenarios" (Maryland Department of Planning 2001). The growth scenarios were generated using population, household, and employment projections, along with other inputs and locational decision rules. New development was estimated "as a function of household demand, existing or hypothetical management choices (e.g., clustering,

transfer of development rights, growth areas, and agricultural land preservation), and other factors that simulate local concerns and policies that may influence the type and locations of future development” (Maryland Department of Planning 2001). The study used 1997 as the base year and made projections to the year 2020. Scenarios in the study were developed in three successive rounds. The scenarios examined included: (1) a Current Zoning Practices scenario; (2) a Sprawl Development scenario, which assumed that most new development occurred on lots two acres or larger; (3) a Concentrated Growth scenario, which assumed higher housing densities in certain zoning districts; (4) a Quality Community Survey 2020 Plan scenario, which used housing densities that were concomitant with a targeted “desirable” outcome; (5) a New Town scenario, which assumed that all new growth occurred in a single new town whose location was predetermined; and (6) a Directed Growth scenario, which was similar to the New Town scenario except that it concentrated growth in a particular target study area. Although projected future land use was the focal point of the Maryland Coastal Bays study, the study also included an analysis of nonpoint source pollution for each future scenario (Maryland Department of Planning 2001).

Wilhere et al. (2006) developed a GIS-based AFA for the Chico Creek Watershed in Washington State, patterned after the previously mentioned studies by Steinitz et al. The three alternative futures, selected by local citizens and county planners, were Planned Trend, Moderate, and Conservation. The study created artificial landscapes for the three alternative futures and projected the spatial distribution of vegetation type and wildlife habitat for nine local species.

Clearly there is no one proper technique for producing alternative futures in an AFA study. Some AFA studies have used statistical or other modeling techniques to project various future scenarios, while in other studies the scenarios have been generated primarily or solely by varying assumptions regarding future population growth, government policies, locational decisions, etc. One common thread among contemporary AFA studies is the involvement of stakeholders in identifying key assumptions used in developing the alternative future scenarios. However, it is apparent from a review of the literature that the degree of stakeholder involvement in shaping the alternative futures varies significantly across studies. Another common thread among contemporary AFA studies is that they all utilize a GIS in developing and communicating the results of the alternative futures. The current study also utilizes stakeholder input and a GIS-based land use change model to develop the alternative futures, as described in Chapter 4.

### **3.2. Land Use Change Literature**

The early classical economists recognized land as a crucial economic resource, largely as it related to agricultural production. Later, the neoclassical economists focused primarily on the economic resources of capital and labor. For a significant period of time, much of the economic literature ignored land in the production process, either subsuming land as part of the general resource “capital,” or assuming production occurs in a kind of non-space in which land is simply not an element.

In more recent decades there has been an increasing recognition of the importance of studying land, and the role human beings play in shaping the land. Much of this inquiry has focused on the patterns of land use (i.e., the causes and processes of land use

change). Theories addressing land use change have been offered by such diverse fields as economics, urban and regional science, sociology, political economy, social physics, environmental history, environmental/cultural anthropology, environmental psychology, biology, ecology, and geography (Briassoulis 2000). To varying degrees, each discipline offers useful insights into the processes of land use change from its own epistemological point of view, but to date there does not exist a single unifying theory that integrates the important insights from all relevant disciplines (e.g., Verburg et al. 2002).

### **3.2.1. Theories of Land Use Change**

This survey of theories of land use change draws heavily on the comprehensive work of Briassoulis (2000) in her West Virginia University, Regional Research Institute web publication *Analysis of Land Use Change: Theoretical and Modeling Approaches*. In her treatise, Briassoulis delineates three broad categories of land use change theories: urban and regional economics (and regional science) theories, sociological and political economy theories, and nature-society theories. Within each of these broad categories, the theories are further classified based on more focused criteria. This review will focus on the first category, as these theories are the most relevant to the proposed study.

Theories in the urban and regional economics category are distinguished by their reliance on traditional neo-classical economic assumptions. The theories in this tradition can be further subdivided into microeconomic-based theories, macroeconomic-based theories, and regional science theories. Microeconomic theories begin with individual consumer behavior and then aggregate over the behavior of all consumers to yield land use patterns that result when utility is being maximized for all consumers (typically,

maximization of profits or minimization of cost or distance, subject to some constraint). Macroeconomic theories of land use change employ aggregate concepts, measures and forms of behavior, indicating how aggregate patterns may be produced. The theories from the field of regional science utilize concepts from both economics and sociology, and are included in the urban and regional economics category due to their emphasis on economic factors (Briassoulis 2000).

### **3.2.1.1. Microeconomic Theories of Land Use Change**

The three main microeconomic theoretical thrusts relating to land use change include agricultural land rent theory, urban land market theory, and agent-based theories of urban and regional spatial structure.

The agricultural land rent theory was first developed in 1826 by the German estate owner J.H. von Thunen. It was von Thunen's intent to find the most economical distribution of rural land uses around a market town using the basic concept of land rent, which is defined as "the price for the use of a piece of land" (Hoover and Giarratani 1984) or, equivalently, as "the price of the services yielded by land during a specific time period" (Romanos 1976). In von Thunen's framework, the land uses analyzed were various types of agricultural land and forest land. Land, it was assumed, was a uniform flat plain of equal fertility, and movement was considered possible in all directions around a market or town center. Since land was assumed to be uniform, the only factor which caused land rent to vary was the distance from the town center, with a negative relationship between the level of rent and the distance from the center (i.e., as the

distance from the town center declines, rent per acre increases). This feature of von Thunen's approach has come to be known as the monocentric city assumption.

In addition to the land uniformity and monocentric city assumptions, the agricultural land rent theory assumes that a given crop type has the same delivered price and unit transport cost regardless of its location or rent. The theory also assumes that land use intensity and yield per acre are fixed for each crop type, and that markets are perfectly competitive. Each crop type, including forest products, has a rent curve which is represented as rent bid per acre plotted against distance from the town center. Although the rent curves for all crop types rise as the distance to the center decreases, they vary in slopes (i.e., how quickly they rise and fall in relation to the town center). The slope of the rent curve for each crop type, or rent gradient, is determined by the value of the products produced per acre of land, which determines the highest rent a land user can afford. Thus, the land use with the highest output per acre in monetary terms has the steepest rent gradient, and, by outbidding the other land uses, will locate closest to the town center. The next highest bidder occupies the next closest location to the center, and so on until each land use or crop type occupies a zone concomitant with the value of its output. The land use pattern that results from this process is a set of concentric rings around the town center, with each ring representing a crop type. In von Thunen's framework, changes in land use may occur with changes in demand or exogenous changes in relative crop prices or in transport costs. Such changes alter the amount land users will bid for particular locations, thus resulting in changes in a region's overall land use pattern (Romanos 1976; Hoover and Giarratani 1984).

Alonso's urban land market theory, first presented in 1964, was a refinement of von Thunen's seminal theory of land use. Alonso's theory utilizes some of the same assumptions as von Thunen's framework, such as a monocentric, flat, uniform urban area. However, the urban land market theory focuses on households and firms as the decision-making units rather than just farmers, with the primary focus on residential location. In Alonso's framework, the market center is the central business district (CBD), where households work and shop. A household's utility is based on its consumption of three goods or categories of goods: housing; distance from the city center; and all other goods. The household maximizes its utility subject to its budget constraint, and its preferences determine the tradeoffs it is willing to make among the three available goods. The price of housing and the price of commuting depend on the distance from the CBD. The farther a household is located from the CBD, the higher are its commuting costs and the less it is able to spend on housing. Thus, the bid rent curves are downward-sloping with the steepness of a particular curve's slope determined by the commuting costs and the household's demand for space. A household or firm with a greater preference for accessibility will have a steeper bid rent curve, reflecting higher commuting costs and/or lower demand for space. Flatter curves reflect lower commuting costs and/or greater demand for space (i.e., preference for more outlying locations) (Alonso 1964).

The urban land market theory uses a two-stage approach to the residential location process. In the first stage, individual equilibria are derived for households based on their bid rent curves. Assuming households have perfect knowledge of the actual land rent structure, each household or household group then chooses a location that maximizes its utility subject to its budget constraint. In the second stage, the equilibrium for the entire



market is determined using a market clearing mechanism—a bidding process much like von Thunen’s—that starts from the CBD and works its way toward the outlying land parcels. A land use pattern similar to von Thunen’s is derived, with the highest bidders getting the parcels closer to the CBD and the lowest bidders located farther out on the edges. The obvious difference in von Thunen’s resulting land use pattern and Alonso’s is that von Thunen’s concentric circles are identified by crop type while Alonso’s are identified by groupings of households with similar utility-maximizing decisions regarding housing location. As with von Thunen’s theory, the mechanism of land use change is implicit in Alonso’s framework. Changes in income, relative prices, or preferences would lead to changes in the distribution of households throughout the study area, although such changes may only involve a shuffling of households from one concentric ring to another, and not any actual change in land use or land cover (Alonso 1964). It should be noted that Alonso’s theory appears to address commercial/industrial land use in an offhand way, as an aside to residential land use, although the theory could be adapted to explicitly address firm-maximizing behavior.

The last category of microeconomic theories of land use change includes agent-based theories of urban and regional spatial structure. This group of theories focuses on the interactions among agents operating in urban contexts and how those interactions influence spatial patterns. Briassoulis (2000) points out that most of these theories are indirect theories of land use change, as they do not always treat land use explicitly: “The agent-based theoretical approaches differ from the micro-economic approach of the urban land rent theory in that they stress particular features of these agents which relate to their linkages and interactions in space; broadly speaking, they take into account the market

structure of the urban setting.” The theories, which generally assume that agents interact in markets, attempt to explain the clustering or dispersion of land uses observed in the real world; clustering of certain activities being attributed to centripetal forces, such as economies of scale, agglomeration economies, and vertical linkages among agents (e.g., buyers of goods and services linked in a particular location to sellers); and dispersion of certain activities being attributed to centrifugal forces, such as negative externalities, diseconomies of scale, competition among land use activities for markets and/or inputs, transportation costs to the sources of inputs or to markets, etc. The resulting land use patterns may be monocentric, polycentric, dispersed, linear, etc. The primary point of the agent-based theories is that decisions of agents are influenced by past locational decisions; thus, future location decisions are endogenously determined, affected largely by changes in the centripetal and centrifugal forces mentioned above.

### **3.2.1.2. Macroeconomic Theories of Land Use Change**

Macroeconomic theories of land use change can be distinguished as either spatial or aspatial theories, aspatial theories concerned with the amount of land used for a given activity but not its location. Spatial economic equilibrium theory is the application of welfare economics to a spatially disaggregated economy. In the spatial economic equilibrium theoretical framework, all the common neoclassical assumptions hold, such as perfectly competitive markets, perfect information, and easy market entry. Preferences are commonly assumed to be uniform, and assumptions are made about the distribution of population, resources, and accessibility. Optimal solutions to the welfare maximizing problem satisfy the Pareto-efficiency criterion. The spatial economic equilibrium theory is typically used at higher levels of spatial analysis (e.g., regional, national, international).

The theory is not a direct theory of land use as it treats land and land use at very high levels of abstraction, reduced to points and spatial patterns that follow basic geometric shapes (Andersson and Kuenne 1986).

The aspatial economic theories include regional disequilibrium theories, such as Myrdal's cumulative causation theory (Myrdal 1957) and Perroux's growth pole theory (Perroux 1955; Boudeville 1966), along with the group of Keynesian development theories. This latter group includes the Harrod-Domar models, the export-base model, the factor-export models, neoclassical multiregional growth analysis, and various versions of input-output models (Cooke 1983; Hoover and Giarratani 1984; Andersson and Kuenne 1986; Bennet and Hordijk 1986). Although regional disequilibrium theories provide a mechanism of land use change—regional imbalances leading to predictable patterns of regional growth—they lack rigorous explanatory power in terms of predicting actual patterns of land use change. The group of theories in the Keynesian development framework is purely aspatial, and cannot be used to directly analyze land use change patterns. They can, however, provide directions for the changes in macroeconomic determinants of land use change, such as incomes, investments, consumption, imports, and exports (Briassoulis 2000).

### **3.2.1.3. Other Regional Science Theories**

In addition to the microeconomic and macroeconomic approaches to land use change, two other streams of research in the regional sciences are pertinent to land use change: social physics and urban and regional mathematical ecology.

Social physics, which dates back to 1858, utilizes concepts from physics to study social phenomenon and provides the theoretical basis for the gravity model. The gravity model, in one typical expression, models the relative bond between two locations based on the population of those locations and the distance between them. The model has been used to examine such factors as migration and transportation patterns (Briassoulis 2000).

Another analogy from physics used in the study of social urban spatial structure and growth is the concept of fractal growth and fractal structures. The fractal growth framework involves comparing the process and pattern of urban growth to the growth of organisms or particles, which leads to certain, predictable fractal patterns (e.g., White and Engelen 1993). The broader theoretical framework of fractal analysis is the basis for the cellular automata models. It should be noted that, although the social physics approaches have been criticized for lack of grounding in economic or sociological theories, the gravity and entropy models have been verified in several empirical applications (Briassoulis 2000).

Urban and regional mathematical ecology combines concepts from ecology and from the Chicago School of Human Ecology, and applies theories from mathematics (e.g., Nijkamp and Reggiani 1998). According to Briassoulis (2000), under this approach,

“[c]ities and population residing in cities are paralleled to animal species in nature whose interactions are governed by symbiotic, predatory, competitive, and other types of ecological relationships. These parallels are transferred to land uses which are seen as appearing in certain places and growing while other land uses in other locations shrink in size or disappear... Urban and Regional Mathematical Ecology addresses the issue of dynamic, non-linear interdependencies, stability, smooth and abrupt evolutionary change, and multiple equilibria of spatial phenomena

and it aims at providing an appropriate basis for modeling these phenomena...The basic point with respect to this theoretical stream is that it focuses on aggregate form, behavior, and processes and does not deal with land use explicitly.”

Additionally, Briassoulis points out that, as with the social physics approach, urban and regional mathematical ecology lacks economic or sociological theoretical foundations even though it can satisfactorily describe observed urban and regional phenomena. It should also be noted that the approach does not deal with land use explicitly.

A host of “non-economic” land use theories exist that issue from a variety of fields, including sociology, anthropology, psychology, political science, and environmental history. Although the macroeconomic and non-economic theories were considered during the development of the model that is used in this study to simulate future land use changes, none of these theories were explicitly represented in the model. This is because many of these theories are simply too impractical to be of use in a functional model of land use change. In theory, the Residential and Commercial-Institutional-Industrial Development model (RECID) rests primarily on the microeconomic theories of land use change because economic agents are asked to assign weights to the attributes of parcels that reflect their preferences for those attributes, and the weights are used to calculate utility scores for parcels of land. The latter are used to determine the order of parcel development. In this respect, RECID assumes that economic agents attempt to make land development decisions that maximize their utility. However, due to the fact that the model does not employ data regarding land or housing prices or an explicit equilibrium mechanism, some might argue that the RECID model

lacks solid grounding in economic theory. Many functional models of land use change have been criticized on similar grounds. The limitations of the current study are discussed in further detail in Chapter 6, Section 6.3.

### **3.2.2. Models of Land Use Change**

The RECID model follows a parallel methodology to several other existing land use change models. It employs input-output analysis, Markovian transition probabilities, and a GIS to simulate both the extent and location of future development.

Land use change models employing Leontief-type input-output analysis include Hubacek and Sun's (2001) model of land use change in China. The purpose of a basic I-O model is to predict the levels of output, value added, and employment associated with a given increase in final demands. Hubacek and Sun (2001) give a rationale for extending the basic I-O framework to analyze land use change: "In order for the final demand of a given sector to expand, the output of other sectors must expand as well, corresponding to the input requirements of the given sector. As all economic activities consume space, in the long-run, in order to achieve significant increases in output, there must be increases or changes in land use or land productivity." The model developers establish a linkage between output and land use by employing a land requirement matrix and a land distribution matrix. I-O analysis is used in a more traditional fashion in the RECID model, although there are other ways to expand the I-O portion of the RECID model.

Several land use change models utilize transition probabilities, including models by Berry et al. (1996), Bockstael (1996), Wood et al. (1997), and Jenerette and Wu (2001). In particular, Wood et al. (1997) describe a land cover change model for southern

Senegal that provides many useful insights regarding Markovian transition probabilities. They observe that “Markov models have substantial scientific appeal. They are mathematically compact, easily developed from observed data and serve as an effective tool for simulation exercises.” In a first order Markov process, the probability that the system will be in a given state at time  $t_2$  is deduced from its state at time  $t_1$ . The probability of such a transition is based solely on the state at time  $t_1$ ; the history before time  $t_1$  plays no role in the future. According to Wood et al. (1997):

“A Markov process is formally described by the transition probability function  $P(t|x, t_0)$  which represents the conditional probability that the state of the system will be  $x$  at time  $t$ , given that at time  $t_0 (< t)$  the system is in state  $x$ . So the transition probability matrix describes the specific character of the system where the elements of the matrix are the individual transition probabilities of one state moving to another state after one time or space increment...A transition probability ( $p_{ij}$ ) is then the probability that the class  $x$  will be in state  $j$  at time  $t + 1$  given it was in state  $i$  and time  $t$ .

$$P_{ij}^{t+1} = \Pr[x_{t+1} = j | x_t = i]$$

Transition probabilities are calculated based on the frequency distribution of the observations...[a] frequency table is developed where a count is made of the transition from one state to another over the specified increment...When completed the frequency table in each row is summed and the values in each matrix element or transition state are divided by the row sums to compute the transition probability values. In each row, the transition probability values should sum to 1.0. The diagonal of the transition probability represent the self-replacement probabilities...When each of the row totals are divided by the total number of transitions the marginal probability for each row or class is obtained. The individual marginal probabilities indicate the relative proportion of each state/class at the starting point.”

A Markov model assumes that the transition process is not independent, or in other words that there is some memory from one time period to the next, but only from

the last state. Wood et al. (1997) test the proposition of independence in their model and find that indeed the process is Markovian (i.e., not independent). They do not however provide evidence that the stationarity condition is met, which is a prerequisite for using a Markov process. Wood et al.'s model is purely probabilistic and apparently has no drivers of land use change. It only gives the probabilities of one land class being converted to another, but does not predict how much land is converted for each class. Wood et al. nonetheless contribute to the literature in that they rigorously demonstrate non-independence of the land conversion process, and develop a useful spatial Markov approach.

More so than any other tool or technique, geographic information systems (GIS) have revolutionized land use change modeling. Over the past several years, numerous models have been developed that utilize GIS tools and databases. Campbell et al. (1992) developed a multiple objective linear programming model whose purpose was to match the expected demand for agricultural products with the ability of the agricultural sector to meet that demand, taking into account the study area's endowment of natural resources and the land suitability. In Campbell's model, the inputs were obtained from a GIS database. The optimal crop allocations in the study area were mapped using the GIS following a rule-based procedure and using expert knowledge. Pontius et al. (2001) developed a GIS-based model to simulate land use change in Costa Rica. Their GEOMOD2 model extrapolates the known pattern of land use over a given time period using digital raster maps of biogeophysical attributes (Pontius et al. 2001). The International Institute for Applied Systems Analysis (IIASA) Land Use Change (LUC) model is a highly complex modeling system that simulates a regional economy using the



concepts of welfare analysis and competitive equilibrium (IIASA n.d.). The model utilizes a GIS to achieve a spatial representation of the economic system. Spatial data employed in the model include physical, geographical and environmental characteristics and information regarding the endowments of the region's economic agents (i.e., commodity endowments available for trade). Exogenous factors, such as changes in technology or consumer preferences, are defined by the user.

Landis's (1995) California Urban Futures (CUF) model for the San Francisco Bay area was considered groundbreaking when it was developed because it was the first large-scale metropolitan simulation model to use a GIS for data integration and spatial analysis rather than just map display. Like the RECID model, the CUF model allows stakeholders to create and compare alternative land use policies. The alternative policies in the CUF model include: (1) a baseline or business as usual scenario, which assumes existing growth policies; (2) a maximum environmental protection scenario which assumes stringent environmental protection policies; and (3) a compact cities scenario, which assumes a region-wide adoption of policies promoting compact and contiguous development forms. Several limitations of the CUF model are also limitations of the RECID model, namely:

- excess demand does not feed back into housing prices or land costs;
- the model is not required to reach any sort of equilibrium; and,
- because the model does not deal explicitly with travel times or costs, the model is not a spatial-interaction model.

Despite these limitations, the CUF model was an improvement over other urban simulation models because: (1) it incorporated a GIS to assemble, manage, and display

millions of pieces of data describing land development potential; (2) it recognized land developers and homebuilders as the primary actors in determining the pattern of new development; and (3) it incorporated realistic local development policies and policy options into the growth forecasting process (Landis 1995). The RECID model developed in this study shares these same positive attributes.

Other models of land use change that warrant mentioning include the California Urban and Biodiversity Analysis Model (CURBA), the Growth Simulation Model (GSM), What if?, the SLEUTH model, UrbanSim, and NELUP (Natural Environment Research Council [NERC]-Economic and Social Research Council [ESRC]: ERC/ESRC Land Use Programme (U.S. EPA 2000).

The CURBA model is “a distant cousin of the second generation of the California Urban Futures Model” (Landis et al. n.d.). According to the model’s authors, the CURBA model was intended to help bridge the gap between urban land use planners and conservationists and wildlife ecologists. The CURBA model features a statistical model of urban growth, a process for simulating the effects of alternative development and conservation patterns on urban growth, and spatially explicit map and data layers detailing habitat types and other environmental factors (Landis et al. n.d.). The model began with only urban/nonurban land use categories, but has since been updated to include 10 density classes (Jones 2005). The GSM utilizes land use plans and management programs to determine the capacity for additional development. Probability of land conversion is based on factors such as distance from highways, retail services, schools, and undeveloped land. The distribution of growth in the study area is then based

on the capacity for development, probability of conversion, and area-specific information on recent development trends (U.S. EPA 2000).

What if? has been used to model land use change in three Ohio counties. It determines land suitability by applying user-defined weights and ratings of land use criteria, projects future growth of various categories of land use for up to four future time periods, and allocates the predicted land uses to the landscape based upon land use suitability, demand, infrastructure, and land use plans and controls (Jones 2005).

The SLEUTH (slope, land use, urban extent, transportation, hillshade) model, developed by the U.S. Geological Survey and researchers at the University of California, Santa Barbara, “captures urban patterns through the application of four types of urban land-use change: spontaneous growth, new spreading center growth, edge growth, and road-influenced growth. These four growth types are applied sequentially during each growth cycle, or year, and are controlled through the interactions of five growth coefficients: dispersion; breed; spread; road gravity; and slope” (Woods Hole Research Center). The SLEUTH model has been used to model urbanization in several metropolitan areas, including San Francisco and Santa Barbara, and in the Chesapeake Bay watershed (Jones 2005). It bears noting that the SLEUTH model “does not explicitly address population, policies, and economic impacts on land use change except in terms of growth around roads” (U.S. EPA 2000).

The UrbanSim model has been used to project future land use in Puget Sound, Honolulu, Hawaii, the Greater Wasatch Front area (Salt Lake City, Utah), and Eugene-Springfield, Oregon (U.S. EPA 2000). UrbanSim is designed to emulate the interaction of the many agents making decisions in urban markets for land, housing, non-residential

space, and transportation. The model requires several forms of exogenous input, such as population and employment estimates, land use plans, density constraints, environmental constraints, etc. (Center for Urban Simulation and Policy Analysis). UrbanSim may be used to examine alternative scenarios, but it is not a spatially explicit model of land use change.

The NELUP model has been used to project patterns of agricultural and forest lands under various scenarios in the River Tyne catchment in northern England. The NELUP model uses land cover data to link socioeconomic data with an ecological sub-model. Using inputs such as soils, weather, input/output farm data, parish census data, species, and land cover, NELUP explicitly models “the choices of farmers, while the actions of others are taken into account through technology or policy constraints” (Agarwal et al. 2002).

Of all the models of land use change reviewed here, the Land-Use Change Analysis System (LUCAS) advanced by Berry et al. (1996) appears most similar to the RECID model in design and purpose.<sup>3</sup> LUCAS involves a transition probability matrix and a GIS, and the output of its landscape change module is used to analyze ecological effects in the study region. LUCAS has three modules: (1) the socio-economic module, which implements the socio-economic models that are used to calculate transition probabilities associated with land cover changes; (2) the landscape-change module, which uses the input from the first module and produces a map of land cover that reflects the socio-economic changes in the study region; and (3) the impacts module, which uses the maps produced by the second module to analyze impacts to select resource-supply

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<sup>3</sup> In addition, the Steinitz et al. (2003) development model provided the basis for the parcel conversion methodology employed in RECID.

and environmental variables (Berry et al. 1996). Each grid cell in each map is assigned to a discrete land cover category, such as forest, unvegetated, etc. The maps are overlaid to form a composite map with the categories from each data layer represented as a string of characters called a landscape label condition. Additionally, each grid cell, or pixel, has its own landscape label condition. Transition probabilities are derived from empirical data using time series analysis of changes in land cover. After transition probabilities are calculated for each grid cell, a random number is chosen from a uniform distribution between 0 and 1. According to Berry et al. (1996), “If the random number falls within an interval associated with a transition probability to a different land cover, the grid cell is changed; otherwise, the grid cell remains in its present land cover.” The process is repeated for each grid cell in the study region to produce a new map of land cover for each five-year time step (Berry et al. 1996).

Although the RECID model shares many common attributes with existing models of land use change, to the author’s knowledge it is the first to use development attractiveness scores based on spatial attributes adjusted (using transition probabilities) for historical changes in land use cover, and the first spatially explicit land use change model to utilize IMPLAN as a basis for employment projections. Based on comments from representatives of the Montana Department of Environmental Quality, it is also believed that RECID is the first land use change simulation model developed for any portion of the state of Montana. Chapter 4 provides a detailed description of the methodology underlying the RECID model and the AFA for Flathead County.

## **CHAPTER 4. METHODOLOGY**

### **4.1. Developing the Alternative Futures**

Traditional economic models focus on optimizing some objective function with respect to one or more variables, subject to a set of constraints. Such models assume there is a clear objective to optimize and that the functions are identifiable and tractable. In analyzing land use change, there is typically a myriad of objectives, many of them conflicting, and many restraints or other factors that are difficult to quantify, particularly when ecological variables are part of the analysis. Since markets typically do not exist for ecological services, traditional economic analysis by itself often falls short of providing an adequate framework for analyzing land use policy decisions. For these reasons Alternative Futures Analysis (AFA) was chosen as the basic analytical framework for this study. Too many uncertainties exist regarding the future of Flathead County. Ordinary statistical forecasting could provide policymakers some guidance. However, due to the nature of the county's growth and development in recent years, one may easily envision policy changes occurring in the county that would render the forecasts wholly inaccurate. The purpose of an AFA study is to allow policymakers and stakeholders to examine a broad range of policy options and the expected impacts of those policies. As such, AFA is not an ordinary forecasting technique even though it does involve projecting various variables into the future. Also, AFA is not the same as hypothesis testing since the models employed in such studies are simulation models. In an AFA the absolute answers—the projected variables—are not the primary concern. The real usefulness of an

AFA is that it demonstrates the impacts of various policy options *relative to* other possible policy options. Most scenarios in an AFA involve modifying more than one policy, so a typical scenario in an AFA represents a future outcome given a particular suite of related or concomitant policies.

In this study, an AFA framework is used to examine several possible versions of the future with respect to land development in Flathead County, both the quantity of land developed in each development category and the location of the land developed. Stakeholders in the study area participated in the model building process by assisting in the development of nine alternative futures, which were modeled to cover a broad range of combinations of economic growth and land use policies. The stakeholder group, known as the Flathead Landscape Analysis Group (FLAG), used a consensus approach to develop the growth rates used in the alternative futures (see Appendix A for a list of FLAG members). A set of alternative futures was developed for each of two time intervals: 2004-2014 and 2004-2024<sup>4</sup>.

The alternative scenarios were generated using the Residential and Commercial-Institutional-Industrial Development (RECID) model. The RECID model assumes that the primary driver of land use change is economic growth, which leads to job growth and increasing amounts of land developed for residential and commercial-institutional-industrial (CI&I) uses. The alternative scenarios were generated with the model by assuming different rates of economic growth, and different land use policies, over the two study periods. The shorter study period, 2004-2014, examines the impact of economic growth and land use policy decisions in the intermediate term; the longer study period,

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<sup>4</sup> The year 2000 was chosen as the base year for economic projections due to the limited availability of IMPLAN data.

2004-2024, examines the long-run impact of county growth and land use decisions. Study periods longer than 20 years were not considered because 20-year periods are often used in planning studies, and improvement and financing plans for infrastructure are commonly done in 20-year phases (Steinitz et al. 2003). Shorter time-steps were considered, but ultimately not used in this study due to the added computational complexity that would be involved. It is conceivable that future versions of the RECID model may be modified to project future scenarios in five-year or even one-year time-steps.

Results from the RECID model take the form of numerical values (e.g., acreage required for new development, number of housing units required, etc.) and spatial display (i.e., map output showing location and type of future development).

Table 2 outlines the nine alternative futures.

**Table 2. Nine Alternative Futures for Flathead County**

Economic growth scenarios	Land use policy scenarios		
	Baseline	Moderately restrictive	Highly restrictive
High	1. High growth, baseline policies	2. High growth, moderately restrictive policies	3. High growth, highly restrictive policies
Moderate	4. Moderate growth, baseline policies	5. Moderate growth, moderately restrictive policies	6. Moderate growth, highly restrictive policies
Low	7. Low growth, baseline policies	8. Low growth, moderately restrictive policies	9. Low growth, highly restrictive policies



The alternative futures for Flathead County were patterned after alternative futures that were generated in a scenario analysis for the Willamette River Basin in Oregon (Hulse et al. 2000; Baker et al. 2004).

#### **4.2. Land Use Policies**

In developing the AFA analysis, three land use policy scenarios were identified: baseline (current), moderately restrictive, and highly restrictive. Land use policies in the alternative futures were specified in terms of:

- densities for home types (urban, exurban, agricultural, etc.);
- setbacks of new homes and commercial structures from water bodies;
- restrictions regarding new residential development and new commercial-institutional-industrial (CI&I) development in relation to environmentally sensitive areas; and
- assumed expansion of sewer infrastructure.

The following setbacks of residential and CI&I parcels from water bodies were used: 20ft for the baseline policy<sup>5</sup>, 35ft for the moderately restrictive policy, and 50ft for the highly restrictive policy. Parcels and portions of parcels within the setbacks for a particular land use policy were removed from consideration for development under that policy (Prato et al. 2007a).

Environmentally sensitive areas are defined as those areas that lie within a 1-mile buffer around national, state, and county parks, and wildlife refuges. The baseline policy allowed for housing units from all density classes to be constructed in environmentally

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<sup>5</sup> Setbacks from water bodies for the baseline land use policy were based on current restrictions (Flathead County Lake and Lakeshore Protection Regulations, Flathead County Planning and Zoning Office Online 2007c).

sensitive areas. The moderately restrictive land use policy restricted development in environmentally sensitive areas to housing units in the urban, suburban, rural, exurban, and agricultural density classes. The highly restrictive land use policy allowed only housing units in the suburban, rural, exurban, and agricultural density classes to be constructed in environmentally sensitive areas. All three policies prohibited new CI&I development in environmentally sensitive areas (Prato et al. 2007a). Table 3 summarizes how the three land use policies treat development in environmentally sensitive areas.

**Table 3. Allowable Development in Environmentally Sensitive Areas by Land Use Policy**

<b>Housing/Development type</b>	<b>Land use policy</b>		
	Baseline	Moderately restrictive	Highly restrictive
High density	Allowed	Not Allowed	Not Allowed
Urban	Allowed	Allowed	Not Allowed
Suburban	Allowed	Allowed	Allowed
Rural	Allowed	Allowed	Allowed
Exurban	Allowed	Allowed	Allowed
Agricultural	Allowed	Allowed	Allowed
CI&I	Not Allowed	Not Allowed	Not Allowed

Certain types of development were also restricted based on accessibility to current or projected sewer facilities. Sewer facilities were assumed to be available within the growth boundaries of the county's three incorporated cities (Columbia Falls, Kalispell, and Whitefish), and within the current boundaries of the unincorporated communities (Bigfork, Evergreen, Hungry Horse, and Lakeside). Only CI&I, high density, urban, and suburban development were permitted on sewer-accessible parcels. Rural, exurban, and agricultural residential development were permitted on all available parcels, regardless of sewer accessibility.

In addition to specifying certain restrictions on residential and CI&I development, the land use policies were used to dictate housing densities for the various categories of residential development. Six density classes were used for residential housing: high density, urban, suburban, rural, exurban, and agricultural. The percentages of new housing units developed in each of the above density classes were varied based on the three land use policies. The assumed percentages are detailed below in Section 4.4

### **4.3. Developable Parcels**

Before parcels were evaluated in terms of relative attractiveness, the set of developable parcels (DP) were identified. DP consists of the entire set of parcels in the county less:

- parcels that are publicly owned
- parcels that lie within the 100-year floodplain
- parcels that are currently under conservation easement
- parcels that are already developed

- parcels that do not qualify for development based on the county's slope restrictions

Parcels identified as already developed were those containing occupied CI&I or urban units (condominiums and townhouses), any parcel with an area of 1 acre or less with an existing dwelling or mobile housing unit, any parcel categorized as "centrally assessed" or "exempt." "Centrally assessed" parcels are owned by utility companies and "exempt" parcels include land owned by churches, schools, water districts, fire departments, hospitals, park boards, airports, fraternal organizations, humanitarian organizations, housing authorities, cemeteries, fairgrounds, and land that is co-owned with the government. Regarding the county's slope restrictions, in general, to be developed, a lot must have an average slope that is less than 30 percent (Flathead County Planning and Zoning Office Online 2007b). More stringent slope restrictions apply to the West Valley area; however, to make the model more tractable and because zoning regulations are malleable over time, a 30 percent restriction was assumed for the entire county.

In addition to the parcels in the above-listed categories, other parcels were removed from DP for water body setbacks (as detailed previously in Section 4.2 of this chapter), resulting in three versions of DP, one for each land use policy. After all the undevelopable parcels were removed, there were 29,214 parcels in the baseline DP, comprising 531,362 total acres. The average size of a developable parcel in the baseline DP is 18.2 acres. Of all the parcels in the baseline DP, 10,940 were identified as crop/grassland land cover type; 12,983 parcels were identified as forest; 4,879 parcels

were classified as urban; and 412 parcels were identified as water land cover type.<sup>6</sup> Table 4 summarizes the number of parcels and total developable acres in the three versions of DP.

**Table 4. Acres and Parcels in DP by Land Use Policy**

	Baseline	Moderately restrictive	Highly restrictive
Total acres	531,362	521,768	504,053
Total parcels	29,214	29,035	28,205
Avg. parcel size (acres)	18.19	17.97	17.87

Appendix B contains maps depicting the set of developable parcels for each of the three land use policy scenarios. Appendix C contains a 2005 map of land use in Flathead County.

#### **4.4. Job Growth and Housing Requirements**

The RECID model framework assumes that all land use changes are caused by changes in residential and commercial development spawned by economic growth. The primary driver of land use change in the RECID model is employment (i.e., changes in the number of new workers in the county), which is driven by growth in output. Rates of economic growth were specified for each of 11 major sectors by a subgroup of FLAG. For each major sector, FLAG defined a low, moderate, and high yearly rates of output growth for the two study periods. The consensus growth rates selected by the group were

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<sup>6</sup> The water parcels were assigned the land cover class “water” based on remote sensing. Based on the parcel data, the property types for those parcels include: vacant land rural, agricultural rural, residential rural, and vacant land urban.

determined based on the historical rate of growth in output for each of the 11 major sectors and knowledge of local economic conditions. The historical rate of growth was the percentage change in IMPLAN (Minnesota IMPLAN Group, Inc.) output between 1990 and 2000.<sup>7</sup> Average yearly historical growth rates for each of the major sectors were considered by FLAG in reaching consensus on future low, moderate, and high yearly growth rates for the each of the 11 major sectors. Tables 5 and 6 provide the projected consensus rates of economic growth for the 11 major sectors for the two study periods.

**Table 5. High, Moderate, and Low Consensus Growth Rates by Sector for Flathead County, MT, 2000-2014**

Sector	Annual average percentage growth rate		
	<i>High</i>	<i>Moderate</i>	<i>Low</i>
Farming and ranching	0.25	0.22	0.15
Agricultural, forestry, and fishery	0.09	-0.14	-0.32
Mining	16	12	8
Construction	11	8	5
Manufacturing (including forest products)	7	5	3
Transportation, communications, and public utilities	4	2	0
Finance, insurance, and real estate	10	8	6
Services	11	9	7
Government	10	8	5
Wholesale trade	9	5	3
Retail trade	9	5	3
Annual average growth rate <sup>a</sup>	8.78	6.26	3.91

a. Weighted average of sector growth rates using market shares in 2000 as weights.

<sup>7</sup> IMPLAN is short for Impact Analysis for Planning.

**Table 6. High, Moderate, and Low Consensus Growth Rates by Sector for Flathead County, MT, 2014-2024**

Sector	Annual average percentage growth rate		
	<i>High</i>	<i>Moderate</i>	<i>Low</i>
Farming and ranching	0.13	0.11	0.08
Agricultural, forestry, and fishery	-0.05	-0.07	-0.16
Mining	8	6	4
Construction	5.5	4	2.5
Manufacturing (including forest products)	3.5	2.5	1.5
Transportation, communications, and public utilities	2	1	0
Finance, insurance, and real estate	5	4	3
Services	5.5	4.5	3.5
Government	5	4	2.5
Wholesale trade	4.5	2.5	1.5
Retail trade	4.5	2.5	1.5
Annual average growth rate <sup>a</sup>	4.39	3.13	1.95

a. Weighted average of sector growth rates using market shares in 2000 as weights.

The growth rates for 2014-2024 are one-half the growth rates for the 2000-2014 period.

The assumption underlying this procedure is that the rate of economic growth will eventually slow in the county. Flathead County contains 182 IMPLAN sectors that were aggregated into the 11 major sectors listed above to simplify the task of FLAG in reaching consensus on a set of growth rates for each sector, and to enable more concise reporting of the model's results.

Appendix D provides a detailed scheme that shows how the 182 IMPLAN sectors were aggregated into the 11 major sectors listed above. It should be stressed that the

aggregated sectors were used only for defining certain inputs and for reporting results. Output multipliers and increases in employment calculated using IMPLAN were applied on a disaggregated basis in order to avoid aggregation error.<sup>8</sup> FLAG's yearly projected growth rates were applied separately for each of the 182 IMPLAN sectors in the study area to obtain projected output for each sector.<sup>9</sup> In this manner, output for each sector was projected for 2014 and 2024. For each of the 182 sectors, projected output was multiplied by an employment-to-output ratio for that sector to arrive at an estimated increase in employment.

Because of the importance of reliable job growth estimates, steps were taken to attenuate one of IMPLAN's larger weaknesses; the assumption that technology remains constant over the study periods. In particular, employment-to-output ratios, calculated using IMPLAN data, were scaled down to account for increases in productivity over the study periods. Productivity increases were obtained from the Bureau of Labor Statistics' projected increases in output per worker from 2002 to 2012 by sector (Berman 2004). The BLS projects total jobs and total domestic output—adjusted for inflation using chain-weighted dollars. These projections were combined to obtain projected output per worker, which was then transformed into a yearly average increase in output per worker. The BLS projections were used to estimate an average yearly increase in output per worker by major sector.<sup>10</sup> Productivity-adjusted employment-to-output ratios were calculated as follows:

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<sup>8</sup> For a discussion of aggregation error in input-output models see, for example, Minnesota IMPLAN Group, Inc. (2000, p. 182).

<sup>9</sup> All sub-sectors within a major sector were assumed to have the same growth rate for each study period.

<sup>10</sup> For most of the 11 major sectors used, BLS provides a corresponding projection of output and jobs (e.g., the BLS projections include an estimate for retail trade, which is one of the RECID model's 11 major sectors). However, for some of the RECID model sectors, no single corresponding BLS sector exists (e.g., TCPU). In such cases, estimates of yearly average increase in output per worker were made by taking a



$$e' = 1/[(1/e)(1 + g)^y] \quad (1)$$

where

$e'$  = adjusted employment-to-output ratio (adjusted for projected increase in output per worker);

$e$  = employment-to-output ratio from IMPLAN;

$g$  = average yearly increase in output per worker; and,

$y$  = number of years in the study period.

The above calculation was carried out for each of the 182 IMPLAN sectors in the study area. The projected new jobs from each of the 182 sectors were then aggregated to obtain the total projected increase in jobs in the county for each study period and for the low, moderate, and high growth rates. The total increase in jobs was then translated into projected new housing units as follows:

$$n = h(jr/p) \quad (2)$$

where:

$n$  = new housing units required

$h$  = housing units-to-households ratio;

$j$  = projected new jobs;

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weighted average of the projected output per worker of the component sectors (in the case of TCPU the component BLS sectors are transportation and warehousing, information, and utilities). Projected output for the component sectors (year 2012) were used as weights.

r = population-to-jobs ratio; and

p = persons per household.

The housing units-to-household ratio, population-to-job ratio, and persons per household defaults were based on year 2000 data from the U.S. Census Bureau and FedStats. The defaults used were 1.18, 1.5, and 2.48, respectively.

Equation 2 accounts for vacant housing units and housing units occupied by nonpermanent residents of the study area. The number of new housing units required was calculated in like manner for each of the three growth scenarios and for both periods, 2004-2014 and 2004-2024.

#### **4.5. Acreage Requirements**

The amount of acreage required for new residential development was determined by multiplying the number of new housing units in each density class required for each alternative future by the housing density for that class and summing over all density classes. The distribution of housing units among housing types—across the three land use policies—is based on the following assumed percentages:

<b>Baseline Land Use Policy</b>	
<b>Density Class</b>	<b>Percentage of New Homes</b>
High Density	11
Urban	11
Suburban	18
Rural	23
Exurban	21
Agricultural	16

<b>Moderately Restrictive Land Use Policy</b>	
<b>Density Class</b>	<b>Percentage of New Homes</b>
High Density	17
Urban	21
Suburban	21
Rural	16
Exurban	13
Agricultural	12

<b>Highly Restrictive Land Use Policy</b>	
<b>Density Class</b>	<b>Percentage of New Homes</b>
High Density	30
Urban	28
Suburban	18
Rural	9
Exurban	8
Agricultural	7

The baseline percentages were based on estimates of the actual distribution of housing types for the year 2005. The housing type distribution for the moderately restrictive land use policy assumed that a greater proportion of residential development will occur in the high density and urban categories, and less development will occur in the suburban category. For the highly restrictive land use policy, it was assumed that an even greater share of the residential development will occur in the high density and urban categories, and that a smaller proportion of development occurs in all the other housing categories.

The following housing densities, which were based on Flathead County Planning and Zoning guidelines<sup>11</sup>, were used for all three land use policies:

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<sup>11</sup> According to Flathead County Planning and Zoning Guidelines, high density housing has a density of 7+ units per acres (zoning classes R-5, RC-1 and RA-1), urban housing has a maximum density of 4 to 7 units per acre (zoning classes R-3 and R-4), suburban housing has a maximum density of 2 units per acres (zoning class R-2), rural housing has a maximum density of 1 unit per acre (zoning class R-1), exurban housing has a maximum density of 1 unit per 5 acres (zoning class SAG-5) or 1 unit per 10 acres (zoning

<u>Housing type</u>	<u>Housing units per acre</u>
High Density	7
Urban	5.5
Suburban	2
Rural	1
Exurban	.13 (1 unit per every 7.5 acres)
Agricultural	.02 (1 unit per every 47 acres)

The assumed percentages of housing units in the various housing types were used to determine how the number of required housing units would be distributed among housing types. After the number of housing units in each housing type was determined, the planning and zoning guidelines outlined above were used to calculate the acres required for each housing type.

The amount of acreage required for new CI&I development was obtained by multiplying the projected increase in jobs by the number of acres required per job. The number of acres required per job was obtained by first identifying the square feet per worker, the acres per square foot of CI&I space, and the number of workers per job. For the year 2000, there were 1,230 square feet per worker for Flathead County (U.S. Department of Energy 2002). Acres per square foot of CI&I space was calculated by dividing total parcel acres in the county by total building square feet, resulting in acres per square foot of CI&I space of 0.00003182.<sup>12</sup> For the year 2000 there were an estimated 0.787 workers per job for the state of Montana.<sup>13</sup> The number of acres required per job

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class SAG-10), and agricultural housing has a maximum density of 1 unit per 20 acres (AG-20), 1 unit per 40 acres (AG-40), or 1 unit per 80 acres (AG-80). Averages were calculated based on these numbers to arrive at the densities used in the study.

<sup>12</sup> Total acres in parcels were 1,991 and total building square feet was 62,541,572. (Source: April 2005 CAMA database, as determined by Richard Charrier of the Center for Agricultural, Resource and Environmental Systems, College of Agriculture, Food and Natural Resources, University of Missouri – Columbia).

<sup>13</sup> There were an estimated 440,000 workers and an estimated 559,055 jobs in Montana in 2000. (Source for

was thus the product of the square feet per worker, the number of acres per square foot, and the workers per job. The last term in the product was required because the RECID model features jobs as an output rather than workers. Hence, the figure for square feet per worker was converted to square feet per job for purposes of internal consistency. For all nine alternative futures, it was assumed that 0.03078 acres of CI&I development were required for each new job in Flathead County.

#### **4.6. Parcel Conversion**

Once acreage requirements were determined for each residential density class and for CI&I development—for each scenario and in each study period—the appropriate number of parcels were converted from undeveloped to developed uses employing the procedure described in this section.

Each parcel in DP was assigned a development attractiveness score (DAS), which is a rating of its attractiveness relative to all other parcels available for development in a given scenario. Each parcel was assigned a separate DAS for CI&I development and for residential development. For CI&I development, a parcel's DAS (i.e.,  $DAS_{ic}$ ) was based on that parcel's maximum acceptable distance from a major highway and maximum acceptable distance from the edge of town. For CI&I development, the distance between parcel  $i$  and a major highway follows the functional form represented by equation 3 and Figure 2.

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number of workers: Nelson (2004) Appendix Table 5. Commercial and Institutional Square Feet Demand for Nation, Regions, and States Ranked by the Percentage of Square Feet in 2030 Built Since 2000; Source for number of jobs: U.S. Commerce Department-Bureau of Economic Analysis 2000).

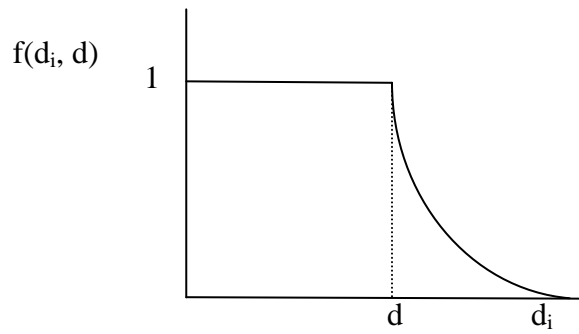
$$f(d_i, d) = 1 \text{ for } d_i \leq d, \text{ and } f(d_i, d) = e^{-(d_i - d)} \text{ for } d_i > d \quad (3)$$

where:

$d$  = maximum acceptable distance from a major highway for CI&I development; and,

$d_i$  = actual distance of parcel  $i$  from a major highway.

**Figure 2. Functional Form for Effect of Parcel  $i$ 's Distance from a Major Highway on Parcel  $i$ 's DAS**



Equation 3 and Figure 2 imply that parcel  $i$ 's attractiveness for development decreases as its distance from a major highway exceeds the maximum acceptable distance, and remains constant for distances below the maximum acceptable distance. The distance between parcel  $i$  and the edge of town follows the same functional form. In calculating each parcel's  $DAS_{ic}$ , the two attributes—distance from a major highway and distance from the edge of town—were weighed equally. Each resulting  $DAS_{ic}$  is between 0 and 1.

A parcel's DAS for residential development (i.e.,  $DAS_{ir}$ ) was based on the parcel's maximum acceptable distance from a major highway, maximum acceptable

distance from the edge of town<sup>14</sup>, maximum acceptable distances from six amenities, elevation difference; and minimum acceptable distances from five disamenities. The six amenities, proximity to which generally increases a parcel's relative desirability, include lakes, rivers, preserves/parks, golf courses, ski resorts, and forests. Elevation difference is also considered an amenity because many residents prefer a lot with a higher elevation, other things equal. The five disamenities, proximity to which generally decreases a parcel's relative desirability, include industrial facilities/parks, trailer parks, commercial centers, railroad tracks, and airports.

For residential development the distance between parcel *i* and a major highway, and the distance between parcel *i* and the edge of town follow the same functional form as represented in equation 3 and Figure 2. Additionally, for residential development, the same functional form was used to model the distances between parcel *i* and six of the amenities, including distance from a lake, river, preserve/park, golf course, ski resort, and forest.

Equation 4 and Figure 3 describe how elevation difference was modeled.

$$f(a_{ie}, a_e) = 0 \text{ for } a_{ie} \leq a_e, \text{ and } f(a_{ie}, a_e) = (a_{ie} - a_e)^* \text{ for } a_{ie} > a_e, \quad (4)$$

where:

$a_e$  = minimum acceptable difference between a parcel's elevation and the elevation of the valley floor;

$a_{ie}$  = actual difference between the elevation of parcel *i* and the elevation of the

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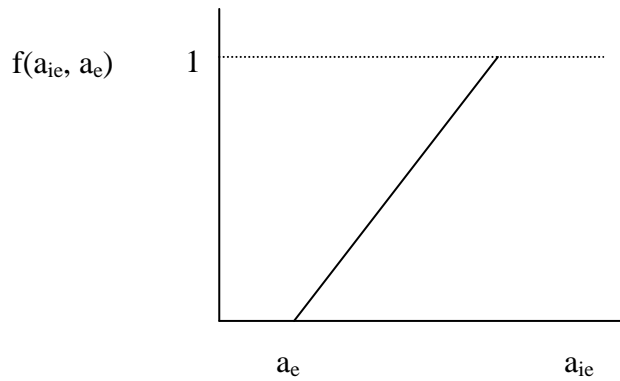
<sup>14</sup> A parcel's distance from the edge of town was measured as the distance between the parcel and the growth boundary for incorporated cities and by the distance between the parcel and city limit for unincorporated cities.



valley floor; and

$$(a_{ie} - a_e)^* = \text{a normalized elevation difference (i.e., } (a_{ie} - a_e)^* = [(a_{ie} - a_e) - \min(a_{ie} - a_e)] / [\max(a_{ie} - a_e) - \min(a_{ie} - a_e)]).$$

**Figure 3. Functional Form for Effect of Parcel i's Elevation Difference on Parcel i's DAS**



This function implies that the effect of elevation on  $DAS_{ir}$  is zero if the elevation difference is less than  $a_e$  and increases linearly with respect to elevation difference for elevation differences above  $a_e$ . Distances from the seven amenities were aggregated with each amenity weighted equally to arrive at parcel i's amenity score for home class r ( $f_{iar}$ ).  $f_{iar}$  is between 0 and 1.

Equation 5 and Figure 4 describe how parcel i's distance from the five disamenities was modeled for residential development.

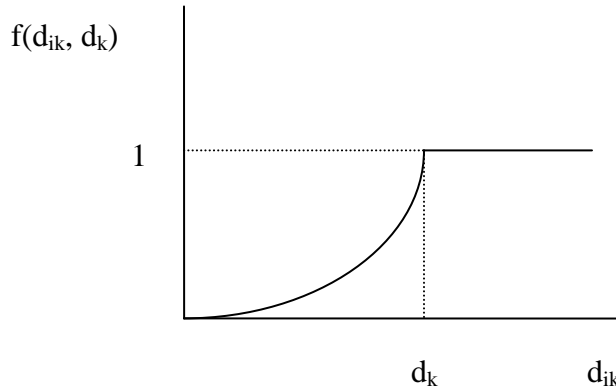
$$f(d_{ik}, d_k) = e^{(d_{ik} - d_k)} \text{ for } d_{ik} \leq d_k \text{ and } f(d_{ik}, d_k) = 1 \text{ for } d_{ik} > d_k, \quad (5)$$

where:

$d_{ik}$  = parcel i's distance from disamenity k; and

$d_k$  = minimum acceptable distance from disamenity  $k$ .

**Figure 4. Functional Form for Effect of Parcel  $i$ 's Distance from Disamenity  $k$  on Parcel  $i$ 's DAS**



Equation 5 and Figure 4 imply that the effect of disamenity  $k$  on  $DAS_{ir}$  is constant when a parcel's distance from a disamenity exceeds  $d_k$  and decreases exponentially as the distance from the disamenity decreases. Distances from the five disamenity attributes were aggregated, with each disamenity weighted equally, to arrive at parcel  $i$ 's disamenity score for home class  $r$  ( $f_{idr}$ ).  $f_{idr}$  is between 0 and 1.

Tables 7-10 contain the attribute values assumed for various development types.

**Table 7. Attribute Values for CI&I Development**

<b>Maximum acceptable distance from a major highway and edge of town (miles)</b>	
<b>Major highway</b>	<b>Edge of town</b>
.25	1.00

**Table 8. Attribute Values (Major Highway and Edge of Town) for Residential Development by Housing Type**

<b>Maximum acceptable distance from a major highway and edge of town (miles)</b>				
Housing type	Major highway		Edge of town	
	Tract	Custom	Tract	Custom
High density and urban	0.25	1 (urban only)	2	3 (urban only)
Suburban and rural	0.5 (suburban only)	1.50	4 (suburban only)	5
Exurban	NA	2	NA	8
Agricultural	NA	5	NA	15

**Table 9. Attribute Values (Amenities) for Residential Development by Housing Type**

<b>Maximum acceptable distance from amenities (miles)</b>						
<b>Amenity</b>	<b>Tract high density and urban</b>	<b>Tract suburban</b>	<b>Custom urban</b>	<b>Custom suburban and rural</b>	<b>Custom exurban</b>	<b>Custom agricultural</b>
Lake	10	12	8	10	18	25
River	10	12	8	10	18	25
Preserve/park	5	5	3	4	10	12
Golf course	12	15	9	10	20	30
Ski resort	20	15	15	10	20	25
Forest	10	10	5	5	15	15
Elevation <sup>a</sup>	0	0	50	100	25	25

a. Difference in feet between the average elevation of the parcel and the elevation of the valley floor.

**Table 10. Attribute Values (Disamenities) for Residential Development by Housing Type**

Minimum acceptable distance from disamenities (miles)						
Disamenity	Tract high density and urban	Tract suburban	Custom urban	Custom suburban and rural	Custom exurban	Custom agricultural
Industrial facility or park	5	6	6	8	10	12
Trailer park	2	2	3	3	5	8
Commercial center	1	3	2	5	8	10
Railroad tracks	3	4	4	5	6	7
Airport	5	6	6	8	10	15

The attribute values in Tables 7-10 are assumptions (based on limited survey data and expert judgment) that eventually may be made into user-defined variables in the decision support tool being developed in conjunction with this study.

The above effects were combined to arrive at  $DAS_{ir}$ , as follows:

$$DAS_{ir} = w_{hr}f(h_{ir}, h_r) + w_{tr}f(t_{ir}, t_r) + w_{ar}f_{iar} + w_{dr}f_{idr}, \quad (6)$$

where, for home type  $r$ ,

$w_{hr}$  = the average weight for maximum acceptable distance from a major highway;

$w_{tr}$  = the average weight for maximum acceptable distance from the edge of town;

$w_{ar}$  = the average weight for maximum acceptable distance from amenities; and

$w_{dr}$  = the average weight for minimum acceptable distance from disamenities.

Weights ( $w_{hr}$ ,  $w_{tr}$ ,  $w_{ar}$  and  $w_{dr}$ ) may also be made into user-adjustable inputs in the web-based decision support tool associated with the RECID model. Table 11 contains the assumed weights for the four housing type categories.<sup>15</sup> For the current study, the values of the weights were based on limited survey data and expert judgment.

**Table 11. Attribute Weights for Housing Types**

<b>Minimum or maximum acceptable distance from:</b>	<b>High density and urban</b>	<b>Suburban and rural</b>	<b>Exurban</b>	<b>Agricultural</b>
Major highway	0.4	0.3	0.2	0.2
Edge of town	0.2	0.2	0.1	0.1
Amenities	0.3	0.3	0.2	0.2
Disamenities	0.1	0.2	0.5	0.5
Sum	1.00	1.00	1.00	1.00

By design, each  $DAS_{ir}$  has a value between 0 and 1.

The raw DAS, calculated as outlined above, were adjusted using transition probabilities for historical changes in land cover from undeveloped urban, forested (conifer and deciduous), and agricultural (crop, grass and shrubland) to built-up. Land cover changes were determined from supervised land cover classifications of 30m Landsat TM imagery for developable areas of Flathead County for 1983-84 and 2001-02. These land cover changes were used to calculate transition probabilities for: (1) forest to

<sup>15</sup> For the purposes of weighting the attributes the high density and urban housing types were collapsed into a single category, and the suburban and rural housing types were collapsed into a single category.

built-up; (2) crop/grassland to built-up; and (3) urban to built-up. Using the transition probabilities to adjust the raw DASs has the effect of increasing or decreasing a given parcel's probability of conversion to a particular land use type depending on historical changes in land use in the county. The following transition probabilities were used to adjust the raw DASs:

<u>Land cover change</u>	<u>Transition probability</u>
Forest to built-up	0.0063
Crop/grassland to built-up	0.0353
Urban to built-up	0.9594

Parcels in the RECID model were converted from undeveloped to developed uses in the following order: CI&I; high density residential; urban-custom residential; urban-tract residential; suburban-custom residential; suburban-tract residential; rural residential; exurban residential; and agricultural residential. In the parcel conversion process, after a given parcel was converted to a particular land use, it was removed from DP for that alternative future. Given the model construct, it was possible in some alternative futures for the total acreage required for CI&I and residential development to exceed the total number of acres available in DP. Any future alternative whose acreage requirement exceeds the available acres in DP may be viewed as being unsustainable (Prato et al. 2007a).

Using the methodology outlined in this chapter, two sets of results were generated. One set assumed an order of parcel conversion based solely on the adjusted

DAS (i.e., the parcel in DP with the highest DAS is converted first and then the parcel with the next highest DAS is converted, and so on). Another entire set of results was generated using the methodology presented in this chapter and one additional assumption. For the latter set of results, the developable parcels for a particular land use were divided into five groups, or quintiles, before parcels were converted to developed uses. The parcels with the highest 20 percent of adjusted DAS comprised the first quintile, the parcels with the next highest 20 percent of adjusted DAS comprised the second quintile, and so on. Developable parcels in the same quintile were considered equally attractive for development, and the acreage required for each land use was randomly allocated to parcels so that 80 percent of the acreage came from the highest ranked quintile and 20 percent came from the second highest ranked quintile. This assumption, which follows from a study by Steinitz et al. (2003), was used to reflect the real-world fact that developers are not able to acquire the most attractive parcels 100 percent of the time (Prato et al. 2007a).

#### **4.7. Data and Sources**

Data for the economic portion of the RECID model were obtained from IMPLAN (Minnesota IMPLAN Group, Inc.), the Bureau of Labor Statistics, the Census Bureau, the U.S. Department of Energy, and the Brookings Institution (Nelson 2004). Parcel data for the land use change portion of the model were obtained from the Computer Assisted Mass Appraisal (CAMA) database developed by the Montana Department of Revenue (Montana Cadastral Mapping 2005). The National Hydrologic Dataset was used to identify water bodies (U.S. Geological Survey and Environmental Protection Agency



2006). Data regarding the location of floodplains were obtained from the Federal Emergency Management Agency (FEMA). Growth boundaries were identified using maps from the Flathead County Planning and Zoning Office. Zoning information was obtained from the Flathead County Zoning Regulations and Lake and Lakeshore Protection Regulations. Primary data were collected from the stakeholder group, the Flathead Landscape Analysis Group, regarding projected future growth rates.

## Chapter 5. RESULTS

Tabular (aspatial) results of the RECID model include projections for the increase in jobs, increase in population, increase in new housing units required, and additional square feet required for CI&I development for each of the three growth scenarios and for both of the study periods. Tabular output of the RECID model also includes projections for the number of acres required for new residential development for each housing type, the number of acres required for new CI&I development, and the number of surplus or deficit acres under each of the nine alternative futures for both study periods. A surplus occurs when the total number of acres required for new development is less than the acres available for development; a deficit occurs when the total acres required for new development is greater than the acres available for development for a given alternative future.

Spatial output of the RECID model includes interactive maps for each alternative future for each study period. Two sets of maps were generated, one which assumes the basic methodology outlined in Chapter 4, and another which utilizes the quintile approach for converting parcels from undeveloped to developed, as described in the last paragraph of Section 4.6.

**Table 12. Simulations for Flathead County, MT**

<b>Economic Growth Rate/ Forecast Variable</b>	<b>Study Period</b>	
	<b>2000-2014</b>	<b>2000-2024</b>
<b>Low Growth</b>		
Increase in Output	\$4,708,000,000	\$7,388,000,000
Increase in Jobs	37,836	51,458
Increase in Population	56,903	77,389
New Housing Units Required	26,965	36,674
Additional Sq. Ft. Required for CI&I Development	46,575,785	63,344,502
<b>Moderate Growth</b>		
Increase in Output	\$5,114,000,000	\$9,892,000,000
Increase in Jobs	63,447	92,723
Increase in Population	95,420	139,450
New Housing Units Required	45,218	66,084
Additional Sq. Ft. Required for CI&I Development	78,103,399	114,142,535
<b>High Growth</b>		
Increase in Output	\$5,577,000,000	\$13,423,000,000
Increase in Jobs	103,470	163,034
Increase in Population	155,613	245,194
New Housing Units Required	73,743	116,194
Additional Sq. Ft. Required for CI&I Development	127,372,044	200,695,207

Table 12 presents projected increases in output, jobs and population; projected new housing units required; and additional square feet required for CI&I development for the three growth scenarios over the two study periods.<sup>16</sup>

Tables 13 and 14 present acres required for new residential development (by housing type) and CI&I development, respectively, and acres developed (by housing type and for CI&I development) along with the number of surplus or deficit acres for the nine alternative futures for the period 2004-2014. Tables 15 and 16 present similar information for the 2014-2024 period.<sup>17</sup>

**Table 13. Additional Land Required (Acres), 2004-2014**

**Baseline land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	424	711	1,137
	Urban – Custom	162	271	434
	Urban – Tract	378	633	1,013
	Suburban – Custom	728	1,221	1,954
	Suburban – Tract	1,699	2,849	4,560
	Rural	6,202	10,400	16,647
	Exurban	42,471	71,219	113,993
	Agricultural	204,780	340,044	544,272
Commercial/Institutional/Industrial		1,165	1,953	3,126
Total		256,007	429,301	687,137

<sup>16</sup> Results for increase in jobs, increase in population, new housing units required, and additional sq. ft. required for CI&I development differ by a factor of .53 percent to .88 percent from previously published results. Due to a mathematical error, the previously published results slightly overstate each of the aforementioned variables.

<sup>17</sup> Results for additional acres required for both study periods differ by a factor of .53 percent to 1.91 percent from previously published results. Due to a mathematical error, the previously published results slightly overstate the number of acres required for development in each land use category.

**Moderately restrictive land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	655	1,098	1,758
	Urban – Custom	309	518	829
	Urban – Tract	721	1,209	1,934
	Suburban – Custom	850	1,424	2,280
	Suburban – Tract	1,982	3,324	5,320
	Rural	4,314	7,235	11,580
	Exurban	26,291	44,088	70,567
	Agricultural	152,085	255,033	408,204
Commercial/Institutional/Industrial		1,165	1,953	3,126
Total		188,371	315,882	505,598

**Highly restrictive land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	1,156	1,938	3,102
	Urban – Custom	412	691	1,105
	Urban – Tract	961	1,611	2,579
	Suburban – Custom	728	1,221	1,954
	Suburban – Tract	1,699	2,849	4,560
	Rural	2,427	4,070	6,514
	Exurban	16,179	27,131	43,426
	Agricultural	88,716	148,769	238,119
Commercial/Institutional/Industrial		1,165	1,953	3,126
Total		113,442	190,233	304,485

**Table 14. Additional Land Developed (Acres), 2004-2014**

**Baseline land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	428	725	1,180
	Urban – Custom	163	283	512
	Urban – Tract	424	645	1,034
	Suburban – Custom	738	1,247	1,991
	Suburban – Tract	1,842	2,913	4,648
	Rural	6,347	10,611	17,083
	Exurban	42,860	72,666	116,184
	Agricultural	204,675	346,997	390,001
Commercial/Institutional/Industrial		1,176	1,991	3,186
Total		258,653	438,078	535,818
Surplus or deficit		277,165	97,740	-164,292

**Moderately restrictive land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	662	1,251	1,793
	Urban – Custom	312	547	847
	Urban – Tract	728	1,275	1,974
	Suburban – Custom	858	1,476	2,390
	Suburban – Tract	2,000	3,397	5,429
	Rural	4,359	7,378	12,135
	Exurban	26,573	44,969	71,905
	Agricultural	153,544	260,007	416,376
Commercial/Institutional/Industrial		1,175	1,993	3,210
Total		190,210	322,292	516,059
Surplus or deficit		345,609	213,527	19,759

### Highly restrictive land use policy

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	1,283	1,990	3,162
	Urban – Custom	426	712	1,209
	Urban – Tract	1,000	1,655	2,640
	Suburban – Custom	735	1,246	2,020
	Suburban – Tract	1,714	2,905	4,655
	Rural	2,477	4,356	6,643
	Exurban	16,847	27,931	44,662
	Agricultural	89,599	151,962	242,629
Commercial/Institutional/Industrial		1,178	1,991	3,192
Total		115,259	194,749	310,811
Surplus or deficit		420,121	340,631	224,569

Note: Surplus = developable land - land developed; deficit = land developed - additional land required.

**Table 15. Additional Land Required (Acres), 2014-2024**

### Baseline land use policy

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	576	1,038	1,796
	Urban – Custom	220	397	686
	Urban – Tract	513	925	1,600
	Suburban – Custom	990	1,784	3,086
	Suburban – Tract	2,310	4,163	7,200
	Rural	8,435	15,199	26,286
	Exurban	57,761	104,082	180,004
	Agricultural	275,787	469,950	859,450
Commercial/Institutional/Industrial		1,584	2,854	4,936
Total		348,178	627,393	1,085,044

**Moderately restrictive land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	891	1,605	2,776
	Urban – Custom	420	757	1,309
	Urban – Tract	980	1,766	3,055
	Suburban – Custom	1,155	2,082	3,600
	Suburban – Tract	2,696	4,857	8,400
	Rural	5,868	10,573	18,286
	Exurban	35,757	79,301	111,431
	Agricultural	206,840	372,713	644,587
Commercial/Institutional/Industrial		1,584	2,854	4,936
Total		256,191	476,507	798,380

**Highly restrictive land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	1,572	2,832	4,898
	Urban – Custom	560	1,009	1,746
	Urban – Tract	1,306	2,355	4,073
	Suburban – Custom	990	1,784	3,086
	Suburban – Tract	2,310	4,163	7,200
	Rural	3,301	5,948	10,286
	Exurban	22,004	39,650	68,573
	Agricultural	120,657	217,416	376,009
Commercial/Institutional/Industrial		1,584	2,854	4,936
Total		154,285	278,011	480,807



**Table 16. Additional Land Developed (Acres), 2014-2024**

**Baseline land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	580	1,097	1,881
	Urban – Custom	222	475	775
	Urban – Tract	518	982	1,642
	Suburban – Custom	1,000	1,895	3,147
	Suburban – Tract	2,477	4,243	7,382
	Rural	8,495	15,776	26,726
	Exurban	58,080	105,840	183,058
	Agricultural	277,286	402,611	306,187
Commercial/Institutional/Industrial		1,597	2,900	5,022
Total		350,254	535,818	535,818
Surplus or deficit		185,564	-101,706	-567,318

**Moderately restrictive land use policy**

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	896	1,632	2,841
	Urban – Custom	422	769	1,331
	Urban – Tract	986	1,825	3,107
	Suburban – Custom	1,310	2,116	3,665
	Suburban – Tract	2,710	4,953	8,592
	Rural	5,902	10,745	18,679
	Exurban	35,950	80,598	113,302
	Agricultural	207,983	378,752	379,130
Commercial/Institutional/Industrial		1,592	3,042	5,171
Total		257,753	484,431	535,818
Surplus or deficit		278,065	51,387	-275,874

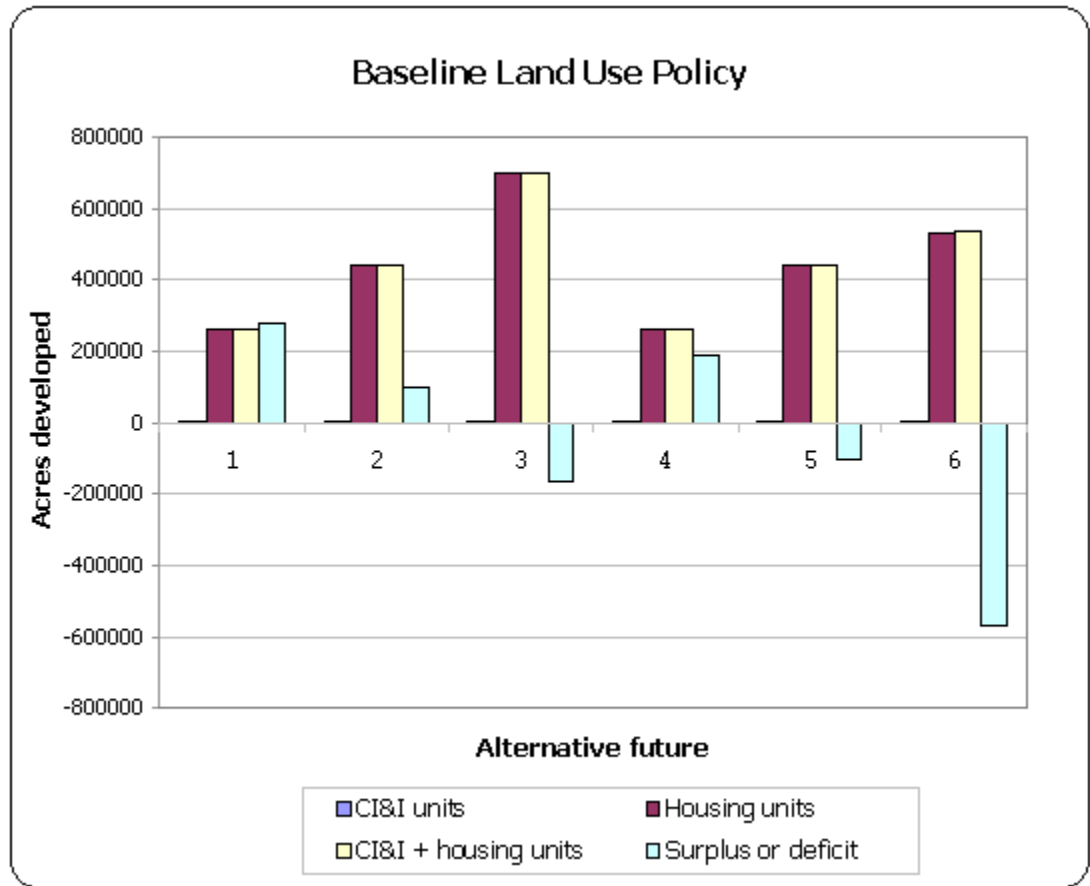
### Highly restrictive land use policy

Land Use		Low Growth	Moderate Growth	High Growth
Housing	High Density	1,632	2,883	4,986
	Urban – Custom	631	1,028	1,778
	Urban – Tract	1,375	2,401	4,141
	Suburban – Custom	998	1,855	3,227
	Suburban – Tract	2,340	4,245	7,330
	Rural	3,320	6,288	10,475
	Exurban	22,511	40,447	69,807
	Agricultural	121,358	220,987	382,280
Commercial/Institutional/Industrial		1,594	2,934	5,057
Total		155,759	283,067	489,081
Surplus or deficit		379,621	252,313	46,299

Note: Surplus = developable land - land developed, deficit = land developed - additional land required.

Figures 5-7 summarize the key information from Tables 14 and 16. It should be noted that Tables 13-16 and Figures 5-7 were taken directly from the online decision support tool that is being developed in conjunction with this study.

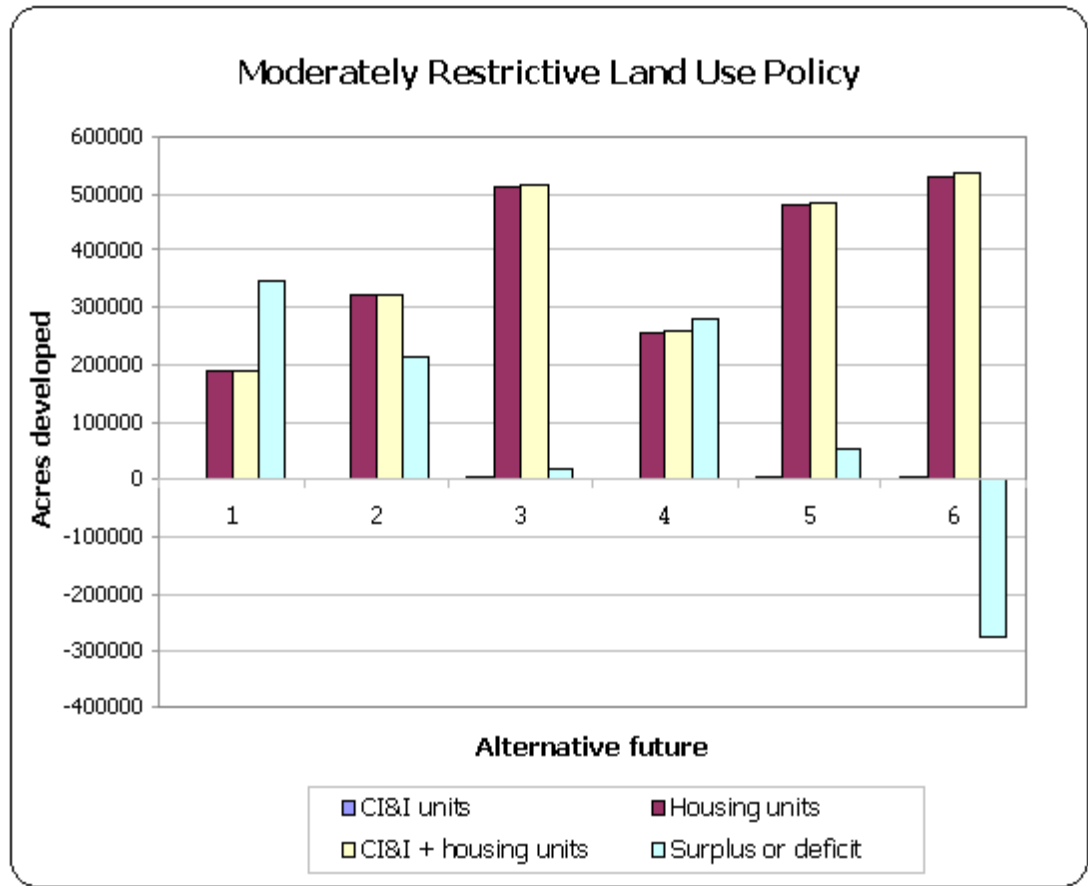
**Figure 5. Acres Developed, Baseline Land Use Policy**



**Legend for alternative futures**

1=2004-2014: low growth      2=2004-2014: moderate growth      3=2004-2014: high growth  
 4=2004-2024: low growth      5=2004-2024: moderate growth      6=2004-2024: high growth

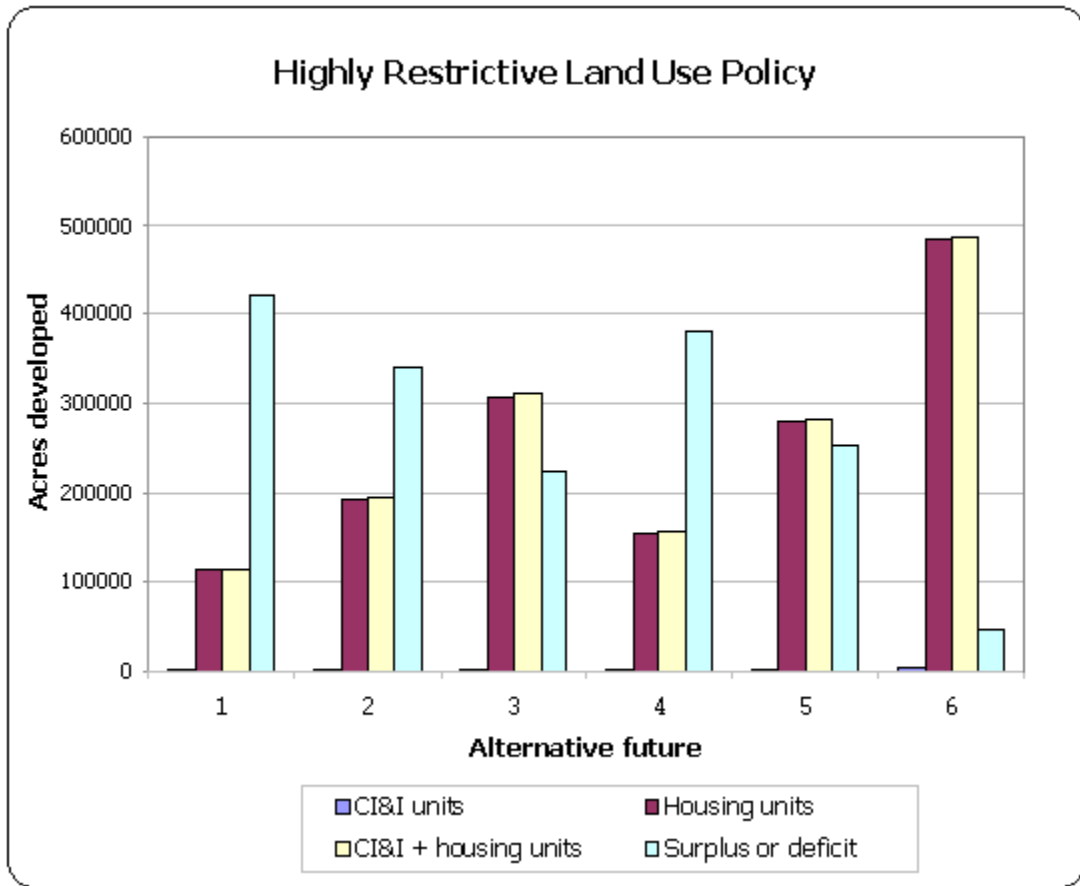
**Figure 6. Acres Developed, Moderately Restrictive Land Use Policy**



**Legend for alternative futures**

1=2004-2014: low growth      2=2004-2014: moderate growth      3=2004-2014: high growth  
 4=2004-2024: low growth      5=2004-2024: moderate growth      6=2004-2024: high growth

**Figure 7. Acres Developed, Highly Restrictive Land Use Policy**



**Legend for alternative futures**

1=2004-2014: low growth    2=2004-2014: moderate growth    3=2004-2014: high growth  
 4=2004-2024: low growth    5=2004-2024: moderate growth    6=2004-2024: high growth

GIS map-based output of the alternative futures may be accessed at <http://ims.missouri.edu/montana/recid/analysis3.htm>. Map results for the Kalispell area are contained in Appendix E; however, the online maps are interactive in the sense that they allow the user to zoom in or out, to obtain parcel information, and to focus on specific areas in the county.

Both the tabular and the spatial results are discussed in the final chapter, Chapter 6.

## **Chapter 6. DISCUSSION**

### **6.1. Interpretation of Tabular Results**

Tabular results from the RECID model indicate that the alternative futures vary greatly with respect to the amount of land required for development. What is not immediately evident from a simple viewing of the tabular results is whether the variability in land requirements is due primarily to varying assumptions regarding economic growth rates or to varying assumptions regarding land use policies. For the 2004-2014 period, there is more than a 500 percent difference in the amount of land required between the alternative future with the lowest requirement for land (i.e., low growth, highly restrictive land use policy) and the alternative future with the highest requirement for land (i.e., high growth, baseline land use policy). In particular, the latter future requires more than five times the amount of land for future development than the former scenario. For the 2004-2024 period, the difference in land requirements between the low growth-highly restrictive land use policy and the high growth-baseline land use policy is greater than 600 percent. More detailed comparisons of the percentage differences in land requirements among the various alternative futures sheds additional light on the results.

Regardless of land use policy, the high growth scenarios require 168 percent more land than the low growth scenarios, the moderate growth scenarios require 68 percent more land than the low growth scenarios, and the high growth scenarios require 60 percent more land than the moderate growth scenarios for the 2004-2014 period. For the

2004-2024 period, the high growth scenarios require 212 percent more land than the low growth scenarios, regardless of which of the three land use policies is assumed. For the longer period, the moderate growth scenarios require 80 percent<sup>18</sup> more land than the low growth scenarios, and the high growth scenarios require 73 percent<sup>19</sup> more land than the moderate growth scenarios. Aside from the variability described in footnotes 18 and 19, these percentages hold true regardless of which land use policy is assumed.

If the growth rate is held constant and the land use policy is varied, the results are equally interesting. Regardless of which growth rate is assumed, the baseline land use policy scenario for the 2004-2014 period requires 126 percent more land than the highly restrictive land use policy scenario. For that same period, the baseline scenario requires 36 percent more land than the moderately restrictive scenario, and the moderately restrictive scenario requires 66 percent more land than the highly restrictive scenario. For the 2004-2024 period, the baseline land use policy scenario requires 126 percent more land than the highly restrictive land use policy scenario, holding the growth rate constant. For the 2004-2024 period, the baseline scenario requires 36 percent<sup>20</sup> more land than the moderately restrictive scenario, and the moderately restrictive scenario requires 66 percent<sup>21</sup> more land than the highly restrictive scenario—similar to the results for the shorter period. Tables 17 and 18 summarize these comparisons for the 2004-2014 period.

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<sup>18</sup> Except for the moderately restrictive land use policy scenario, for which the difference is 86 percent.

<sup>19</sup> Except for the moderately restrictive land use policy scenario, for which the difference is 68 percent.

<sup>20</sup> Except for the moderate growth scenario, for which the difference is 32 percent.

<sup>21</sup> Except for the moderate growth scenario, for which the difference is 71 percent.

**Table 17. Comparison of Land Requirements for Different Growth Rates, 2004-2014 Period**

<b>Growth Comparison</b>	<b>Percentage Increase in Amount of Land Required for Development</b>
Low Growth to Moderate Growth	68%
Moderate Growth to High Growth	60%
Low Growth to High Growth	168%

Note: Holding land use policy constant

**Table 18. Comparison of Land Requirements for Different Land Use Policies, 2004-2024 Period**

<b>Land Policy Comparison</b>	<b>Percentage Increase in Amount of Land Required for Development</b>
Moderately Restrictive to Baseline	36%
Highly Restrictive to Moderately Restrictive	66%
Highly Restrictive to Baseline	126%

Note: Holding growth rate constant

Based on these comparisons, it appears that, for the most part, the growth rates have a relatively larger effect on the amount of land required for residential and CI&I development than the land use policy. However, the land use policy has a substantial effect on the amount of land required. In general, for both periods, there is a greater increase in the amount of land required when moving from a low growth scenario to a moderate growth scenario than when moving from a moderate growth to a high growth



scenario. Similarly, for both periods, there is a larger increase in the amount of land required when moving from the highly restrictive land use policy to the moderately restrictive land use policy than when moving from moderately restrictive to the baseline land use policy.

As Tables 14 and 16 in Chapter 5 indicate, the amount of land required for development exceeds the amount of land available for development for several of the alternative futures. For the 2004-2014 period, the high growth-baseline land use policy scenario overshoots the amount of land currently available for development. For the 2004-2024 period, the moderate growth-baseline land use policy, high growth-baseline land use policy, and high growth-moderately restrictive land use policy scenarios require more land than what is available for development. One might initially be surprised by the tabular results—both acres required and acres developed—particularly the results for the alternative futures that result in sizable land deficits. However, when examining the results one should bear in mind that the vast majority of acres required for development is in the agricultural density class, which requires 47 acres per housing unit. The majority of the land developed in the model is already classified as agricultural land, meaning that no change in land use classification will occur for a sizable portion of the land developed in the model (e.g., a 100 acre tract of land with one house may be subdivided into two 50 acre tracts with one house each, but the 100 acres as a whole is still classified as agricultural). For the baseline land use policy, 80 percent of the additional land required for houses is in the agricultural density category, regardless of the growth rate. For the moderately restrictive land use policy, 81 percent of the additional land required is for the

agricultural housing density category<sup>22</sup>, and for the highly restrictive land use policy, 79 percent of the additional land required for housing development is in the agricultural density category.

Tables 19 and 20 indicate the percentage of total land required for developed uses that falls in the agricultural housing category.

**Table 19. Percentage of Land Developed in the Agricultural Category under each Land Use Policy, 2004-2014 Period**

	Percentage of Total Land Developed in the Agricultural Category by Growth Rate and Land Use Policy		
Land Use Policy	Low Growth	Moderate Growth	High Growth
Baseline	80	80	80
Mod. Restrictive	81	81	81
Highly Restrictive	79	79	79

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<sup>22</sup> The only exception is for the moderate growth scenario, moderately restrictive land use policy for the 2004-2024 period, for which 79 percent of the additional land required for development is in the agricultural housing category.

**Table 20. Percentage of Land Developed in the Agricultural Category under each Land Use Policy, 2004-2024 Period**

	Percentage of Total Land Developed in the Agricultural Category by Growth Rate and Land Use Policy		
Land Use Policy	Low Growth	Moderate Growth	High Growth
Baseline	80	80	80
Mod. Restrictive	81	79	81
Highly Restrictive	79	79	79

In the RECID model, when there is a shortfall of land available for development (i.e., a land deficit) the agricultural land use category absorbs the deficit since it is the last category to have parcels developed in the land conversion process. A closer look at the scenario with the largest land deficit—the high growth, baseline land use policy for the 2004-2024 period—demonstrates how the distribution of land among land use categories differs when there is a shortfall of land available for development.

**Table 21. Percentage of Total Acres Required and Total Acres Developed by Land Use Category, Baseline Land Use Policy-High Growth Scenario, 2004-2024**

Land Use	Percentage of Total Acres Required	Percentage of Total Acres Developed
High Density	.17	.35
Urban-Custom	.06	.14
Urban-Tract	.15	.31
Suburban-Custom	.28	.59
Suburban-Tract	.66	1.38
Rural	2.42	4.99
Exurban	16.59	34.16
Agricultural	79.21	57.14
CI&I	.45	.94

As illustrated in Table 21, the percentage of the total acres developed is more than twice the percentage of total acres required for all land use categories except for the agricultural category. Although the agricultural housing category represents approximately 79 percent of the total acres required it represents only 57 percent of the acres actually developed. This assumption of the model reflects the idea that as the county continues to grow, an increasing proportion of the available land will be converted to uses other than agricultural (i.e., the county will become more urbanized).

The RECID model tabular results indicate that some future scenarios are potentially unsustainable in that they deplete the amount of land available for development. In actuality, land available for development will not be depleted because as growth intensifies in the land prices will rise, moderating the county's rate of growth. In practice, an unsustainable outcome might take the form of a lack of affordable housing; or development in more remote areas of the country, perhaps near environmentally sensitive areas; or rapid transformations of the county's agricultural land to urban uses. Extrapolating from the results, one may easily imagine that if actual growth occurs at an even greater rate than the high growth rate used in the study, then an even greater proportion of land will shift from agricultural uses to the more urban land use categories. Such changes in land use alter the character of a region over time. It is clear that exceptionally high growth is only "sustainable" in the county if the local governments place restrictions on land development or take measures to reduce the rate of economic growth. In general, county and municipal governments have more direct control over land use policy (e.g., zoning restrictions) than they do over the rate of economic growth in their localities. In fast-growing areas such as Flathead County, the county and municipal governments may have very little influence on the rate of economic growth (except by land use), in which case the local governments would be best advised to focus on designing land use policies based on their best forecast of future growth. If economic growth is expected to be high, then the local governments could implement the moderately restrictive land use policy to avoid a shortfall of land in the intermediate term (2004-2014). In the long run term (2004 to 2024), if growth is expected to be moderate or high, then the moderately restrictive land use policy could be instituted in order to avoid a

land shortfall. This discussion presumes that the county will grow at a pace at or above the high growth rate employed in this study. Obviously if growth in the county were to slow for some reason, additional land use restrictions may be unnecessary. However, as the tabular results demonstrate, in the long run, even if the county grows at a moderate pace, the local governments may have to increase land use restrictions to avoid unsustainable outcomes. It is worth noting that none of the alternative futures require implementation of the highly restrictive land use policy in order to avoid unsustainable outcomes.

## **6.2. Interpretation of GIS-based Map Results**

Interpreting the GIS-based map output of RECID is less straightforward than interpreting the tabular results. Two sets of maps were generated by the model. The first set was based on the standard parcel conversion process described in Chapter 4. The second set employed the standard methodology plus the quintile assumption described in the last paragraph of Section 4.6. Map results for the Kalispell area based on the standard parcel conversion process are contained in Appendix E. All of the GIS map-based results, with and without the quintile assumption, are accessible online at

<http://ims.missouri.edu/montana/recid/analysis3.htm>.

The maps were reviewed extensively and the following general trends were observed:<sup>23</sup>

- 1) Regardless of land use policy, the majority of non-agricultural/non-exurban/non-rural development occurs in or near five key areas:

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<sup>23</sup> For the sake of conciseness, this discussion only considers the spatial results for the 2004-2014 period using the standard parcel allocation methodology (i.e., without the quintile assumption).

Kalispell; Whitefish; Whitefish Lake; Columbia Falls; and Flathead Lake, particularly the northern shore with the largest cluster of development occurring in the Bigfork area.

- 2) Regardless of land use policy, shifting from low to moderate growth results in a significantly greater amount of suburban development, generally occurring near the incorporated cities and along the northern shore of Flathead Lake.
- 3) By design, shifting to a more restrictive land use policy shifts residential development into higher density classes. Spatially, this causes suburban development to shift into the urban and high density classes, particularly near Kalispell, Whitefish, and along the northern shore of Flathead Lake.
- 4) In the high growth scenarios, new residential development spreads to more remote areas. Most notably, there is an increase in the amount of development in two areas along Highway 2; the first one approximately two miles north of Hungry Horse and about midway between Columbia Falls and Hungry Horse, and the second one along the western shore of Flathead Lake. Development also tends to spread to these areas when the growth rate is low and the highly restrictive land use policy is assumed.
- 5) Not surprisingly, as the growth rate increases, development tends to spread from the edges of the incorporated cities along major highways, particularly along Highway 93 north and south of Kalispell, along

Highway 2 northeast of Kalispell, along Highway 93 south of Whitefish, and along Highway 2 east and west of Columbia Falls.

- 6) Interestingly, for the moderate and high growth scenarios, when the land use policy shifts from moderately restrictive to highly restrictive, the higher density development (i.e., suburban, urban, and high density) all but disappears around Whitefish Lake and moves south and southeast of the town of Whitefish.
- 7) An interesting anomaly occurs for the moderately restrictive land use policy scenarios. A large cluster of relatively higher density development (ranging from rural to high density) appears in the southwest portion of the county, approximately 4 to 6 miles north of Highway 28. This cluster appears in the results for the moderately restrictive scenarios regardless of the growth rate assumed. For the baseline and highly restrictive land use policies, this cluster of development is in the exurban and agricultural classes.

Generally, in all the scenarios, development tends to cluster near the fastest growing areas of the county, and as the rate of economic growth increases a pattern of development occurs that some would deem as sprawl, with primarily suburban but also urban, high density and CI&I development fanning out from the incorporated cities along the major travel routes. As was expected, development springs up in some less populated areas when the country grows at a faster rate. As evidenced by the spatial results, the resort area of Bigfork, near the northeastern shore of Flathead Lake, is highly likely to



develop rapidly. Based on the results, the unincorporated city of Bigfork and its vicinity is a more attractive area for future development than the incorporated city of Columbia Falls, which is not generally viewed as a resort area. This reflects the idea that a significant portion of new development in Flathead County is occurring and will continue to occur because of the rapid influx of nonpermanent residents into the county.

The spatial results reveal a tradeoff that occurs between the highly restrictive land use policy and the baseline land use policy in regards to the future pattern of development in the county. The tradeoff can most readily be seen by comparing the baseline-high growth scenario results for the 2004-2024 study period to the highly restrictive-high growth scenario results for the same period (see Appendix E). In the highly restrictive scenario, land is preserved in the sense that it is not used for development (the gray area on the map). This is land—either agricultural land or forestland—that will remain in its undeveloped state. Preserving such land may have important implications from an environmental standpoint (e.g., wildlife habitat may be preserved, water quality maintained, etc.). However, when viewing the highly restrictive-high growth map for the 2004-2024 study period, one important consequence of implanting the highly restrictive policy becomes evident. Forcing future residential development to conform to higher densities causes more development to occur at the edges of the urban areas. Another way of stating it is to say that the cities become even more urbanized as people are driven in from the hinterland. This tradeoff revealed by the study results has important public policy implications for decision makers in the county, and is exactly the kind of issue AFA studies are intended to identify. In order to fully frame the issue, more data is needed concerning the potential environmental impacts of future development in the

various scenarios. Data regarding the potential impacts of the scenarios on wildlife habitat in the county is being gathered for use in the decision support tool that is being developed in tandem with the current study. Although the tradeoff revealed in this study is certainly relevant to Flathead County, it may have broader implications as well. A cross-sectional analysis verifying this seemingly counterintuitive result for other areas is warranted.

When considering the map-based results, it is interesting to note how the quintile assumption described in the last paragraph of Section 4.6 affects the spatial distribution of future simulated development. A single scenario was analyzed to determine how the quintile assumption affects the spatial distribution of development, namely the 2004-2014 low economic growth, baseline land use policy scenario. Map results were compared for the selected scenario, with and without the quintile assumption. In general, there was a greater dispersion of the projected rural, exurban, and agricultural development with the quintile assumption. In particular, the quintile approach generally resulted in a more scattered pattern of development for all the development categories, including CI&I. However, one noteworthy exception was observed: a large suburban development north of Columbia Falls was more clustered (i.e., less scattered) with than without the quintile assumption. Maps demonstrating the differences between the results with and without the quintile assumption are accessible online at <http://ims.missouri.edu/montana/recid/analysis3.htm>. The maps demonstrating these differences are only available for the baseline land use policy.

Comparing the map-based results with and without the quintile assumption is an interesting exercise although it fails to prove which of the two parcel conversion

procedures is superior. As previously stated, the quintile assumption, patterned after a previous study by Steinitz et al. (2003), was used in order to simulate certain aspects of the local real estate market. Both sets of results, with and without the assumption, are equally plausible and are thus equally valid. Moreover, both sets of results point to development occurring in or near the same general areas of the county: Kalispell, Whitefish, Columbia Falls (including Hungry Horse), Whitefish Lake, Bigfork and the northern and western shore of Flathead Lake. These areas are indeed the fastest growing parts of the county. Whether or not the development pattern is ultimately more clustered or more scattered will depend on the bargaining power of developers, the willingness of sellers to sell, and other vagaries of the local real estate market.

As part of the county's growth policy a land use map was developed for Flathead County representing current use in 2006 (Flathead County Planning and Zoning Office Online 2007a).<sup>24</sup> The land use map, developed by Flathead County Planning and Zoning, utilizes different land use categories than the RECID model, and the land uses are based on zoning classifications rather than actual uses. Still, even a cursory viewing of the 2006 map, depicts development occurring in the same broad pattern as the basic pattern indicated by the RECID simulations, with the majority of development occurring near the three incorporated cities, around Whitefish Lake, and along the major travel routes near the incorporated cities. The 2006 land use map, it should be noted, does not foretell the growth indicated by the RECID simulations for the area north of Flathead Lake near Bigfork.

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<sup>24</sup> The 2006 land use map developed by Flathead County Planning and Zoning may be accessed at [www.co.flathead.mt.us/fcpz/Growth%20Policy/Present%20Land%20Use%20in%20Flathead%20County%20\(Valley\).jpg](http://www.co.flathead.mt.us/fcpz/Growth%20Policy/Present%20Land%20Use%20in%20Flathead%20County%20(Valley).jpg).

### **6.3. Limitations of the Study Methodology**

The RECID model uses modeling approaches that are consistent with existing models of land use change. Its components generally resemble components of existing models, but they are assembled in a unique manner. Furthermore, the RECID model can be viewed as state-of-the-art because it resembles other models developed in recent years. No land use change modeling approach has emerged that is deemed to be superior to all other approaches. In fact, at present, there is no agreed upon best approach to land use change modeling.

Helen Briassoulis (2000) would likely contend that the RECID model lacks rigorous theoretical underpinning, a comment she made regarding many of the models of land use change she reviewed. For example, in modeling the supply and demand of acreage for residential or commercial development, RECID does not explicitly take into account land values (i.e., the market prices of land). Ideally, the more attractive parcels of land would be valued at higher prices and those prices would be among the attributes considered when ranking the relative attractiveness of various parcels for development, which implies the developer is interested in an attractive piece of land and is concerned about price. Stating that the model lacks an explicit underlying theory is more an observation than a criticism. The models Briassoulis reviewed that utilize existing theory in an explicit and rigorous way, such as the economic utility maximization models, were criticized because of their restrictive, unrealistic assumptions. In the study of land use change, at present, there is a trade off between theoretical grounding and grounding in reality. In a model like RECID, which is being developed for practical application, erring in the latter direction seems preferable. Additionally, as has been previously discussed,

since there is no unifying theory of land use change, it is unclear what theoretical framework should be used in modeling land use change.

In this study, land use is examined at one spatial scale, the county level. This can be viewed as a limitation. Verburg et al. (2002) believe that a model of land use change should meet certain requirements in regards to spatial scale, namely that “[m]odels should not analyze land use at a single scale, but rather include multiple, interconnected spatial scales because of the hierarchical organization of land use systems.” In particular, land use change decisions during the forecast period could be affected by changes in macroeconomic variables such as business cycle fluctuations and changes in interest rates (the latter potentially affecting the availability of capital for commercial or residential development). National policies can also impact land use in the county, such as federally mandated environmental restrictions or changes in immigration policies. Houghton (1994) even suggests that the global economy and international trade are important agents in land use change. The RECID model does not directly capture the effects on land conversion of factors operating at higher spatial scales.

Because the economic portion of RECID is based on IMPLAN, a more complete discussion of IMPLAN’s weaknesses is warranted. IMPLAN uses various multipliers to account not only for an initial change in spending or output, but also for subsequent rounds of spending spurred by the initial change. Since the multiplier effects are incorporated into the model, IMPLAN projects changes in employment levels in a more sophisticated and realistic way than would a simple regression model relating changes in output to changes in employment. Despite this fact, IMPLAN is limited by the linearity assumption; a limitation that holds for most statistical models. Propst (2000), who used

IMPLAN to assess economic impacts of recreation and tourism, summed it up well: “[e]conomic impacts (i.e., sales, income, jobs, etc.) grow in direct proportion to the number of tourists or recreationists that are attracted to a region. There are no implicit constraints to this growth, yet environmental and social systems cannot withstand unlimited human impact.” As part of the linearity assumption, IMPLAN assumes that technology does not change over the forecast period (i.e., production functions are constant over time) (Lazarus et al. 2002). This assumption may be valid for short time intervals, but not for long time intervals. Additionally, it should be noted that IMPLAN’s production function coefficients for each industry are based on national averages, and that, “[w]hile IMPLAN has a very high level of disaggregation (528 sectors), it is still forced to aggregate the production functions of related sectors” (Lazarus et al. 2002). To the degree that production processes in the study region deviate from national trends and an industry’s production process is subsumed under that of another (related) industry, the production function coefficients utilized in the IMPLAN matrix will yield inaccurate projections of output and employment changes.

Another limitation of IMPLAN is that it cannot predict the entry of new industries in a region. For example, the Flathead County IMPLAN model includes 182 industries in 2000, but only 170 industries in 1990. The emergence of 12 additional industries in the study area over a 10-year period did not occur because the model predicted those industries would emerge; rather the industries appeared in 2000 because the data were updated. Thus, to the extent the industries in the study area change over time, IMPLAN will not capture such growth or the associated increases in employment.

Many of IMPLAN's limitations are difficult to alleviate, although an attempt was made to correct one of its larger weaknesses, as described in Section 4.4 of Chapter 4. Nonetheless, these limitations should be kept in mind when viewing results of the model. For example, the intermediate-term projections may be viewed as being more reliable than the longer-term projections. Perhaps IMPLAN's greatest strength is the validation it has received through its level of acceptance across various disciplines. IMPLAN appears to be the most widely utilized regional economic computer-based input-output model in existence. According to Ransom and Buland (2000), "Over 500 clients across the country use the IMPLAN model." Utilizing its various data sources, the Minnesota IMPLAN Group, Inc. "extrapolates and interpolates data as necessary in order to create a database which blends the best of each data source in order to produce data which are consistent at county, state, and local levels" (Ransom and Buland 2000). Because of its sophisticated treatment of interactions among various sectors of the regional economy and its wide use and acceptance among regional economists, IMPLAN provides a suitable framework for modeling economic changes in Flathead County, despite its inherent limitations.

The RECID model shares some of the same limitations as other land development simulation models. As mentioned in Chapter 3, Section 3.1, limitations of the Steinitz et al. (2003) development model include the fact that future road and infrastructure development in the study area and the impact of growth in areas immediately adjacent to the study area are ignored. Future road and infrastructure development was not entirely disregarded in developing RECID. One road, whose development was imminent, was manually added to the initial GIS map of the study area. However, no attempt was made to project the location of other future road developments. Regarding other future

infrastructure, it was assumed that sewer infrastructure, and by default other utility infrastructure, will be built within the planned growth boundaries of the county's incorporated cities. No attempt was made to project the location of future utility infrastructure in areas outside the incorporated cities' growth boundaries, which constitute the majority of the county's developable land area. As with the Steinitz development model, the impact of growth in areas adjacent to the study area was not explicitly modeled in RECID, which harkens to the previous discussion regarding modeling land use change at only one spatial scale.

As mentioned in the Chapter 3, Section 3.2.2, several limitations of Landis' (1995) CUF model are also limitations of the RECID model, namely: (1) the model is not required to reach any sort of equilibrium in the market for land or housing; (2) excess demand does not feed back into housing prices or land costs; and (3) it is not a spatial-interaction model because it ignores travel times or costs. The first two factors are among the larger weaknesses of RECID. That the model is not required to reach equilibrium is largely due to the fact that the model does not rest strictly on economic theory. Although RECID simulates demand for land by considering factors that directly influence land purchase decisions, land and housing prices were not explicitly included in the model because the necessary data were unavailable for the study area.

The RECID model does not account for other forms of feedback. For example, it is conceivable that over some time interval— particularly longer intervals—feedback would occur between previous and current land use policies. RECID assumes that policy decisions related to land use change are in effect throughout the simulation period (i.e., policymakers do not modify policy decisions based on the outcomes of those policies).



For shorter time intervals, such feedback effects can be safely assumed away, but over longer time intervals it is not reasonable to assume that policy makers do not adjust policies, particularly knowing their propensity to “tinker” with existing policies. In the context of the current results, it is highly unlikely, for example, that the county commissioners would allow the residential development required in the 20-year high-growth projection without making policy adjustments. However, keeping in mind the purpose of the current study and the purpose of an AFA study in general, dynamic policy adjustments of this type could be viewed as being counterproductive. Since the study’s purpose is to allow policymakers and stakeholders to compare various possible future scenarios, it is useful to allow them to examine the potential consequences of a particular policy. Furthermore, the results of AFA can be used to determine when land use policies should be adjusted to avoid land shortages.

Because RECID is a static model of land use change it does not explicitly account for potential spatial interactions, which may be viewed as a limitation. RECID simulates development patterns over a 10- and 20-year time period, and therefore does not account for how development in year 1 impacts development in year 2, and how development in year 2 affects development in year 3, and so on. Adjacent parcels are likely to have similar development attractiveness scores in RECID, a fact which mitigates the spatial interaction issue to some extent. However, this issue is definitely a limitation in regards to future CI&I development given that distance from a commercial center is one of the attributes that determines a parcel’s DAS.

In its simulations, RECID assumes that certain structural factors will remain unchanged. For example, RECID assumes that the proportion of vacation homes (i.e.,

homes owned by nonpermanent residents) will remain the same over both study periods. RECID also assumes an essentially horizontal pattern of future growth. More specifically, RECID assumes that the housing density classes currently contained in the county zoning regulations do not change over the study period to accommodate even higher densities (i.e., a more vertical pattern of growth).

Regarding simulating future CI&I development, RECID projects the number acres required per new job on an aggregate basis. As different sectors require varying amounts of space per new job, projecting CI&I acreage requirements on a disaggregated, sector-by-sector basis would be warranted. However, such disaggregated data (i.e., acres per job by sector) are not available.

In general, RECID shares many of the same limitations as other past and current models of land use change. Some of these limitations are inherent in nearly all static models. Some of RECID's limitations cannot be easily corrected or addressed without greatly increasing the computational complexity of the model; inevitably, adding such complexity would create additional problems. Many of the model's limitations can be addressed in future research (areas for future research are discussed in Section 6.5).

#### **6.4. Contribution**

Land use change is an increasingly important field of study, particularly its ecological implications. Since the early 19<sup>th</sup> century various theories of land use and land use change have appeared. As outlined in Chapter 3, theories of land use change have come from such diverse fields as economics, urban and regional science, sociology, political economy, social physics, environmental history, environmental/cultural

anthropology, environmental psychology, biology, ecology, and geography (Briassoulis 2000). To varying degrees each discipline offers useful insights into the causes and processes of land use change. However, to date, a single unifying theory has not been developed that integrates the important insights from multiple disciplines. Without a comprehensive, tested theory of land use change, the development of land use change models has been a challenging endeavor. Each model tends to focus on a few of the relevant determinants of land use change, often ignoring or assuming away other potentially important drivers of the land use change. Economic models are criticized for their reliance on a set of rigid and often unrealistic assumptions. Models from the natural sciences are criticized for their failure to adequately incorporate socio-economic variables. Models that focus on achieving realistic/practical/useful results—primarily by using historical land use change patterns to predict or simulate future changes in land use—are faulted for their lack of theoretical grounding in explaining the process of land use change.

The primary contribution of the current study to the literature on methods of analyzing land use change is the proposed method for allocating parcels to developed uses. The method should be particularly appealing to modelers examining study areas for which parcel price data are not available. It should be noted that RECID proposes no new theories of land use change; rather it is based on existing theoretical and modeling frameworks. For example, RECID: (1) uses Markovian transition probabilities and a GIS, both widely used in the field of land use change modeling; (2) produces spatially explicit output in a GIS format, a requirement for any modern day land use change model if its results are to be practically applied; (3) utilizes historical land use change data as input

and information provided by stakeholders and decision makers involved in the land use change process; and (4) incorporates assumptions about future conditions in the study area. Although the RECID model shares many common attributes with existing land use change models, and existing AFA studies, to the author's knowledge it is the first to combine the particular methodologies utilized in the current study. Almost all current-day land use change models employ a GIS, but the manner in which development attractiveness scores are calculated and then adjusted for historical land cover change using transition probabilities is unique to RECID. Although there is no way to easily demonstrate that this assumption achieves more realistic results it offers much in the way of conceptual appeal. The Steinitz et al. (2003) development model, on which the RECID allocation model is based, is thus improved up in the sense that the development attractiveness scores calculated for each parcel are adjusted for historical changes in land cover. This combination of techniques in land unit allocation is not only unique within the broader field of land use change modeling, but also within much narrower field of AFA studies. Additionally, the particular suite of land use policies considered in developing the alternative futures is unique to this study. To the author's knowledge, RECID is the first land use change model to use IMPLAN to estimate the economic impacts of development and use those estimates to simulate future land use change. Based on discussions with Montana state officials, it appears that the RECID model is the first full-scale land use change simulation model developed for any portion of the state of Montana.

The study results hold many implications for public policy in the study area. Increasingly, local governments are using GIS tools for land-use planning (O'Looney

2000). The economic and land use results of the current study are being incorporated into a web-based decision support tool that the developers, planners, and other stakeholders of Flathead County may use to simulate the effects of different policies on economic growth and employment, land use, and wildlife habitat. Specific public policy implications of the study results include the following:

- 1) The single most important determinant of future acreage requirements is the rate of economic growth.<sup>25</sup> From a policy standpoint, the rate of economic growth is the variable county policymakers have the least ability to influence directly, although measures intended to attract businesses—such as those typically carried out by the Flathead County Economic Development Authority (e.g., relocation incentives)—could be abated or increased as necessary.
- 2) Housing densities are also a key determinant of future acreage usage (see Table 18 and the discussion in Section 6.1). Local policymakers have more direct control over housing densities permitted in various locations in the county; however, the spatial results reveal an important tradeoff that must be considered in any decision to adjust density requirements. Although forcing development from lower density classes into higher density classes preserves farm and forestland in the hinterland (and perhaps some key environmental amenities), it leads to increased build-up on parcels adjacent to the urban areas. Some of this

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<sup>25</sup> Sensitivity analysis of the results of RECID’s economic model reveals that a 10 percent increase in the growth rates leads to an increase in acres required of 15 to 23 percent, depending on the alternative future being examined. Increasing other variables in the economic model (persons per household, population-to-jobs ratio, housing units-to-households ratio) leads to a change in acres required of 9 or 10 percent (also see Table 17 and the discussion in Section 6.1).

build-up could be alleviated through efforts to increase the amount of infill development in the cities.

- 3) None of the alternative futures in either study period require implementation of the highly restrictive land use policy in order to avoid unsustainable outcomes. The low and moderate growth scenarios in the 2004-2014 study period, and the low growth scenarios in the 2004-2024 study period, do not even require the moderately restrictive land use policy in order to avoid unsustainable outcomes (i.e., shortages of land). Thus, the results offer policymakers a potential adaptive management approach to future land use policy in which decisions about land use restrictions are made and adjusted based on actual growth rates in the county. The results indicate that if growth in the county occurs at or above the rates in the high growth scenario, measures may be needed to prevent unsustainable outcomes.
- 4) The spatial results indicate that development will continue to occur in the fastest growing areas of the county, regardless of the growth rate and the land use policy employed. In particular, the resort town of Bigfork on the northeastern shore of Flathead Lake is a prime location for future development and all the alternative futures indicate significant development in this area.
- 5) The tabular results, particularly the estimates of job increases, may be considered on a disaggregated basis. The estimated job increases may be analyzed across sectors and used to help formulate the county's

economic development strategy. County planners may wish to focus economic development efforts on attracting specific industries or industry types based on the estimates. In particular, planners could employ an adaptive management strategy (similar to the one discussed above) to the issue of job growth, either in aggregate or in the various sectors.

Ideally the web-based decision support tool will result in a better-informed citizenry, better-informed policymakers, and better land use policy for Flathead County. The decision support tool may prove especially useful to county officials and stakeholders in implementing the new growth policy for Flathead County, which was developed during the course of this study and which replaces the county's existing master plan. Work on the growth policy was initiated to bring the county into compliance with Montana Senate Bill 97 and Section 76-1-601 of the Montana Code Annotated (MCA), which requires the growth policy to include "community goals and objectives; maps and text describing an inventory of the existing characteristics and features of the jurisdictional area, including: land uses, population, housing needs, economic conditions, local services, public facilities, natural resources, and other characteristics and features proposed by the planning board and adopted by the governing bodies." The growth policy is also required to include projected trends for the life of the policy for most of the above-mentioned elements. In addition to these elements, the growth policy must include a description of policies, regulations, and other measures to be implemented in order to achieve the established goals and objectives (Montana Legislative Services 2001).

One of the main purposes of this study was to engage the community in a discussion of land use issues facing the county. The study has begun to achieve its intended purpose. In September 2007, a workshop was held with stakeholders in Flathead County during which the basic methods and results of the study were presented and discussed. The stakeholders were shown the prototype of the decision support tool that is being developed in the current study, which is accessible online at <http://www.cares.missouri.edu/montana/DSS/index.asp>. The workshop was attended by representatives from state and local government, citizens groups, and private interests (see Appendix F for a list of attendees and organizations represented) who were receptive to the study. The presentation generated lively discussion that centered on potential uses of the study results and the decision support tool. As expected, different stakeholders had different ideas regarding uses of the research. For example, representatives from the Montana Department of Environmental Quality expressed interest in using the online tool to study impacts of future development on the quality of water in the Flathead River Basin. The head of the Flathead County Planning and Zoning Office expressed interest in conducting his own analysis of the sensitivity of model results to different assumptions and using RECID to create a predictive map of future growth in the county. A Flathead County commissioner stated that the results verified his belief that higher density development in the future would be necessary to maintain affordable land and housing prices in the county. The commissioner pointed out that it was useful having scientific validation of his long-held views of the county's future. The commissioner also expressed interest in potentially using the tool to study housing affordability and cost of public services in the county. The stakeholders at the workshop discussed other possible



scenarios that could be examined with the RECID model, such as a scenario that combines the higher densities of the highly restrictive land use policy and the unrestrictive setbacks of the baseline land use policy. Since some of the alternative futures simulated in the study indicate potential land shortfalls at some future date, the stakeholders discussed potential ways to avert such shortfalls, such as creating incentives for communities to increase their housing densities and/or expand their growth boundaries.

Recently the Flathead County Planning Board held a public workshop concerning the issue of river and stream setbacks (May 2007). Although lake setbacks currently are not part of the discussion they could presumably be raised as an issue at some point in the future. The RECID model contemplates setbacks to 50 feet for all water bodies. Various stakeholder groups are proposing setbacks of 20 feet (i.e., which would maintain the current setback) up to 300 feet for all Flathead County waterways. Another option would specify a 250-foot setback on the Flathead, Swan, Stillwater, and Whitefish Rivers; a 200-foot setback on Ashley Creek and Pleasant Valley/Fisher River; and a 100-foot setback on all perennial streams (May 2007). From the RECID model results it can be estimated that a 1-foot increase in water body setbacks decreases the amount of land available for development in the county by approximately 900 acres. This estimated number includes setbacks on lakes, but the model could be modified in order to obtain an estimated loss in developable acres per 1-foot increase in river/stream setbacks. Such information can provide valuable insight into discussions regarding changes in the county's water body setbacks.

This study verifies what previous researchers have found regarding the AFA process: there is value in collaboratively designing the broad parameters of the study with contribution of stakeholders in the study area. The fact that groups with such diverse views and backgrounds as those that exist in Flathead County were able to reach consensus on a set of alternative futures and a set of growth rates is significant. Moreover, the mere fact that stakeholders from the county participated in the study generated discussion among the participants that might not have occurred otherwise. For example, members of the stakeholder group FLAG requested that a scenario be simulated that reflects high economic growth and an unrestrictive land use policy, a scenario which was eliminated from the field of possibilities due to its seeming infeasibility.

The RECID model and web-based decision support tool can be used in other areas besides Flathead County. The RECID model can be employed in any area for which similar data are available.<sup>26</sup> For Flathead County, the RECID model can be updated as new data become available, and used to simulate patterns of land use change and associated economic and ecological impacts well into the future. Furthermore, the simulation results provided by RECID are already being used in related studies in Flathead County. One such study involves analyzing the potential impacts of future climate change on agricultural production in the county. A proposal has been developed to examine the interactions among future climate change, land use change, and wildfire risk in the county's wildland-urban interface areas. The proposed project would use the RECID model to simulate the effects of future land use change in the interface areas.

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<sup>26</sup> However, some assumptions of the RECID model may need to be modified to include factors relevant to the study area.

## 6.5. Directions for Future Research

Although it is beyond the scope of the current study, development of a more dynamic version of RECID would be useful. In particular, the model can be strengthened by incorporating constraints to growth in the form of market feedback. Since the data required for a market feedback mechanism are not currently available for the study area, such an adaptation could be considered at some point in the future for Flathead County, as data become available, or in a parallel model created for another study area.

It would also be useful to incorporate a feedback mechanism that automatically adjusts future land use policy based on projected future outcomes, which is essentially an adaptive management approach to land use policy.<sup>27</sup> Currently a theoretical framework for analyzing the relationships among various institutional-political factors and land use change is lacking (e.g., NCGIA 2001), even though many developers of land use change models acknowledge the importance of the effects of institutional-political factors on land use change. Hubacek and Vazquez (2002) state it well when they note: “Institutional factors set the frame influencing (economic) behavior. Contributing to this institutional setting are cultural, economic, political, religious, social, and traditional factors, as well as organizations, representing manifestations of how things are done in a society. Public regulations, such as community plans, zoning ordinances, rent controls, subdivision regulations, building codes, and laws pertaining to mortgage finance shape the development and use of real property.”

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<sup>27</sup> It should be noted that such a revision would make the model more predictive in nature and thus not wholly suitable for an alternative futures analysis.

Future research should be conducted into the impact of institutions on land use change. Useful research in this direction would explore the ways in which relevant institutions react to various land uses, both what causes the reactions and what form (e.g., what specific policies) those reactions take. Ultimately models of land use change should strive to include institutions, particularly those that shape land use policy, as endogenous features of the models.

The results reported here will hopefully prove useful to stakeholders in developing policies related to economic growth and land use in Flathead County. However, some stakeholders may have difficulty interpreting some of the results. In particular, the spatial results may be difficult to interpret without having some experience with GIS tools. A framework could be developed that would allow easier comparisons among the projected scenarios. One possibility is to compare alternative futures using the tools of welfare economics. Such an analysis would take the form of a cost-benefit analysis, with a final dollar value attached to each alternative future representing the net social benefit of that scenario to the county. In addition to an assessment of the overall net benefit to the county, the analysis could include monetary impacts on various groups of stakeholders in the county. Completing a cost-benefit analysis of this type would be possible, though it would require the collection of copious amounts of data. The RECID model includes simulations of job growth, but contains no information regarding wages. Wage data for each economic sector in the county would be necessary in order to estimate the monetary impact of job creation for alternative futures. The RECID model also includes simulations of housing units developed, but no data regarding construction costs or land values before and after development. Such data would be necessary to

estimate the monetary impact of residential development under each scenario. Similar data would also be required to estimate the monetary impacts of commercial development for alternative futures. Ideally data regarding wages, construction costs, and land values can be obtained for the study area. But the scenarios include several features or attributes for which monetary data do not exist. For such attributes, extensive contingent valuation (CV) studies would be required to develop estimates of the monetary impacts of, for example, protecting wildlife habitat or preserving open spaces.

An alternate framework for comparing alternative futures is to use multiple criteria evaluation (MCE). MCE is part of a suite of analytical decision making techniques that does not require all decision criteria to be expressed in the same units. In particular, it does not require assigning monetary values to intrinsically non-monetary attributes, such as the impacts of land use change on wildlife habitat. Herath and Prato (2006) contend that “[MCE] techniques have emerged as a major approach for solving natural resource management problems and integrating the environmental, social, and economic values and preferences of stakeholders while overcoming the difficulties in monetizing intrinsically non-monetary attributes.” MCE techniques allow stakeholders in a given decision context to identify and quantify the tradeoffs implied by different management decisions.

In the context of the current study, MCE can be used to integrate various economic, environmental, and social/political impacts of land use change that have a significant bearing on an individual’s quality of life. The quality-of-life attributes can be tied directly to data that are readily available and quantifiable. Various techniques exist for allowing decision makers/stakeholders to rank their preferences regarding the

attributes of particular land use changes. MCE can be used to determine a particular preference ranking for a set of alternative futures for each stakeholder. Such a framework can be incorporated in the decision support tool, thereby allowing a user of the tool to input preferences for quality-of-life attributes and immediately have a complete ranking of alternative futures corresponding to those preferences. The advantage of using an MCE approach is that it would overcome some of the difficulties that arise when attempting to use traditional welfare economics, particularly those problems that arise in trying to monetize non-monetary attributes.

Lastly, since the study of land use change is still a relatively new field, its basic theory requires much in the way of verification and fortification. Models of land use change have proven to be so useful that they are being developed even absent a sound unified theory of land use change. Scientists from many disciplines must continue to seek a theory that employs the most salient insights from those disciplines, a theory that has significant explanatory power and survives the scrutiny of rigorous empirical testing. As theoreticians who study land use and land use change come closer to developing a unified theory of the land use change process, and as empiricists verify the relevant factors driving the process, models of land use change will become more robust, generating more reliable and more useful results. Until such time, land use change modeling will remain at least as much an art as it is a science.

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# Appendix A

**Panel Members for Economic Growth Scenarios  
(Flathead Landscape Analysis Group)**

Ronald Buentemeier, General Manager, *Stoltz Land and Lumber Company*

Gary Hall, *Montanans for Multiple Use*

Fred Hodgeboom, President, *Montanans for Multiple Use*

Marcy Mahr, Ecologist and science advisor, *Yukon to Yellowstone Conservation Initiative*

Tony Prato, Economist, *University of Missouri*

Mary Riddle, Environmental Protection and Compliance Specialist, *Glacier National Park*

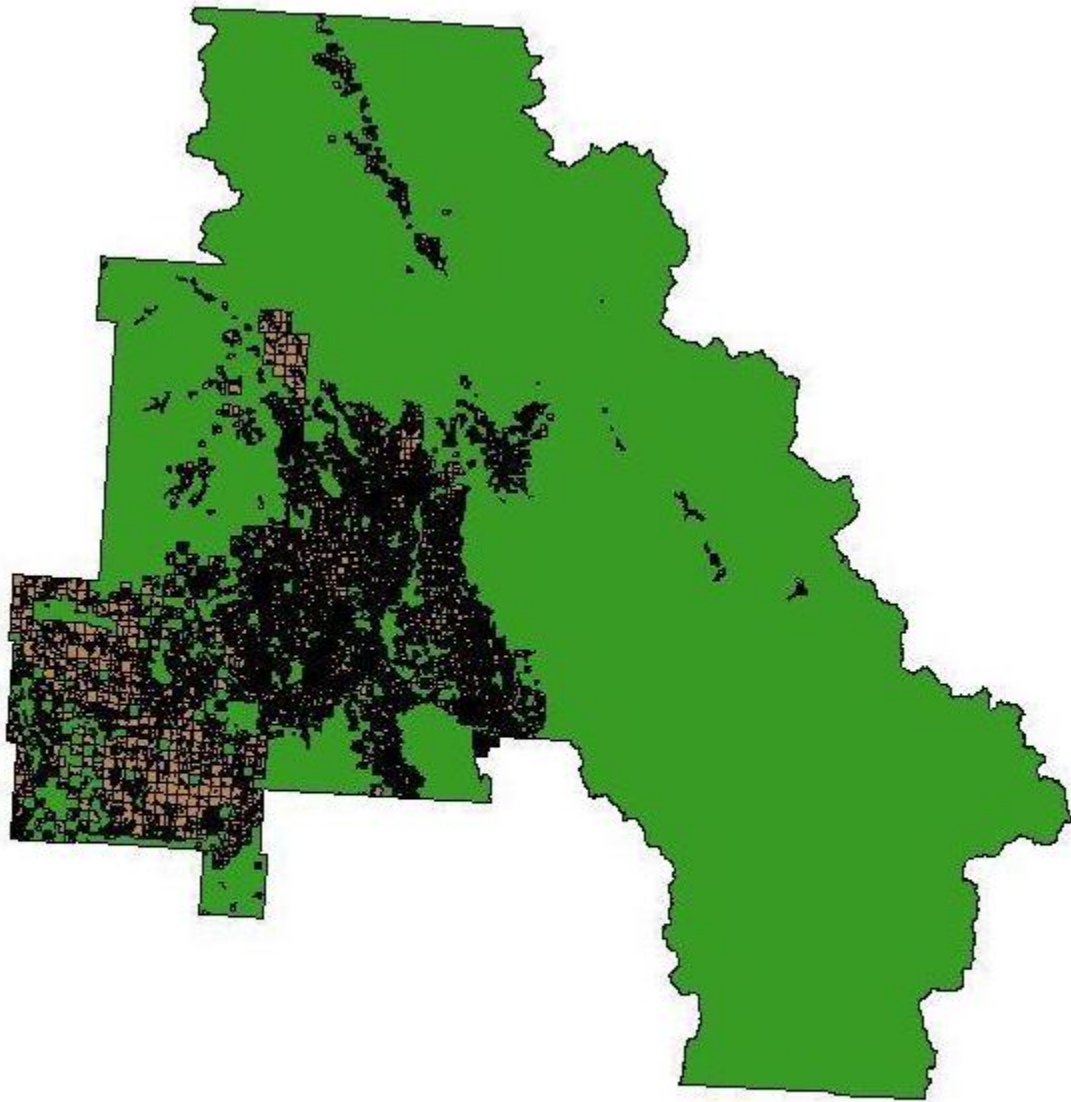
Constanza von der Pahlen, Critical Lands Project Leader, *Flathead Lakers*

Leigh Welling, Director, *Crown of the Continent Research Learning Center-  
Glacier National Park*



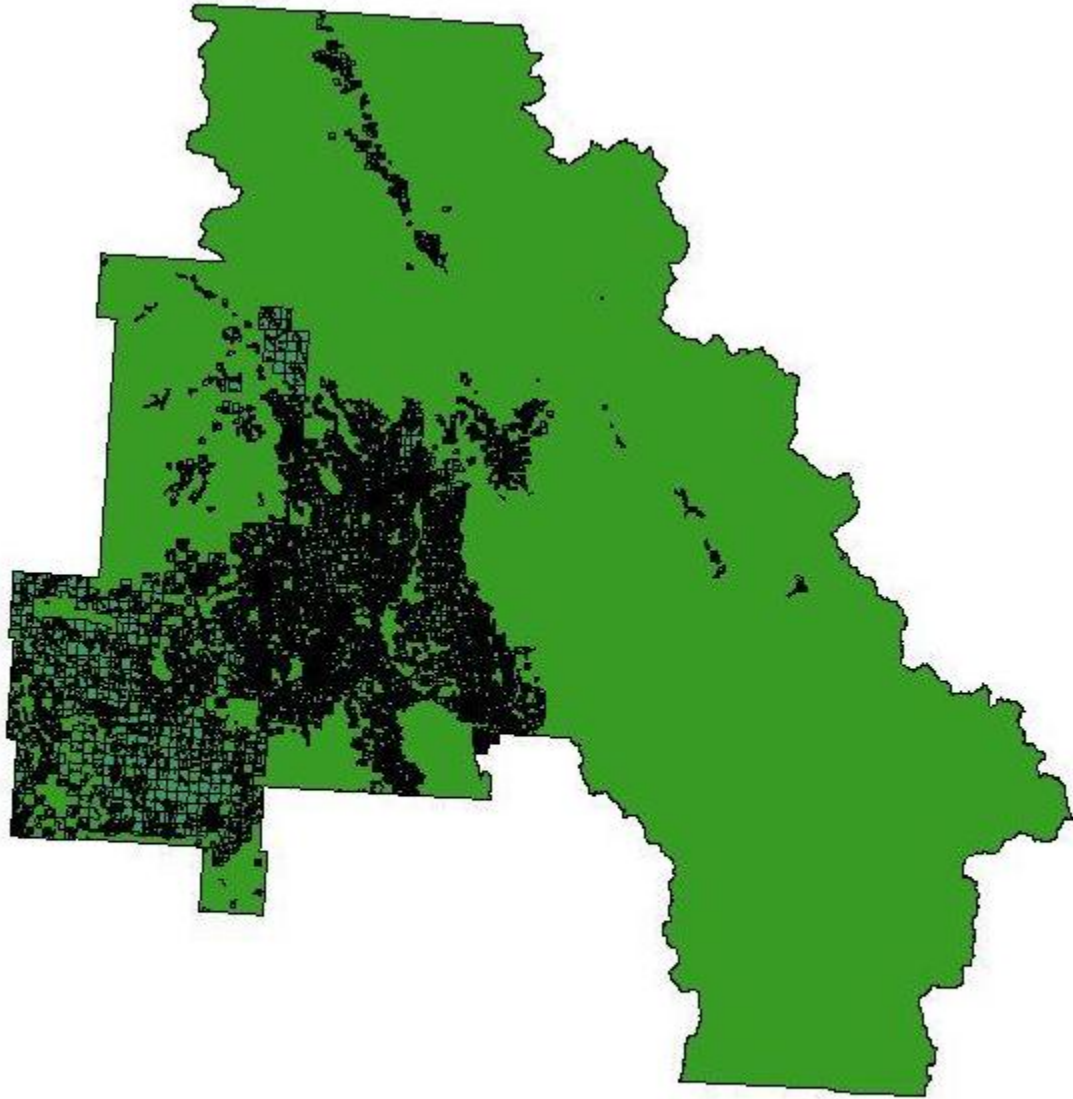
## **Appendix B**

# Developable Parcels – Baseline



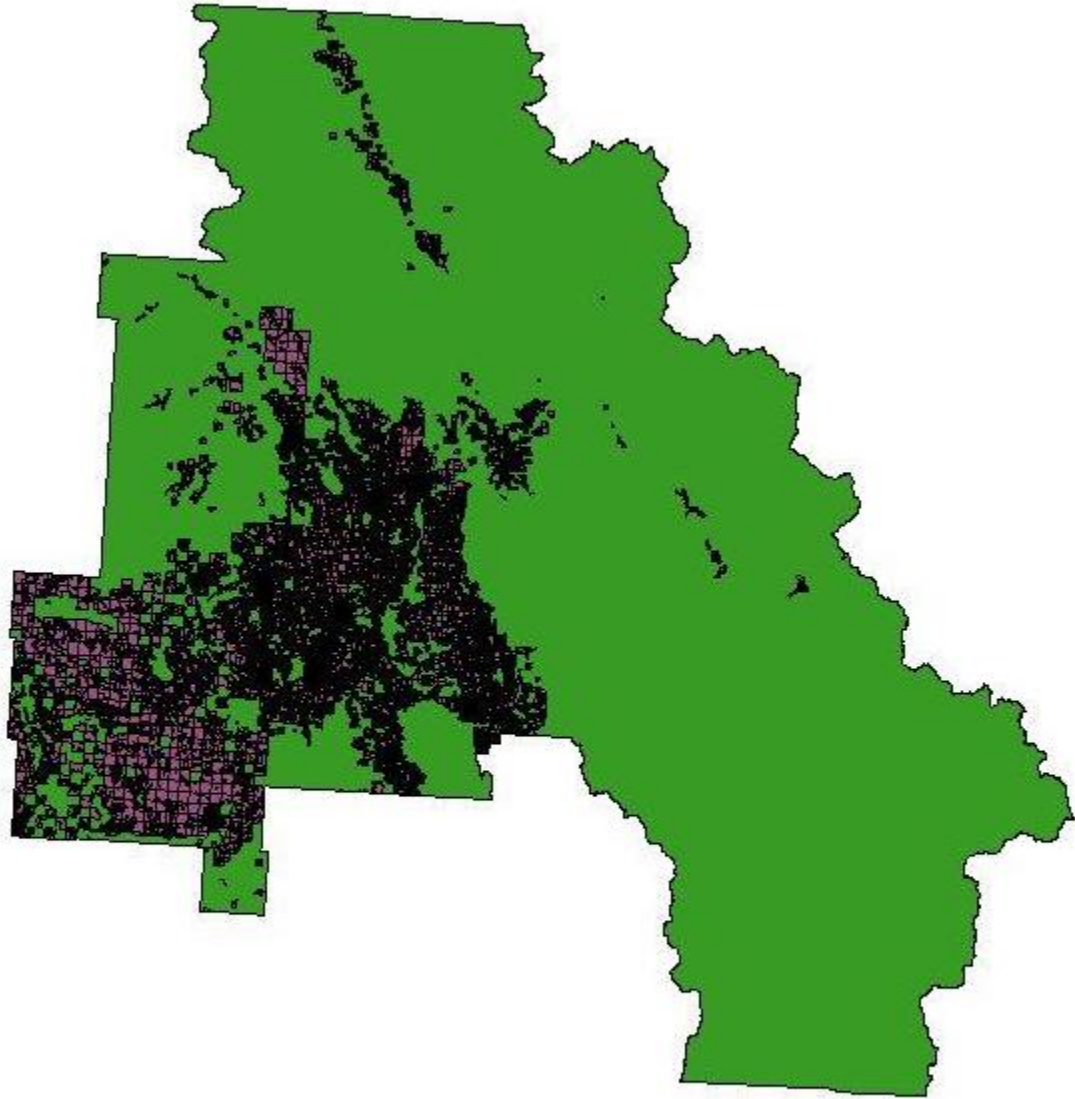
 **Developable  
Parcels**

# Developable Parcels – Moderately Restrictive



 **Developable  
Parcels**

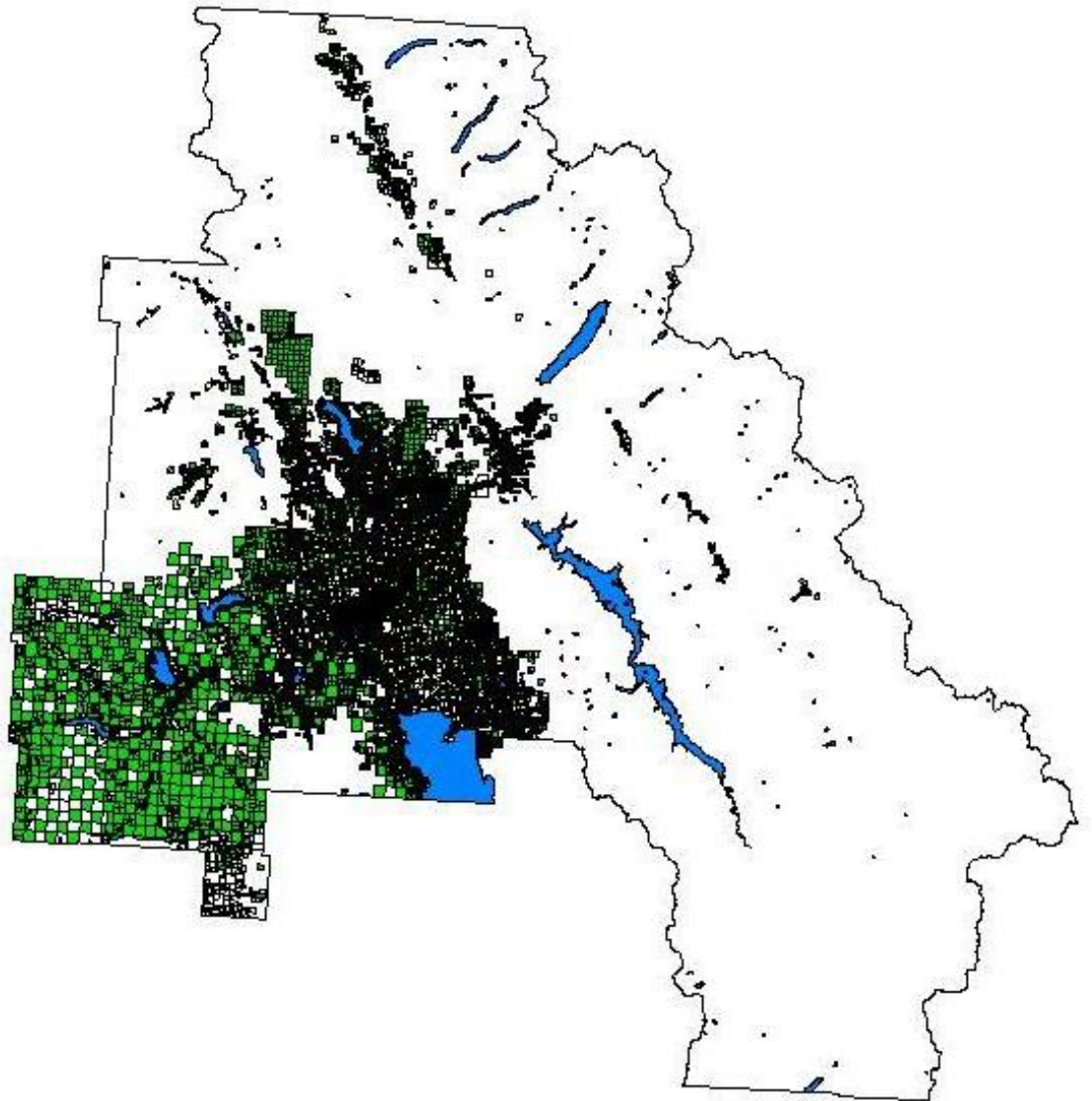
# Developable Parcels – Highly Restrictive



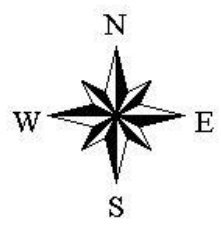
 **Developable  
Parcels**

## **Appendix C**

# Flathead County - Land Use 2005



- Agriculture
- CI&I
- Exurban
- High Dens
- No Data
- Rural
- Suburban
- Urban



## **Appendix D**

## **Aggregation Scheme** **(11 Major Sectors are in boldface)**

### Sector # **Farming and Ranching**

- 1 Dairy Farm Products
- 3 Ranch Fed Cattle
- 4 Range Fed Cattle
- 5 Cattle Feedlots
- 6 Sheep, Lambs and Goats
- 7 Hogs, Pigs and Swine
- 9 Miscellaneous Livestock
- 11 Food Grains
- 12 Feed Grains
- 13 Hay and Pasture
- 16 Fruits
- 18 Vegetables
- 21 Oil Bearing Crops
- 23 Greenhouse and Nursery Products
- 25 Commercial Fishing
- 27 Landscape and Horticultural Services

### Sector # **Agricultural, Forestry, and Fishery**

- 26 Agricultural, Forestry, Fishery Services

### Sector # **Mining**

- 34 Metal Mining Services
- 37 Coal Mining
- 38 Natural Gas & Crude Petroleum
- 40 Dimension Stone
- 41 Sand and Gravel

### Sector # **Construction**

- 48 New Residential Structures
- New Industrial and Commercial
- 49 Buildings
- 50 New Utility Structures
- 51 New Highways and Streets
- 52 New Farm Structures
- 54 New Government Facilities
- 55 Maintenance and Repair, Residential
- Maintenance and Repair Other
- 56 Facilities
- Maintenance and Repair Oil and Gas
- 57 Wells



Sector # **Manufacturing**

- 22 Forest Products
- 24 Forestry Products
- 58 Meat Packing Plants
- 59 Sausages and Other Prepared Meats
- 65 Fluid Milk
- 67 Canned Fruits and Vegetables
- 68 Dehydrated Food Products
- 82 Confectionery Products
- 87 Soybean Oil Mills
- 91 Malt Beverages
- 97 Canned and Cured Sea Foods
- 108 Broadwoven Fabric Mills and Finishing
- 127 Textile Bags
- 132 Fabricated Textile Products, N.E.C.
  - Logging Camps and Logging
- 133 Contractors
- 134 Sawmills and Planing Mills, General
- 137 Millwork
- 138 Wood Kitchen Cabinets
- 139 Veneer and Plywood
- 140 Structural Wood Members, N.E.C
- 144 Prefabricated Wood Buildings
- 145 Wood Preserving
- 146 Reconstituted Wood Products
- 147 Wood Products, N.E.C
- 148 Wood Household Furniture
- 160 Furniture and Fixtures, N.E.C
- 174 Newspapers
- 175 Periodicals
- 176 Book Publishing
- 178 Miscellaneous Publishing
- 179 Commercial Printing
- 199 Toilet Preparations
- 203 Fertilizers, Mixing Only
- 209 Chemical Preparations, N.E.C
- 220 Miscellaneous Plastics Products
- 229 Leather Goods, N.E.C
- 241 Pottery Products, N.E.C
- 243 Concrete Products, N.E.C
- 244 Ready-mixed Concrete
- 247 Cut Stone and Stone Products
- 258 Steel Pipe and Tubes
- 261 Primary Aluminum
  - Nonferrous Wire Drawing and
- 267 Insulating
- 269 Brass, Bronze, and Copper Foundries
- 276 Hand and Edge Tools, N.E.C.

278 Hardware, N.E.C.  
285 Sheet Metal Work  
286 Architectural Metal Work  
297 Small Arms Ammunition  
306 Fabricated Metal Products, N.E.C.  
314 Elevators and Moving Stairways  
317 Industrial Trucks and Tractors  
327 Woodworking Machinery  
331 Special Industry Machinery N.E.C.  
354 Industrial Machines N.E.C.  
    Radio and Tv Communication  
373 Equipment  
385 Truck and Bus Bodies  
389 Aircraft  
391 Aircraft and Missile Equipment,  
393 Boat Building and Repairing  
395 Motorcycles, Bicycles, and Parts  
397 Travel Trailers and Camper  
403 Mechanical Measuring Devices  
413 Photographic Equipment and Supplies  
415 Jewelry, Precious Metal  
417 Jewelers Materials and Lapidary Work  
421 Sporting and Athletic Goods, N.E.C.  
429 Signs and Advertising Displays  
432 Manufacturing Industries, N.E.C.

Sector # **TCPU**

433 Railroads and Related Services  
434 Local, Interurban Passenger Transit  
    Motor Freight Transport and  
435 Warehousing  
436 Water Transportation  
437 Air Transportation  
    Arrangement Of Passenger  
439 Transportation  
440 Transportation Services  
441 Communications, Except Radio and TV  
442 Radio and TV Broadcasting  
443 Electric Services  
445 Water Supply and Sewerage Systems  
446 Sanitary Services and Steam Supply

Sector # **FIRE**

- 456 Banking
- 457 Credit Agencies
- 458 Security and Commodity Brokers
- 459 Insurance Carriers
- 460 Insurance Agents and Brokers
- 461 Owner-occupied Dwellings
- 462 Real Estate

Sector # **Services**

- 463 Hotels and Lodging Places
- 464 Laundry, Cleaning and Shoe Repair
- 465 Portrait and Photographic Studios
- 466 Beauty and Barber Shops
- 467 Funeral Service and Crematories
- 468 Miscellaneous Personal Services
- 469 Advertising
- 470 Other Business Services
  - Photofinishing, Commercial
- 471 Photography
- 472 Services To Buildings
- 473 Equipment Rental and Leasing
- 474 Personnel Supply Services
  - Computer and Data Processing
- 475 Services
- 476 Detective and Protective Services
- 477 Automobile Rental and Leasing
- 478 Automobile Parking and Car Wash
- 479 Automobile Repair and Services
- 480 Electrical Repair Service
  - Watch, Clock, Jewelry and Furniture
- 481 Repair
- 482 Miscellaneous Repair Shops
- 483 Motion Pictures
- 484 Theatrical Producers, Bands Etc.
- 485 Bowling Alleys and Pool Halls
- 487 Racing and Track Operation
  - Amusement and Recreation Services,
- 488 N.E.C.
  - Membership Sports and Recreation
- 489 Clubs
- 490 Doctors and Dentists
- 491 Nursing and Protective Care
- 492 Hospitals
- 493 Other Medical and Health Services
- 494 Legal Services
- 495 Elementary and Secondary Schools
- 497 Other Educational Services

498 Job Trainings & Related Services  
499 Child Day Care Services  
500 Social Services, N.E.C.  
501 Residential Care  
502 Other Nonprofit Organizations  
503 Business Associations  
504 Labor and Civic Organizations  
505 Religious Organizations  
506 Engineering, Architectural Services  
507 Accounting, Auditing and Bookkeeping  
508 Management and Consulting Services  
    Research, Development & Testing  
509 Services  
525 Domestic Services

Sector # **Government**

512 Other State and Local Govt Enterprises  
513 U.S. Postal Service  
514 Federal Electric Utilities  
519 Federal Government - Military  
520 Federal Government - Non-Military  
522 State & Local Government - Education  
    State & Local Government - Non-  
523 Education

Sector # **Wholesale Trade**

447 Wholesale Trade

Sector # **Retail Trade**

448 Building Materials & Gardening  
449 General Merchandise Stores  
450 Food Stores  
451 Automotive Dealers & Service Stations  
452 Apparel & Accessory Stores  
453 Furniture & Home Furnishings Stores  
454 Eating & Drinking  
455 Miscellaneous Retail

## **Appendix E**

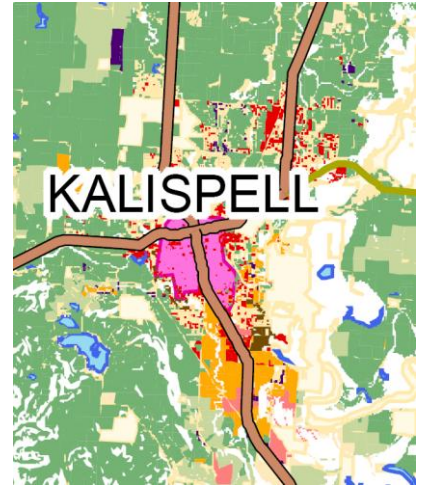
# 2004-2014

## Baseline

Low Growth

Moderate Growth

High Growth

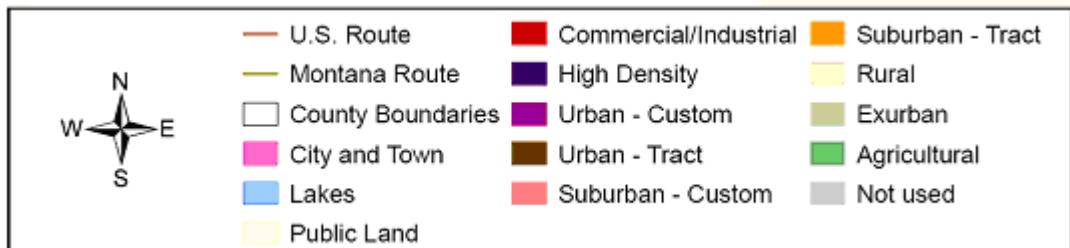
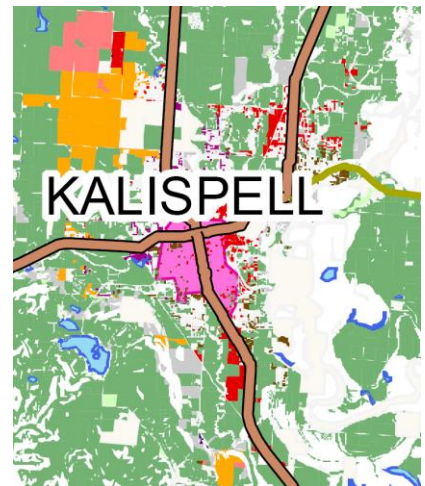
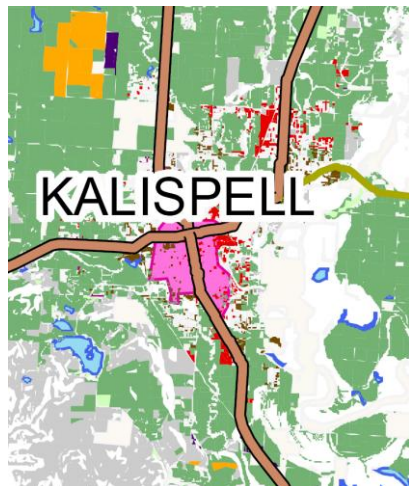
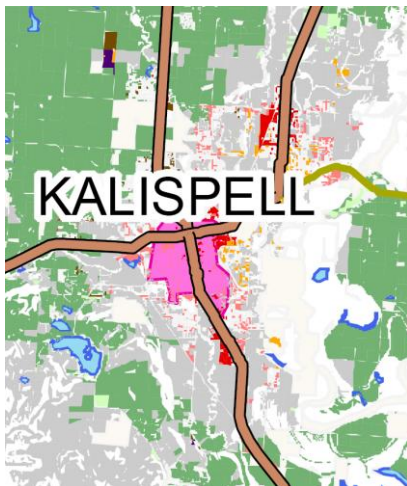


## Moderately Restrictive

Low Growth

Moderate Growth

High Growth

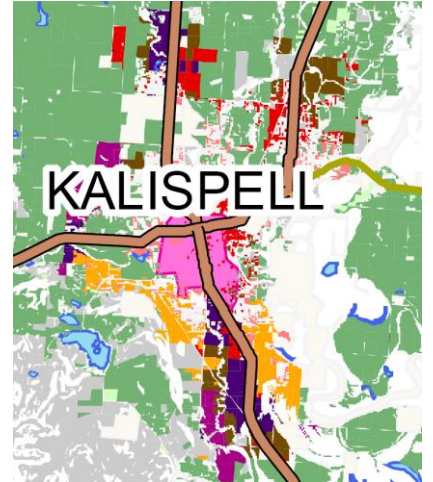
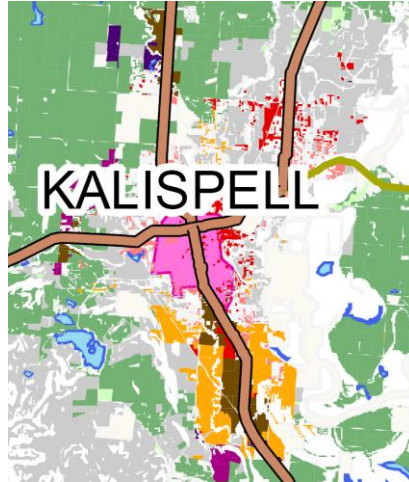
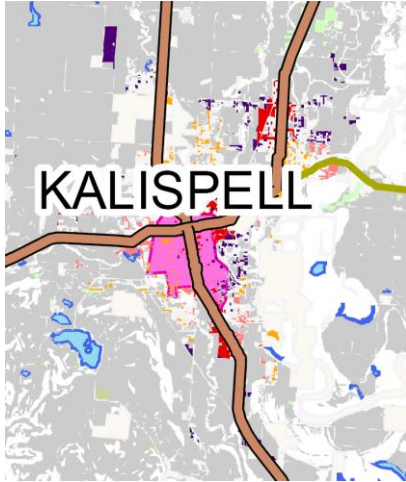


**Highly Restrictive**

Low Growth

Moderate Growth

High Growth



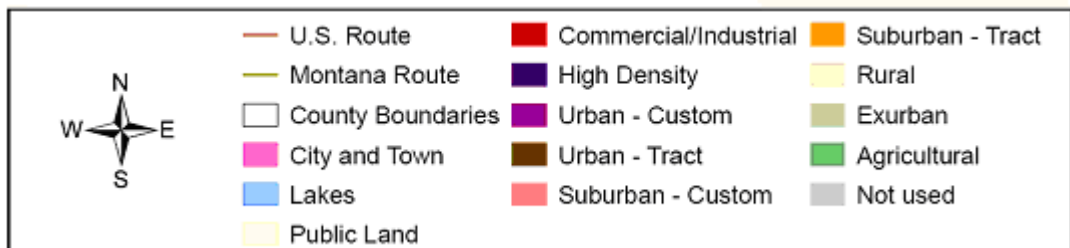
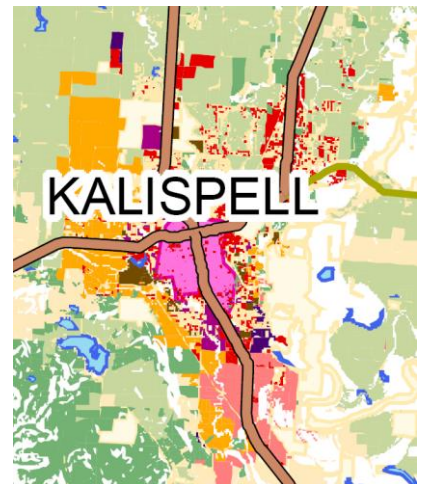
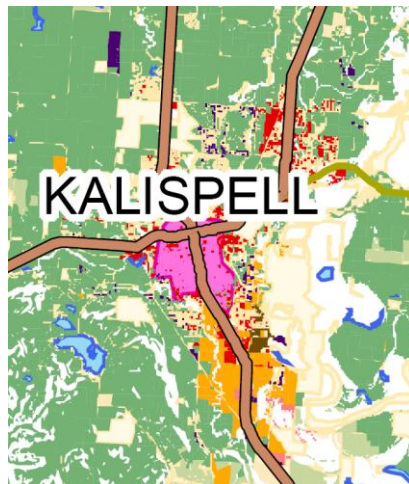
**2004-2024**

**Baseline**

Low Growth

Moderate Growth

High Growth

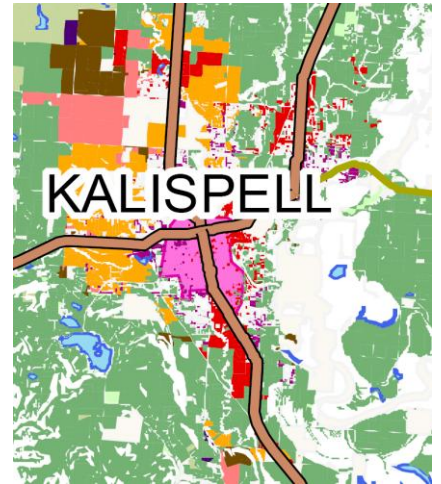
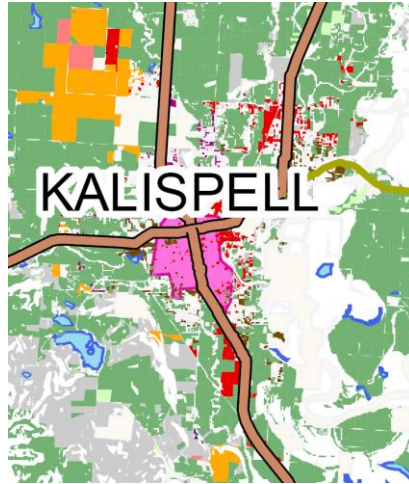


## Moderately Restrictive

Low Growth

Moderate Growth

High Growth

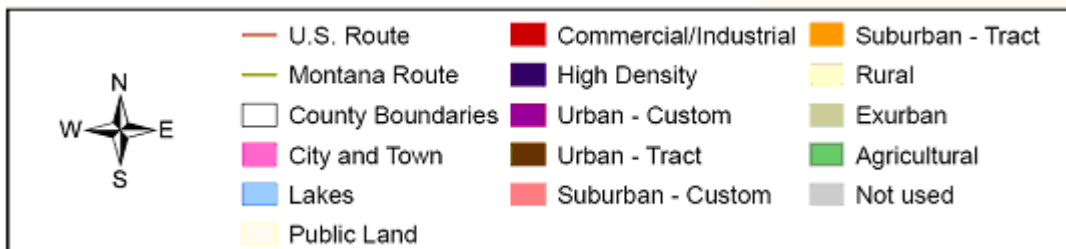
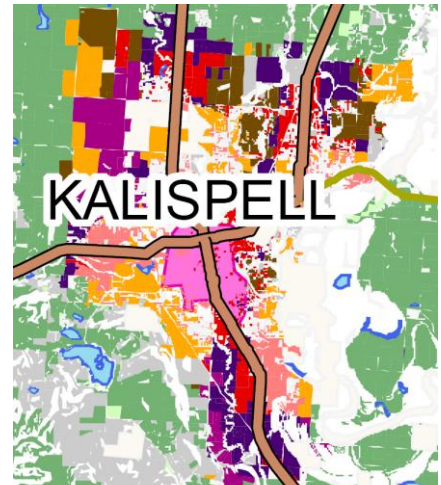
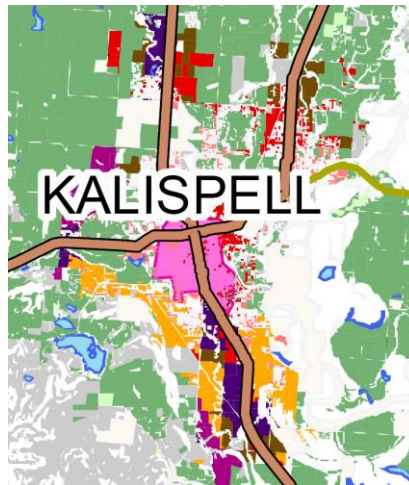
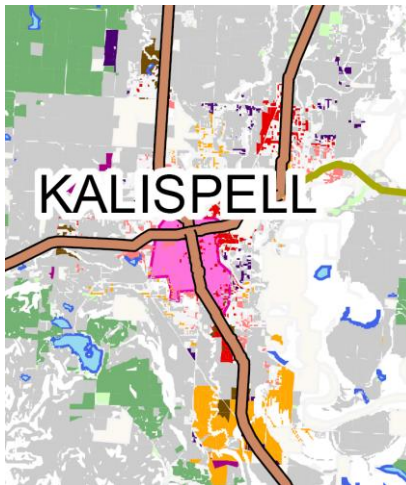


## Highly Restrictive

Low Growth

Moderate Growth

High Growth





## **Appendix F**

Attendees at September 19, 2007 Workshop:  
Assessing Ecological Economic Impacts of Landscape Change in  
Montana's Flathead County

<u>Name</u>	<u>Affiliation</u>
Kyle Flynn	Montana Department of Environmental Quality
Andy Welch	Montana Department of Environmental Quality
Tom Reynolds	Flathead County GIS
Carol Davies	City of Kalispell
Joe Brenneman	Flathead County (Commissioner)
Alan Wood	Montana Fish, Wildlife, and Parks
Steve Lorch	Montana Department of Natural Resources and Conservation
David Greer	Plum Creek Timber Company
Mayre Flowers	Citizens for a Better Flathead
Robin Steinkraus	Flathead Lakers
Jeff Harris	Flathead County Planning and Zoning
Dan Fagre	U.S. Geological Survey
Fred Hodgeboom	Montanans for Multiple Use
Marcy Mahr	Flathead Land Trust
Ronald Buentemeier	Stoltz Land and Lumber Company

## VITA

Anthony S. Clark earned a B.S. degree in Business Administration with an emphasis in Economics in May 1994 and a M.S. degree in Economics in December 1995, both from the University of Missouri, Columbia. From January 1996 to August 2000 he was employed as a Regulatory Economist for the Missouri Public Service Commission–Missouri Department of Economic Development. When he left this position he was managing a team of four economists in the MoPSC’s Telecommunications Department. From August 2000 to the present he has been employed at William Woods University in Fulton, Missouri, where he has taught Microeconomics, Macroeconomics, Intermediate Microeconomics, Money and Banking, International Trade, Comparative Economic Systems, and Entrepreneurship in the traditional undergraduate program and Economics for Managers in the MBA program. In 2004, he began pursuing a PhD in Agricultural Economics with an emphasis in Resources and Development at the University of Missouri, Columbia. While completing coursework, he served as a Research Assistant for Dr. Tony Prato. His research interests include land use change, ecological economics, and selected issues in regional economics, particularly relating to planning and zoning, public policy and entrepreneurship. Anthony also has a strong interest in economics education.