A Report by

HEADWATERS ECONOMICS

Land Use Effects of Paving Rural Roads in Western Montana

September 2008

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ABOUT HEADWATERS ECONOMICS

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions in the West.

ABOUT THIS REPORT

Headwaters Economics partnered with Chris Servheen of the U.S. Fish and Wildlife Service and the University of Montana to undertake this study in order to understand better the land use effects of rural paving projects in the state.

ACKNOWLEDGEMENTS

This project was supported by funding from the Kendall Foundation and the National Fish and Wildlife Foundation. We thank Corey Baker and Corinne Selby for their resourcefulness and organization in collecting the data used in this study. County road office staff throughout western Montana were patient and generous with their time.

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INTRODUCTION

As western Montana grows in population and activity on rural roads increases, rural dirt roads are being paved. A rural road may be paved for a variety of reasons. Most frequently these include maintenance cost reduction, and dust or mud reduction. In the majority of cases, paving projects are prioritized by counties. Some paving projects are the result of landowner requests.

The future impacts of paving on land use and other natural and wildlife resources are not well understood. Transportation planning, specifically decision-making that determines whether or not rural roads are paved, generally occurs without knowledge of the consequences for nearby property owners, land managers, and natural resources.

This report is a first step in understanding how land use is impacted by road paving. We provide eight case studies of rural paving projects in which we summarize land development rates prior to and after completion of a paving project. For each case study, we also report a number of facts about the paving project, including the reason for paving, the road surface type, and who paid for the paving.

From this information we can start to see patterns emerge related to how these factors influence subsequent land use. In some cases development rates increased after paving, while in other cases development slowed.

In order to quantify the relationship between paving and change in adjacent land use, a larger sample and a statistical approach are required. The case studies presented in this report are instructive about initial relationships, and suggest trends for further investigation.

Questions Covered in this Report:

1. What is the quality and availability of information on rural road paving projects in western Montana?
2. What trends are apparent in the rate of adjacent development following paving in eight case studies?
3. What possibilities exist for expanding this work in order to quantify relationships between paving and land use change?

SUMMARY FINDINGS

1. Road paving was followed by an increase in the rate of residential development on surrounding lands in the majority (six of eight) of the case studies.

2. In half of the case studies, development increased after paving and during a period when the rate of development in western Montana was decreasing.

3. Only two of eight paving projects cited residential traffic as a primary reason for paving. These were also the only two case studies with faster rates of development prior to paving.

4. In the six case studies in which roads were paved for reasons other than residential traffic (for example, timber use, recreation use, or cheaper maintenance), development increased in the subsequent decade.

Road Surface Types

Asphalt is the most common road surface. It is used on most primary roads and highways in Montana. When a road needs to be resurfaced, usually every 15 to 20 years, 1-1/2 inches of asphalt is placed over the existing road.

Chip sealing is common on rural roads. It involves spraying an application of a binder in the form of an emulsion or hot spray followed by an application of aggregate chips. Chip sealed roads usually require maintenance at 5 to 7 year intervals.

Bituminous Surface Treated (BST) is a form of chip sealing and that uses lighter weight aggregate material than other chip-sealing methods to reduce shipping costs and damage to windshields from airborne aggregates. BST offers superior skid-resistance than many other road surfaces, and lasts for approximately 5 years, at which time it is recovered with a chemical binder and a layer of aggregate 1 inch or less in thickness.

Millings road surface materials consist of fine particles or bitumen and inorganic material produced during the mechanical grinding of concrete surfaces. These particles are attached to the road surface using a spray-on chemical binder. Average durability of millings coated roads are 5-8 years, depending on climate and traffic intensity.

Plant or road-mix surfaces are mixed in place by means of travel plants or conventional farm equipment. The coarse aggregate is spread over the road surface, bituminous material is sprayed on the aggregate, and the mass is mixed in place and then bladed to uniform thickness and compactness. Durability depends on the quality and quantity of the aggregate and binder.

METHODS

Our effort to collect information on road paving projects in rural western Montana led us to contact the Montana Department of Transportation (MT DOT), the Western Federal Lands Highway Division (WFLHD), county road offices from 27 counties, and road supervisors from 11 national forests.

Much of our data collection was done in the summer of 2008, and the majority of the data was provided by the individual county road offices. Although the individuals we contacted were generally helpful, the summer is a busy time for road offices, which resulted in our acquiring data from only 11 of the 27 county road offices. Our contacts from MT DOT, WFLHD, the road offices, and the national forest road supervisors are provided in Appendix A

We used the following five criteria to limit our data collection to those data that would be relevant for this study. We collected information only if roads met all five criteria:

1. Roads paved since 1980, which allowed us to study relatively recent paving projects.
2. Rural roads outside of municipal boundaries.
3. Roads that were not paved using impact fees, since these road improvements are made due to subsequent development.
4. Roads where greater than a 0.25 mi. segment was paved.
5. Smaller classes of roads where adjacent residential development may occur:
    - Primary or secondary state roads
    - National forest system roads
    - County roads
    - Other local roads outside of city limits

For each paved road segment that we identified, we attempted to compile a database with the following information: the location of the road segment, the reason for paving, how the paving was paid for, the road surface type, the year of paving, length (in miles) of paved road, and the contact who provided the information.

We were able to collect information on 101 paved segments of rural roads in western Montana that met these criteria (see Appendix B), of which 74 were identified and mapped in GIS. In most cases, roads were not mapped if information critical to the project (for example, the year of paving) could not be ascertained.

We used four criteria to select the eight case studies from the 74 mapped paved road segments:

1. Roads paved on or before 1996, which allowed us to examine the development rate in areas adjacent to the paved road for 10 years before and 10 years after paving. Our housing database is current through 2006.

2. Roads surrounded by at least two homes in 2006, since developments rates cannot be calculated if no homes are present.

3. Paved road segments greater than two miles in length, since shorter segments may not impact drive time or ease.

4. Roads that lead to public lands, since focusing on these roads allowed us to identify homes that were likely being accessed via the road in question.

Paved road segments that were located in valleys were complicated to analyze because there tended to be a relatively large number of intersecting roads. In these cases it was difficult to determine what private lands were affected by the paving. Whereas roads that led to public lands tended to be the only access to particular quarter sections of private land.

For each case study, we identified quarter sections (160 acre blocks of land) with homes that were "affected" by the paving. In cases where quarter sections could only be reached by the segment, affected quarter sections could be as far as three miles from the paved road. In cases where quarter sections could be reached by other roads, the quarter sections that we identified as "affected" by the paving were required to intersect the paved road segment. Quarter sections within the 1st mile of paving were not considered "affected", since it's unlikely that driving less that one mile on a dirt road provides any incentive or disincentive for development.

We totaled the number of homes in the quarter sections in the decade before and after paving. In order for these totals to be comparable among case studies, we divided by area and reported the number of new homes built per square mile of residential land within the decades before and after paving. In order to compare these numbers with general housing trends in Montana, we calculated the average rate of development in western Montana over the same time periods.

The locations of the paved road segments and the observed rates of residential development prior to and after paving are reported in the following pages for each of the eight case studies.

Case Study: BATAVIA LANE, FLATHEAD COUNTY

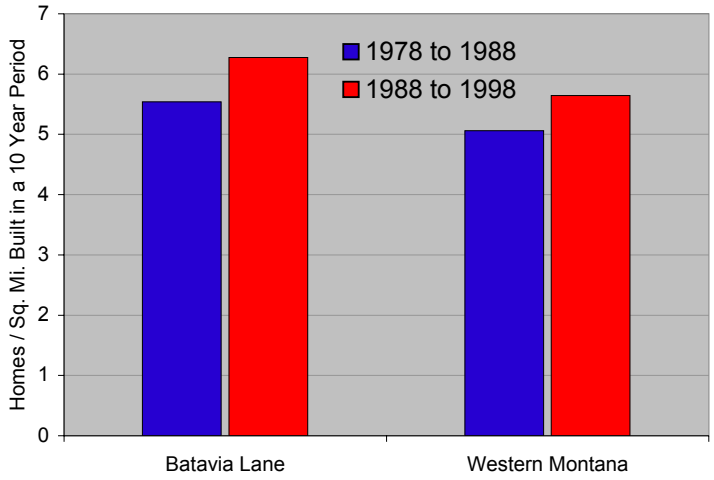
Batavia Lane is located west of Kalispell in Flathead County. From its starting point on Highway 2, the road heads west toward Ashley Lake. Upon reaching Ashley Lake, the road intersects sections of the Flathead National Forest and Plum Creek Timber Company lands.

The road was paved in 1988 for safety and easier maintenance due to a steep hill that frequently washed out. The 2.7 miles of asphalt were authorized and paid for by Flathead County.

Since the road was paved in 1988, the rate of development increased on parcels accessed by Batavia Lane. Between 1978 and 1988, 15 homes were built on parcels that were accessed via Batavia Lane, averaging 5.5 new homes per square mile during this time period. From 1988 to 1998, 17 new homes were built on parcels access by Batavia Lane, averaging 6.3 new homes per square mile during this time period.

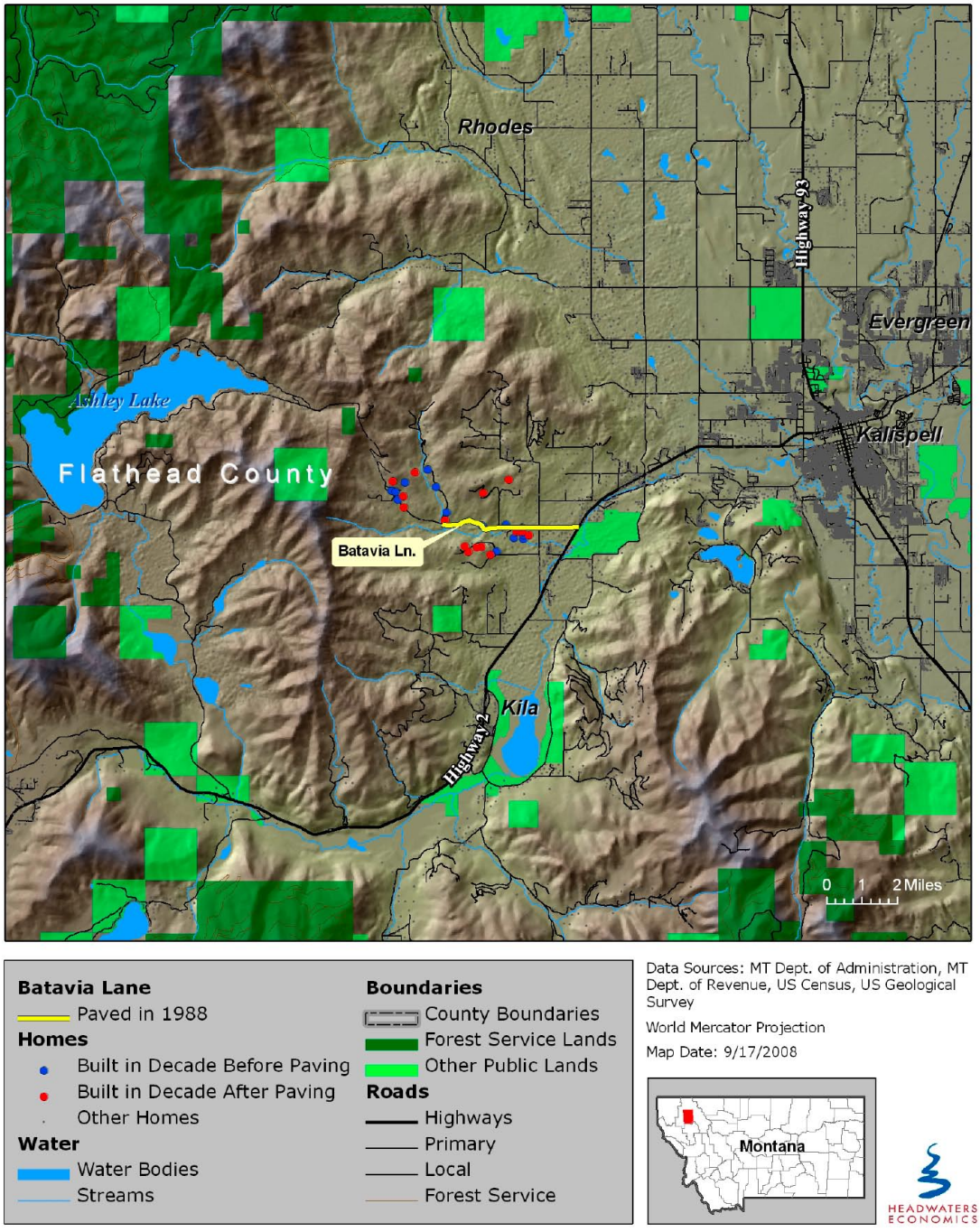
The increase in development seen on parcels accessed by Batavia Lane was comparable to the average increase in development rates seen throughout western Montana. During the decades before and after Batavia Lane was paved, the average development rate in western Montana increased from 5.1 to 5.6 new homes per square mile of residential land. This increase is slightly less than the increase of land development surrounding Batavia Lane.

In order to be conservative in our estimates of which homes were impacted by the paving of Batavia Lane, we limited our inclusion of homes to only those within one mile of the newly paved road.



Area	1978 to 1988 New Homes	1978 to 1988 New Homes per Sq. Mile	1988 to 1998 New Homes	1988 to 1998 New Homes per Sq. Mile
Batavia Lane	15	5.5	17	6.3
Western Montana	47,315	5.1	52,792	5.6

However, today over 350 homes are actually accessed via Batavia Lane. Roughly 200 of these homes surround Ashley Lake (5 miles past where pavement ends). The highest peak in development, particularly for those parcels bordering Ashley Lake, occurred during the late 1990s after Batavia Lane had been paved. It is possible that paving Batavia Lane facilitated the increase in the amenity-driven growth surrounding Ashley Lake and bordering the Flathead National Forest.



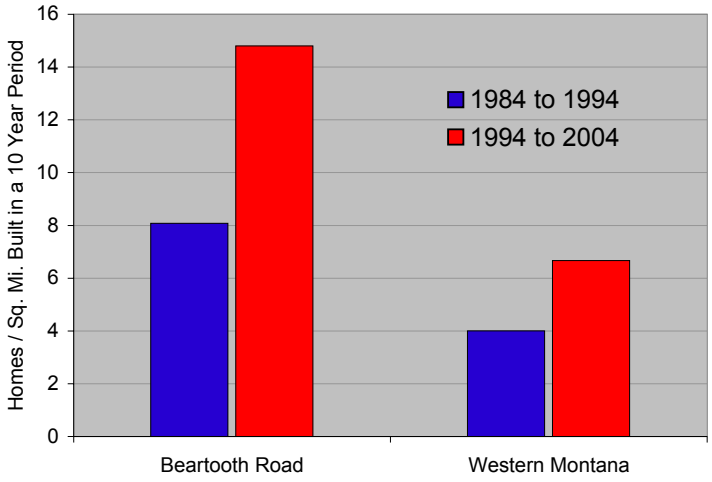
Case Study: BEARTOOTH ROAD, LEWIS AND CLARK COUNTY

Beartooth Road is located in Lewis and Clark County, approximately 40 miles north of Helena. East of Wolf Creek, the road starts at Craig Frontage Road and follows the Missouri River south, along the shore of Holter Lake. For much of its length, the road runs through BLM land, MT Fish Wildlife and Parks' Beartooth Wildlife Management Area, and ends up on Helena National Forest land.

The road was paved in 1994 due to heavy recreational use. The 5.2 miles of chip-sealed paving were authorized and paid for by Lewis and Clark County.

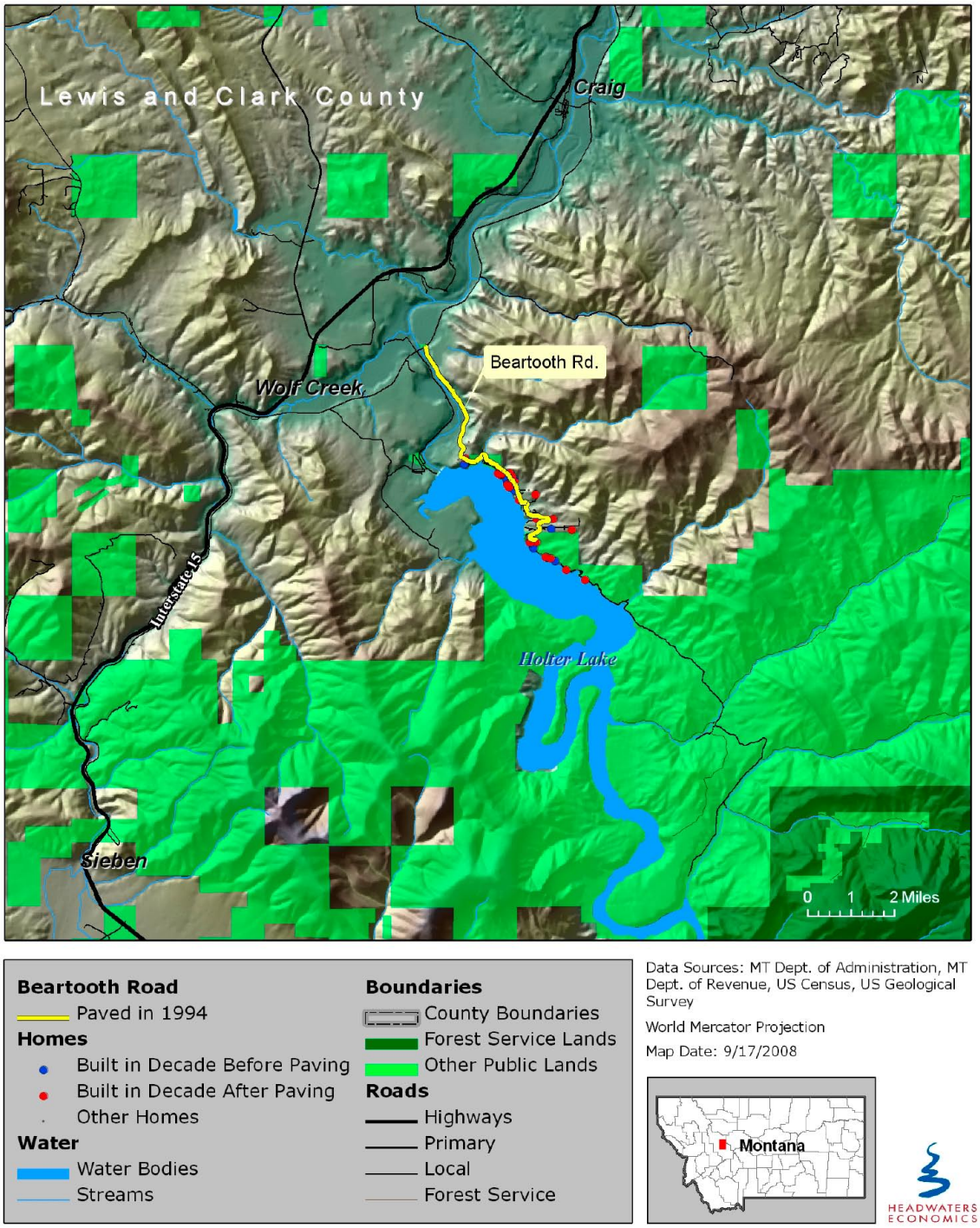
Since the road was paved in 1994, the rate of development on parcels accessed by Beartooth Road increased substantially. Between 1984 and 1994, 18 homes were built on parcels that were accessed via Beartooth Road, averaging 8.1 new homes per square mile during this time period. From 1994 to 2004, 33 new homes were built on parcels access by Beartooth Road, averaging 14.8 new homes per square mile during this time period.

The increase in development seen on parcels accessed by Beartooth Road was faster than the average increase in development rates seen throughout western Montana. During the decades before and after Beartooth Road was paved, the average development rate in western Montana increased from 4.0 to 6.7 new homes per square mile of residential land. This is an increase of 2.7 more new homes per square mile from 1994 to 2004, compared to the increase of 6.7 more new homes per square mile experienced in that same time period on the lands accessed by Beartooth Road.



Area	1984 to 1994 New Homes	1984 to 1994 New Homes per Sq. Mile	1994 to 2004 New Homes	1994 to 2004 New Homes per Sq. Mile
Beartooth Road	18	8.1	33	14.8
Western Montana	39,506	4.0	65,799	6.7

The highest peak in development along Beartooth Road occurred during the late 1960s and early 1970s. Development slowed in this area during the late 1970s and throughout the 1980s. However, since 1990 development rates have been at a sustained high. It is possible that paving Beartooth Road facilitated the increase in the amenity-driven growth during the late 1990s and early 2000s.



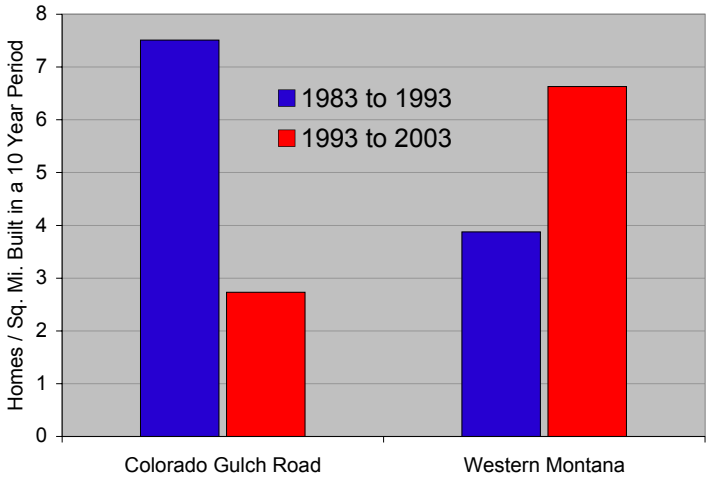
Case Study: COLORADO GULCH ROAD, LEWIS AND CLARK COUNTY

Colorado Gulch Road is located west of Helena in Lewis and Clark County, and intersects Highway 12 east of MacDonald pass. From its starting point on Highway 12 the road heads south, following Colorado Gulch Creek, toward the Helena National Forest. For much of its length, the road is flanked on either side by National Forest land.

The road was paved in 1993 in response to homeowner complaints regarding road conditions, mainly dust. The 3.6 miles of chip-sealed paving were paid for by a Rural Improvement District (RID), a method offered by the State of Montana for assistance in the management of the costs of infrastructure improvements and the maintenance of these improvements. The creation of an RID is according to a petition and vote process whereby individual property owners in the proposed District each participate.

Since the road was paved in 1993, the rate of development on parcels accessed by Colorado Gulch Road slowed. Between 1983 and 1993, 22 homes were built on parcels that were accessed via Colorado Gulch Road, averaging 7.5 new homes per square mile during this time period. From 1993 to 2003, 8 new homes were built on parcels access by Colorado Gulch Road, averaging 2.7 new homes per square mile during this time period.

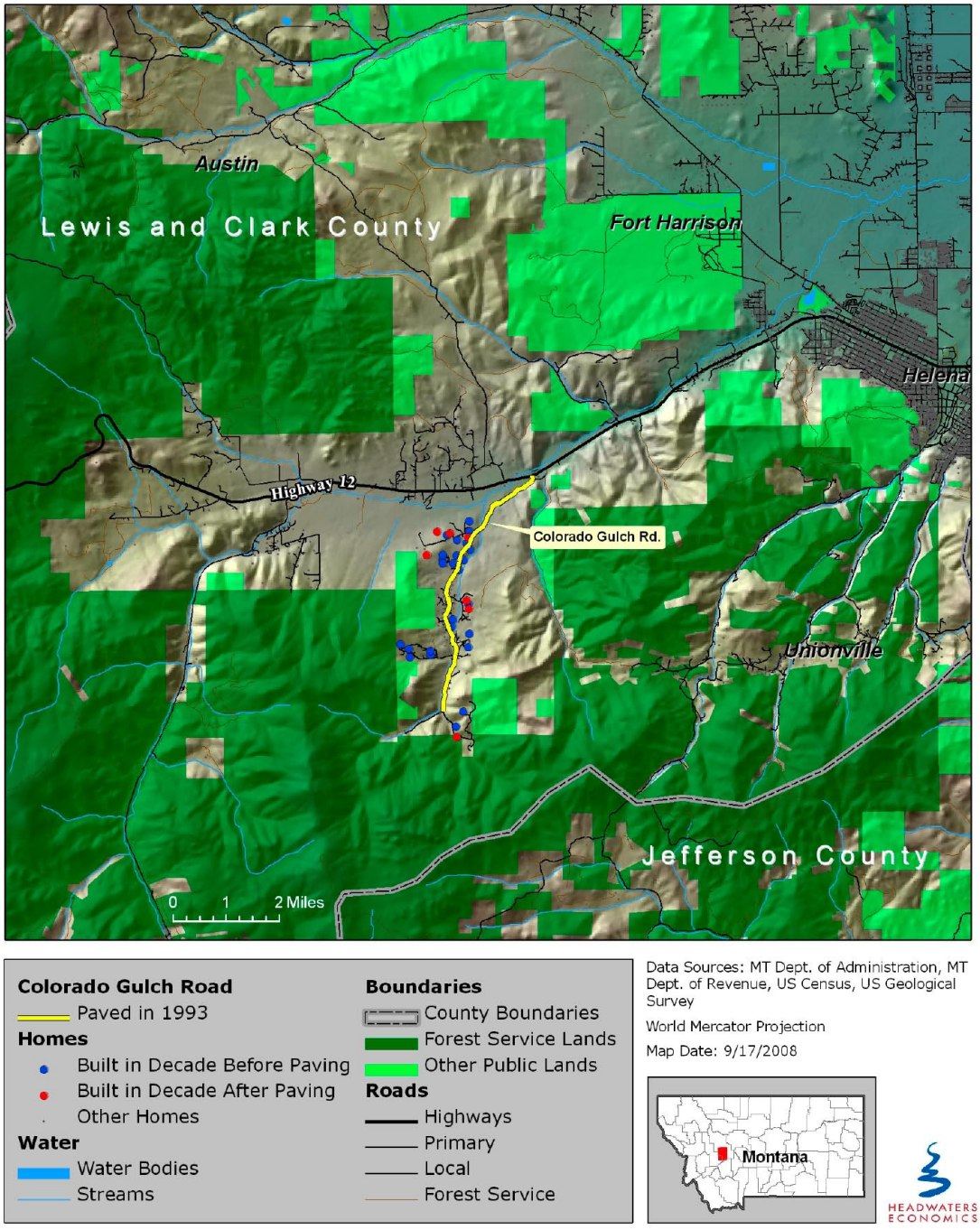
By comparison, average development rates in western Montana increased over this time period from 3.9 to 6.6 new homes per square mile of residential land. In other words, development around Colorado Gulch Road slowed despite the average increase in development rates seen in western Montana.



Area	1983 to 1993 New Homes	1983 to 1993 New Homes per Sq. Mile	1993 to 2003 New Homes	1993 to 2003 New Homes per Sq. Mile
Colorado Gulch Road	22	7.5	8	2.7
Western Montana	37,953	3.9	64,928	6.6

Today, over 100 homes are accessed via Colorado Gulch Road. It appears that the main burst of development in this area, which occurred during the 1960s and 1970s, led to the demand for road improvements. In this case, paving has not lead to a subsequent increase in development.

The fact that rural development can initiate or accelerate demands for improvements to infrastructure and services has been well established, and is an important planning and fiscal point supported by this particular case study.[1]



Case Study: GOOD CREEK ROAD, FLATHEAD COUNTY

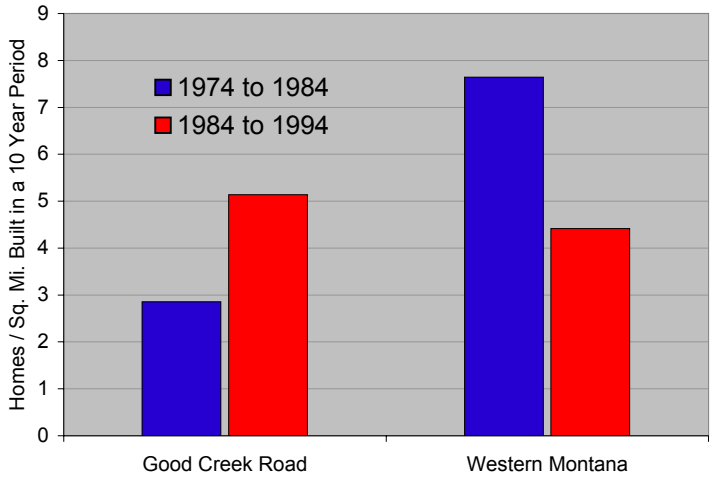
Good Creek Road, also known as Forest Service Road 60, is located northwest of Whitefish in Flathead County. The road heads west from Highway 93 at the town of Olney and continues for 17 miles through public lands with private in-holdings. Outside of Olney, the road passes for a short distance through Montana state trust lands, but the majority of the road's length is through the Flathead National Forest.

The road was paved in 1984 because of heavy use due to an active timber sale program. The first six miles of Good Creek Road was paved with asphalt. The project was paid for with funding from the Federal Highway Administration/Western Federal Lands Highway Division's Forest Highway program.

Since the road was paved in 1984, the rate of development increased on parcels accessed by Good Creek Road. Between 1974 and 1984, only 3 homes were built on parcels that were accessed via Good Creek Road, averaging 2.9 new homes per square mile during this time period. From 1984 to 1994, an additional 8 homes were built on parcels access by Good Creek Road, averaging 5.1 new homes per square mile during this time period.

The increase in development seen on parcels accessed by Good Creek Road occurred during a period when the rate of development in western Montana was decreasing. During the decades before and after Good Creek Road was paved, the average development rate in western Montana changed from 7.6 to 4.4 new homes per square mile of residential land. This implies that development pressure surrounding the newly paved portion of Good Creek Road was higher than average for western Montana.

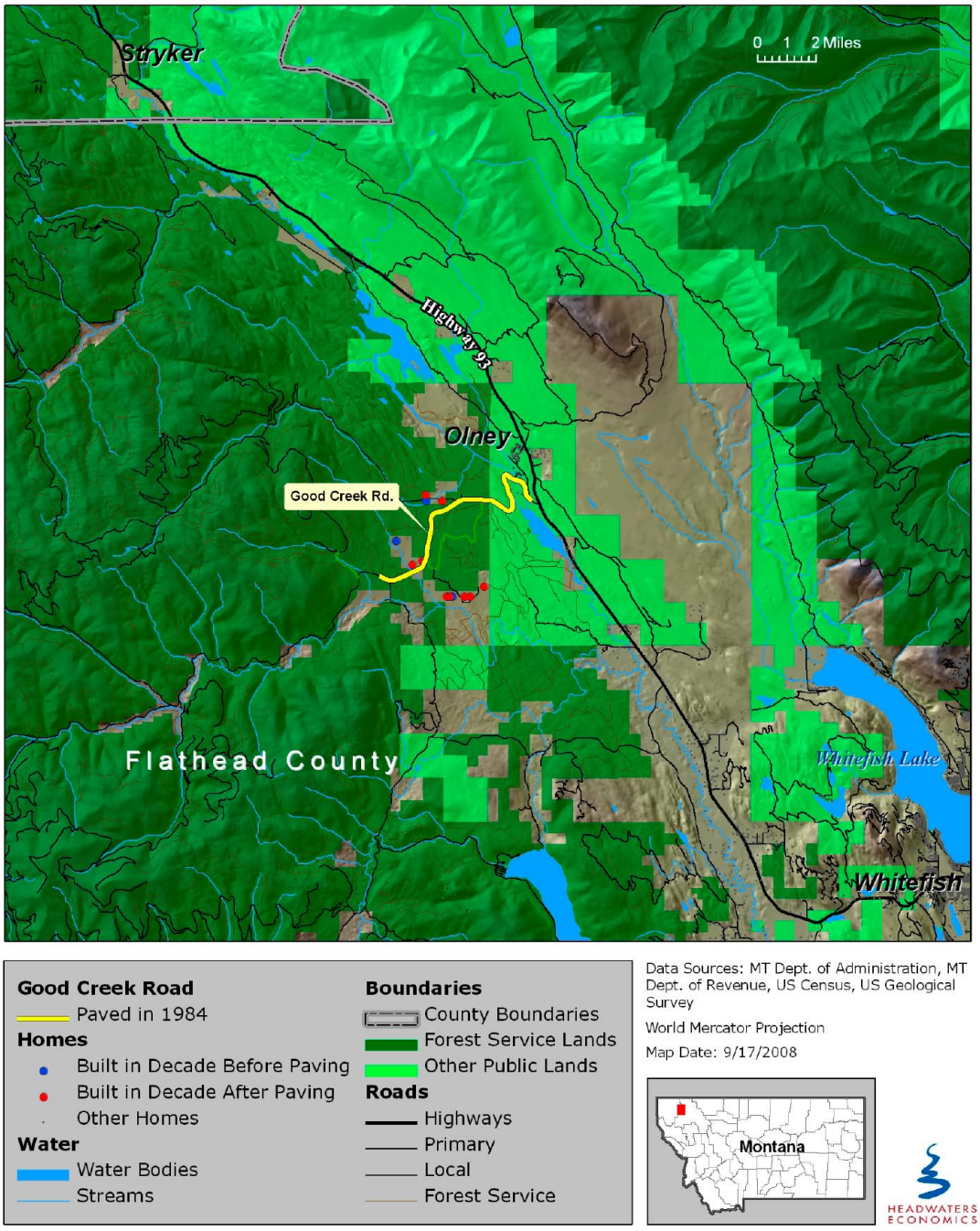
The highest peak in development in the parcels surrounding Good Creek Road occurred during the late 1990s and early 2000s—more than 10 years after the road was paved. Since 1994, 11 new homes have been built on parcels accessed by Good Creek Road.



Area	1974 to 1984 New Homes	1974 to 1984 New Homes per Sq. Mile	1984 to 1994 New Homes	1984 to 1994 New Homes per Sq. Mile
Good Creek Road	3	2.9	8	5.1
Western Montana	68,362	7.6	39,506	4.4

In order to be conservative in our estimates of which homes were impacted by the paving of Good Creek Road, we limited our inclusion of homes to only those within one mile of the newly paved road. However, an additional 24 homes are located in a private in-holding 6 miles past where pavement ends. All but four of these homes were built after Good Creek Road was paved.

It is possible that after Good Creek Road was paved, this relatively undeveloped area proximate to public lands was discovered, or made more attractive for development due to the paving. Today, the paved road may still be contributing to the attractiveness of this area for home construction.



Case Study: GRANITE LAKE ROAD, LINCOLN COUNTY

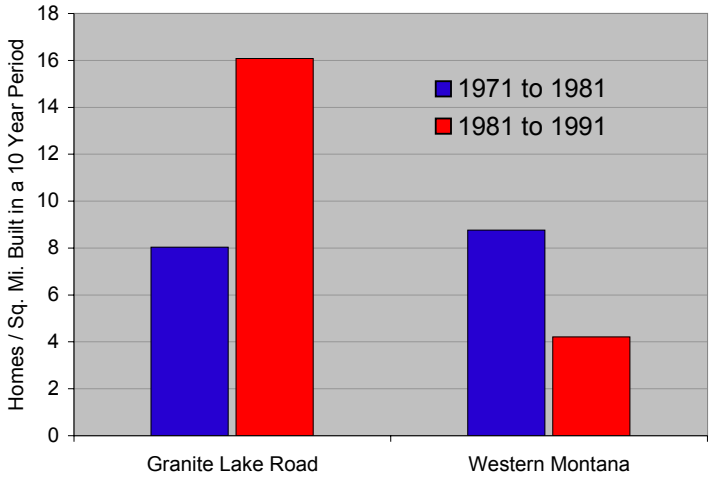
Granite Lake Road is located south of Libby and west of White Haven in Lincoln County. The road starts at Snowshoe road, which parallels Highway 2, and continues for 8 miles through Kootenai National Forest lands with private in-holdings.

The road was paved in 1981 in order to reduce maintenance costs and dust. The 4.6 miles of chip-sealed paving were authorized and paid for by Lincoln County.

Since the road was paved in 1981, the rate of development increased on parcels accessed by Granite Lake Road. Between 1971 and 1981, only 4 homes were built on parcels that were accessed via Granite Lake Road, averaging 10 new homes per square mile during this time period. From 1981 to 1991, an additional 8 homes were built on parcels accessed by Granite Lake Road, averaging 11 new homes per square mile during this time period.

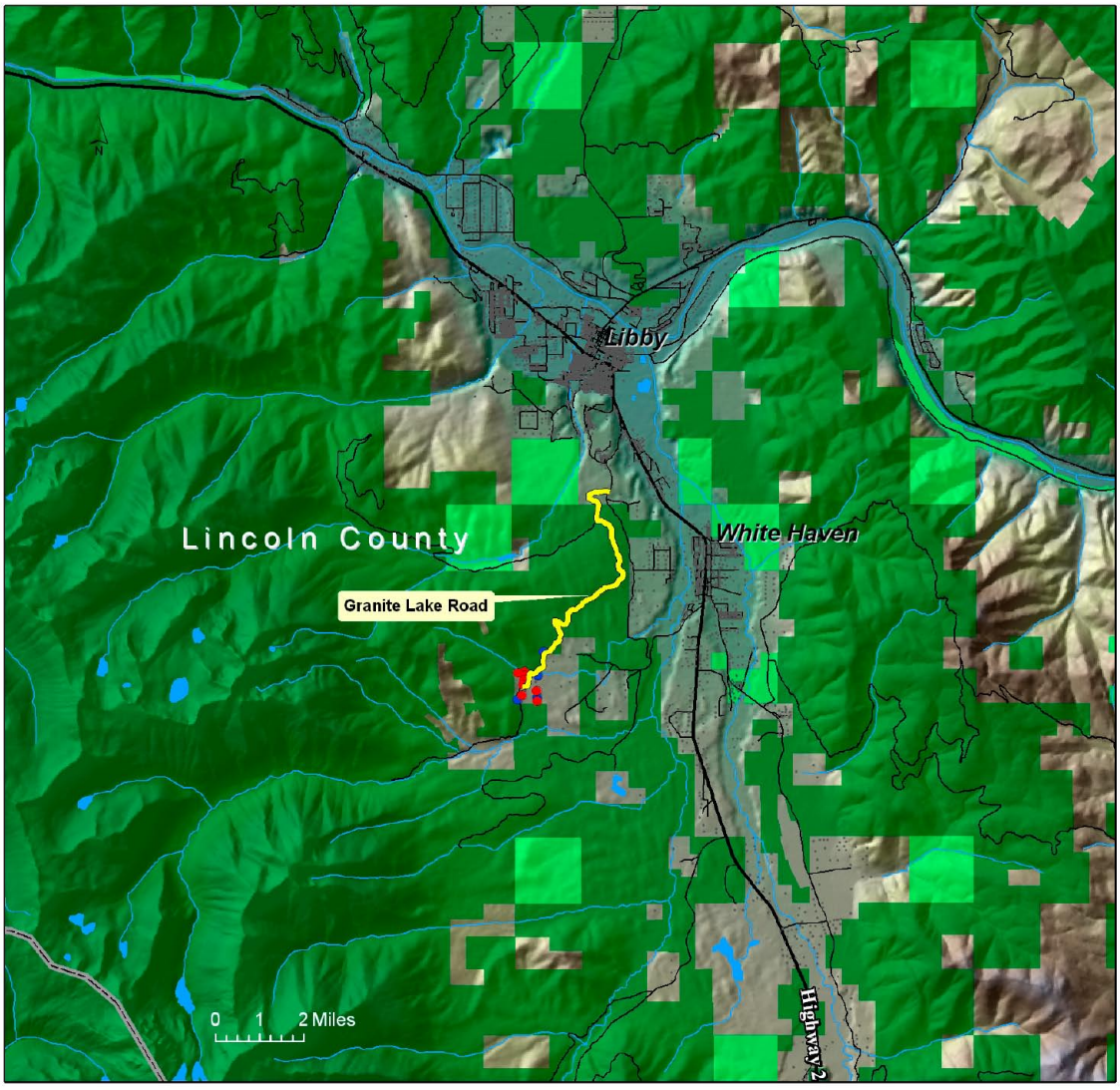
The increase in development seen on parcels accessed by Granite Lake Road occurred during a period when the rate of development in western Montana was decreasing. During the decades before and after Granite Lake Road was paved, the average development rate in western Montana slowed from 8.8 to 4.2 new homes per square mile of residential land. This implies that development pressure surrounding the newly paved portion of Granite Lake Road was higher than average for western Montana.

The highest peak in development in the parcels surrounding Granite Lake Road occurred during the mid 1980s, in the years immediately following paving. Since the 1980s, only 2 homes have been built on parcels accessed via Granite Lake Road.



Area	1971 to 1981 New Homes	1971 to 1981 New Homes per Sq. Mile	1981 to 1991 New Homes	1981 to 1991 New Homes per Sq. Mile
Granite Lake Road	4	10.0	8	11.0
Western Montana	75,847	8.8	36,428	4.2

The decrease in home construction that occurred since 1990 around Granite Lake Road was also observed in the town of Libby and in other rural areas surrounding Libby. The major asbestos contamination discovered in this area during the 1990s led to a substantial economic slow-down for the entire area.



Granite Lake Road
Paved in 1981

Homes
Built in Decade Before Paving
Built in Decade After Paving
Other Homes

Water
Water Bodies
Streams

Boundaries
County Boundaries
Forest Service Lands
Other Public Lands

Roads
Highways
Primary
Local
Forest Service

Data Sources: MT Dept. of Administration, MT Dept. of Revenue, US Census, US Geological Survey

World Mercator Projection

Map Date: 9/17/2008

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Case Study: ROCK CREEK ROAD, GRANITE COUNTY

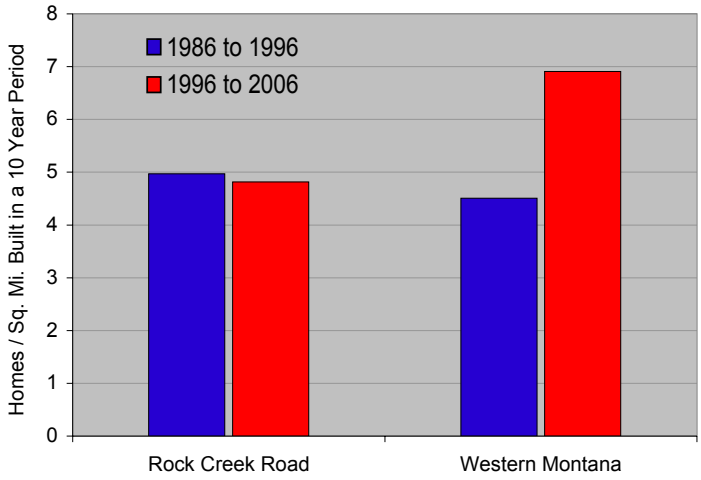
Rock Creek Road is located south of Clinton. The road runs along Rock Creek and along the border of Missoula and Granite Counties. For the majority of the road's length, it lies within Granite County. From its starting point on Interstate 90, the road heads south and after roughly one mile enters the Lolo National Forest. The road crosses through a series of private in-holdings for roughly 12 miles.

The road was paved in 1996 in response to heavy residential traffic and the costly upkeep directly related to this traffic. The 11 miles of chip-sealed paving were paid for Granite County.

Since the road was paved in 1996, the rate of development on parcels accessed by Rock Creek Road remained roughly constant. Between 1986 and 1996, 32 homes were built on parcels that were accessed via Rock Creek Road, averaging 5.0 new homes per square mile during this time period. From 1996 to 2006, 31 new homes were built on parcels access by Rock Creek Road, averaging 4.8 new homes per square mile during this time period.

By comparison, average development rates in western Montana increased over this time period from 4.5 to 6.9 new homes per square mile of residential land. In other words, development around Rock Creek Road remained constant despite the average increase in development rates seen in western Montana.

Today, over 180 homes are accessed via Rock Creek Road. The highest peak in development in the parcels surrounding Rock Creek Road occurred during the early 1970s. The next highest peak occurred in the 5 years following paving. It appears that development in this area led to the demand for paving, and that paving was followed by a sustained level of development.



Area	1986 to 1996		1996 to 2006	
	New Homes	New Homes per Sq. Mile	New Homes	New Homes per Sq. Mile
Rock Creek Road	32	5.0	31	4.8
Western Montana	45,337	4.5	69,484	6.9

Rock Creek Road
- Paved in 1996

Homes
- Built in Decade Before Paving
- Built in Decade After Paving
- Other Homes

Water
- Water Bodies
- Streams

Boundaries
- County Boundaries
- Other Public Lands
- Forest Service Lands

Roads
- Highways
- Primary
- Local
- Forest Service

Data Sources: MT Dept. of Administration, MT Dept. of Revenue, US Census, US Geological Survey

World Mercator Projection

Map Date: 9/17/2008

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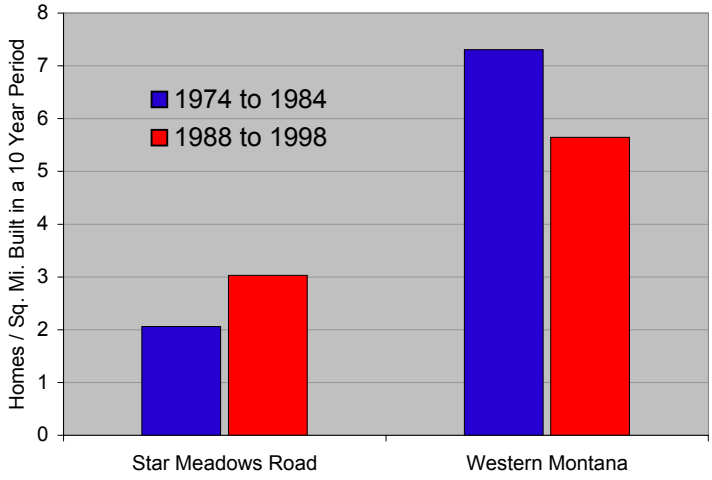
Case Study: STAR MEADOWS ROAD, FLATHEAD COUNTY

Star Meadows Road, also known as Forest Service Road 113, is located roughly 12 miles northwest of Whitefish in Flathead County. The road starts at Farm to Market Road, which parallels Highway 93, and continues for 17 miles through Flathead National Forest lands with private in-holdings.

The road was paved in three sections. Milepost 3.35 to 10.87 was paved in 1984. The segment from Farm to Market Road to milepost 3.35 was paved in 1987. Also in 1987, the segment of Farm to Market Road from Highway 93 to the start of Star Meadows Road was rebuilt. Lastly, in 1988, the segment from milepost 10.77 to 16.85 was paved. This last phase rebuilt 0.10 of the segment that was originally paved in 1984. In total, 16.9 miles of paving using asphalt were paid for with funding from the Federal Highway Administration/Western Federal Lands Highway Division's Forest Highway program.

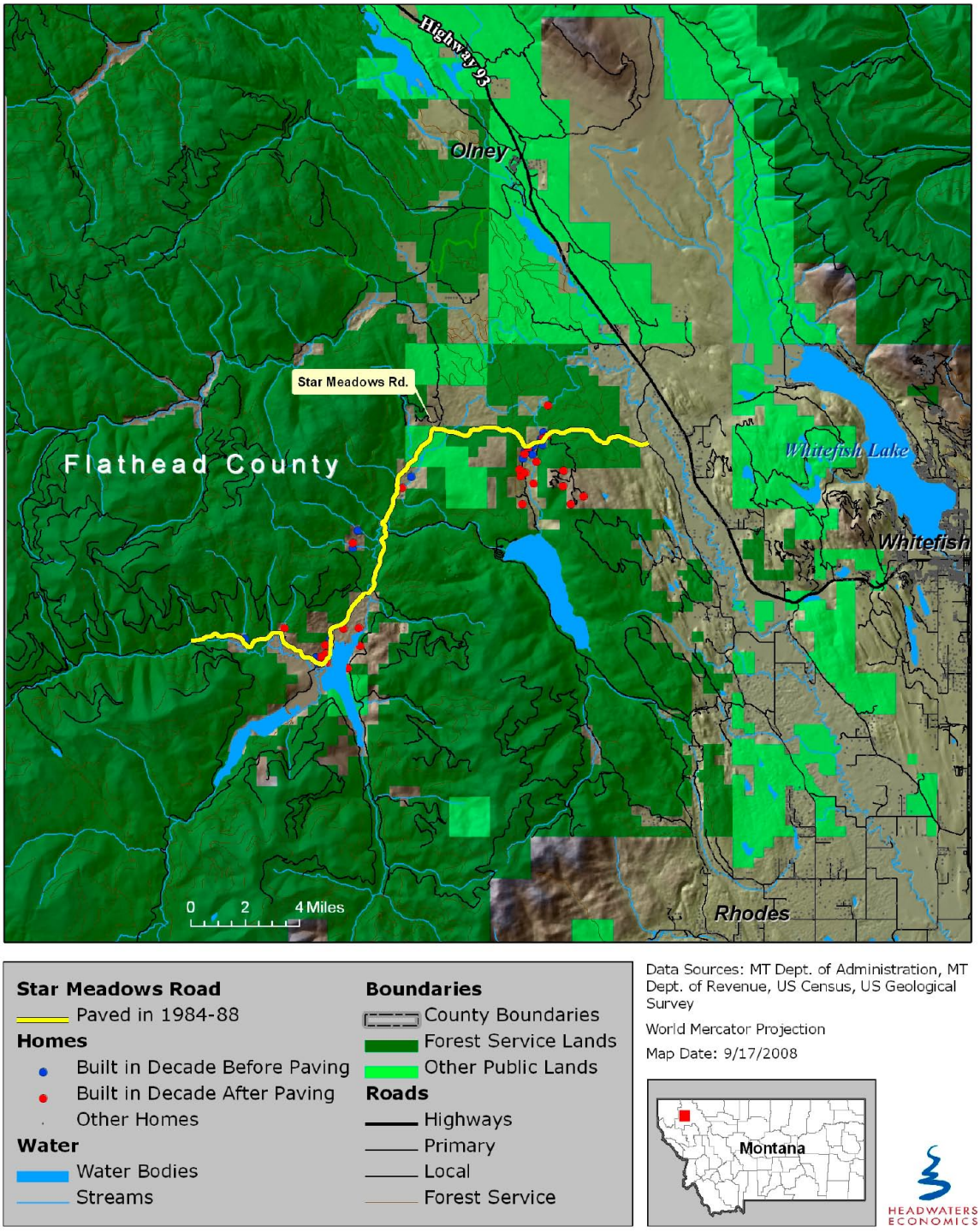
After paving was completed in 1988, the rate of development increased on parcels accessed by Star Meadows Road. Between 1974 and 1984, 17 homes were built on parcels that were accessed via Star Meadows Road, averaging 2.1 new homes per square mile during this time period. From 1988 to 1998, an additional 25 homes were built on parcels access by Star Meadows Road, averaging 3.0 new homes per square mile during this time period.

The increase in development seen on parcels accessed by Star Meadows Road occurred during a period when the rate of development in western Montana was decreasing. During the decades before and after Star Meadows Road was paved, the average development rate in western Montana slowed from 7.3 to 5.6 new homes per square mile of residential land. This implies that development pressure surrounding the newly paved portion of Star Meadows Road was higher than average for western Montana.



Area	1974 to 1984 New Homes	1974 to 1984 New Homes per Sq. Mile	1988 to 1998 New Homes	1988 to 1998 New Homes per Sq. Mile
Star Meadows Road	17	2.1	25	3.0
Western Montana	68,362	7.3	52,792	5.6

The highest peak in development on parcels surrounding Star Meadows Road occurred since 2002, more than 10 years after paving. Since paving was completed in 1988, more than 50 homes have been built along the road. It is possible that the paved road has contributed to the attractiveness of this area for home construction.



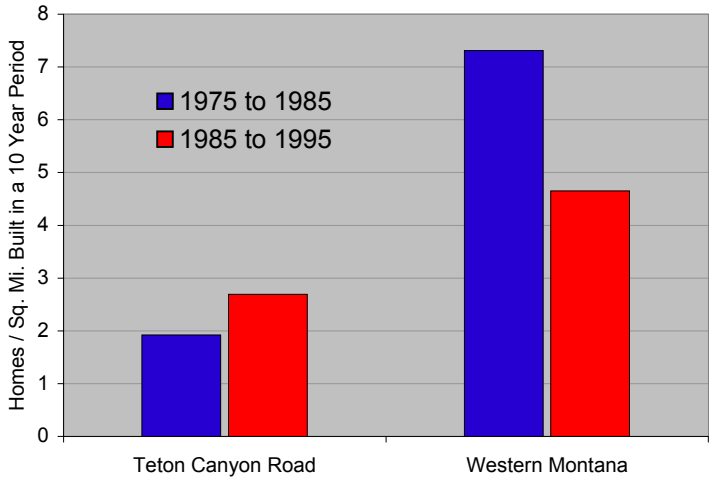
Case Study: TETON CANYON ROAD, TETON COUNTY

Teton Canyon Road is located roughly 5 miles northwest of Choteau in Teton County. The road starts at Highway 89, and continues for 20 miles through private lands and then another 9 miles through Lewis and Clark National Forest lands with private in-holdings.

The road was paved in 1985 because of heavy recreational use associated with Teton Pass Ski Area, the Forest Service trailhead, and the Bynum Reservoir. The first 15 miles of Teton Canyon Road had previously been paved, but were in extremely poor shape, and were rebuilt. The next 1.5 miles up to the South Fork Bridge were converted from dirt to pavement. A chip-sealed road surface was used. The paving was paid by Teton County.

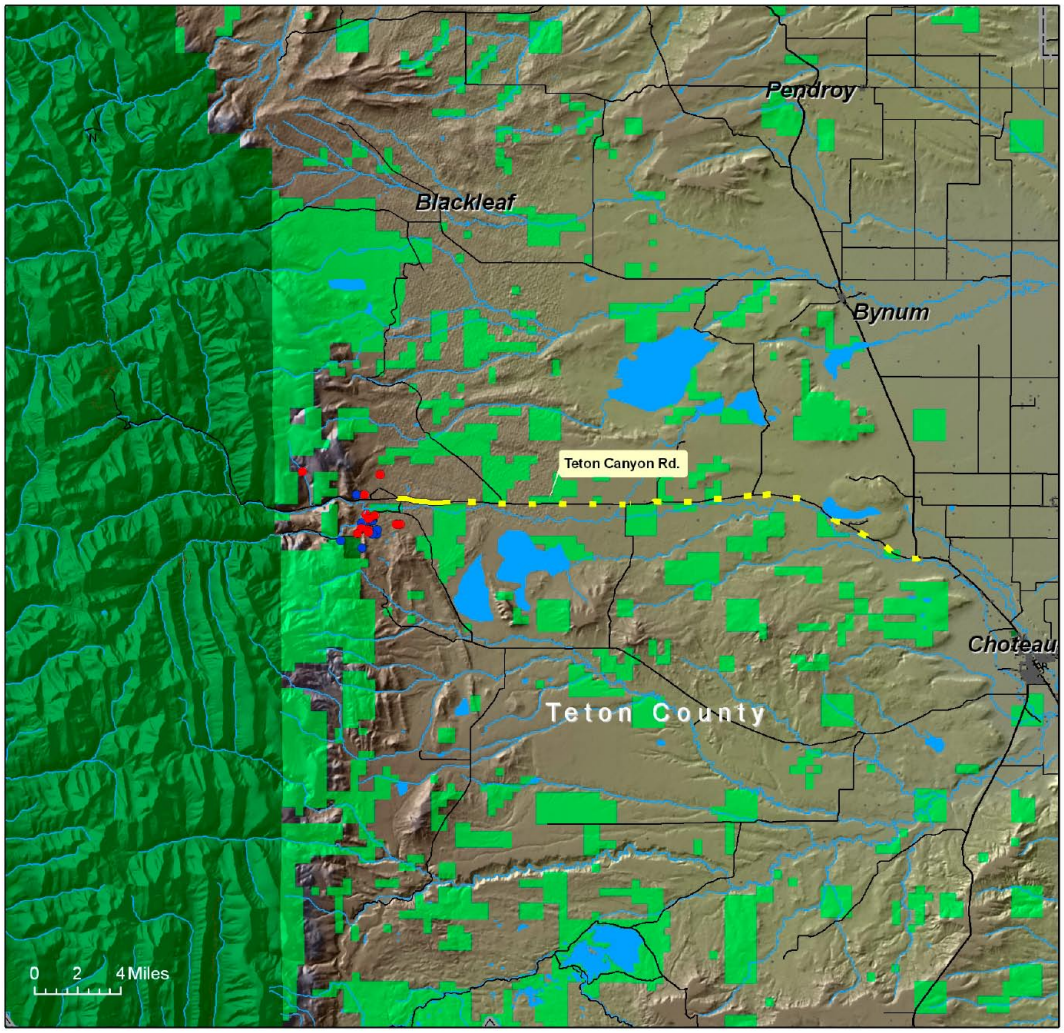
After the road was paved in 1985, the rate of development increased on parcels accessed by Teton Canyon Road. Between 1975 and 1985, 10 homes were built on parcels that were accessed via Teton Canyon Road, averaging 1.9 new homes per square mile during this time period. From 1985 to 1995, an additional 14 homes were built on parcels access by Teton Canyon Road, averaging 2.7 new homes per square mile during this time period.

The increase in development seen on parcels accessed by Teton Canyon Road occurred during a period when the rate of development in western Montana was decreasing. During the decades before and after Teton Canyon Road was paved, the average development rate in western Montana slowed from 7.3 to 4.6 new homes per square mile of residential land. This implies that development pressure surrounding the newly paved portion of Teton Canyon Road was higher than average for western Montana.



Area	1975 to 1985 New Homes	1975 to 1985 New Homes per Sq. Mile	1985 to 1995 New Homes	1985 to 1995 New Homes per Sq. Mile
Teton Canyon Road	10	1.9	14	2.7
Western Montana	66,188	7.3	42,110	4.6

The highest peak in development on the parcels surrounding Teton Canyon Road occurred during the early 1970s. The second highest peak in development in this area occurred during the early 1990s, shortly after the road was paved. Today, the road provides access to over 75 homes, one-third of which were built after the road was paved. Although nearly 50 homes were present in this area prior to Teton Canyon Road being paved, it is possible that the paving contributed to the subsequent boost in the rate of residential development that occurred after 1985.



Teton Canyon Road
- Paved in 1985
- Repaired in 1985

Homes
- Built in Decade Before Paving
- Built in Decade After Paving
- Other Homes

Water
- Water Bodies
- Streams

Boundaries
- County Boundaries
- Forest Service Lands
- Other Public Lands

Roads
- Highways
- Primary
- Local
- Forest Service

Data Sources: MT Dept. of Administration, MT Dept. of Revenue, US Census, US Geological Survey

World Mercator Projection

Map Date: 9/17/2008

HEADWATERS ECONOMICS

CONCLUSIONS

In the majority of our case studies (six of the eight), road paving was followed by an increase in the rate of residential development on surrounding lands. On average, the rate of development increased after paving by one home per square mile over the 10 year period. The rate of change ranged from -4.8 to 6.7 homes per square mile per decade.

Development decreased after paving in two case studies: Colorado Gulch Road and Rock Creek Road. The only substantial decrease in development occurred in the areas surrounding Colorado Gulch Road, west of Helena. This was also the only road paving project paid for by a rural improvement district.

The rate of development also slowed around Rock Creek Road, southeast of Missoula, but only by a negligible amount—in the decade prior to paving 32 homes were built, and in the decade following paving 31 homes were built on parcels accessible only by Rock Creek Road.

Four of the six case studies in which development increased after paving occurred during a period when the rate of development in western Montana was decreasing. This implies that development pressure surrounding these newly paved roads was higher than average for western Montana.

No patterns were evident between the type of paving surface and subsequent land use change after paving. Three of our case study roads were paved with asphalt, and the remaining five were chip-sealed. With the exception of the paving of Colorado Gulch Road, which was paid for by a rural improvement district, there were no other obvious relationships between who commissioned and paid for the paving project, and the level of subsequent development. Five of our case study roads were paved using county funds, and two were paid for by the U.S. Forest Service.

Of the eight case studies, only two (Rock Creek Road and Colorado Gulch Road) cited homeowner complaints and residential traffic as primary reasons for paving. These were also the only two case studies with faster rates of development prior to paving, and the two roads in our sample that provide access to the highest number of homes. In these cases, it appears that the large numbers of homes already present in these areas led to the demand for road improvements.

The fact that rural development can initiate or accelerate demands for improvements to infrastructure and services has been well established, and is an important planning and fiscal point supported by these two case studies.[2]

Area	Paved Road Length	Changes Prior To and After Paving	
		Difference in New Homes per Decade	Difference in New Homes per Sq. Mile per Decade
Batavia Lane, Flathead County	2.7	2	0.7
Beartooth Road, Lewis & Clark County	5.2	15	6.7
Colorado Gulch Road, Lewis & Clark County	3.6	-14	-4.8
Good Creek Road, Flathead County	6.0	5	2.3
Granite Lake Road, Lincoln County	4.6	4	1.0
Rock Creek Road, Granite County	11.0	-1	-0.2
Star Meadows Road, Flathead County	16.9	8	1.0
Teton Canyon Road, Teton County	1.7	4	0.8

The reasons for paving in the six case studies where development increased after paving included heavy timber use, heavy recreation use, cheaper maintenance, and safety (in the case of Batavia Lane, a steep hill regularly washed out). Although these roads were paved for reasons other than residential use, home building increased in the subsequent decade.

It is possible that newly paved roads in undiscovered areas proximate to public lands contribute to the attractiveness of these areas for home construction. This is precisely the pattern that appears to emerge in these eight case studies. However, more research is needed to confirm and evaluate the relationship between rural paving, development, and the presence public lands with and their natural amenities to make more definite conclusions.

POSSIBILITIES FOR AN EXPANDED STUDY

Ultimately, case studies can only provide anecdotal information. The problem is that case studies are not necessarily typical; only statistical evidence can determine how typical something is. Therefore, a statistical approach is required to evaluate whether a quantifiable relationship exists between paving and change in adjacent land use.

One approach to analyzing these data would be to use a one-sided paired t-test to compare the development rates before and after paving, with the null hypothesis being that the difference between the before-and-after paving development rates is zero. In the case of this study, the alternative hypothesis would be that the rate of development after paving is greater than the rate prior to paving.

We conducted a "power" analysis to calculate the necessary sample size for avoiding Type 2 error with a probably of 80%. Type 2 error occurs when an analysis fails to reject the null hypothesis when it is truly false and should be rejected.

A "power" analysis requires several pieces of information including significance level, population variability, and effect size. For this exercise, we specified a significance level of 0.05 and a population variability (measured in terms of the standard deviation of the differences in development rates before and after paving in our eight case studies) of 3.14.

We used the "pwr.t.test" function in the R statistical package to calculate the necessary sample size, using the above parameters, to detect small and moderate effects. With this approach, we estimated that to detect an increase in development rate of one new home per square mile following paving, a sample size of 63 paved road segments would be required. Detecting an increase in development rate of 1.5 new homes per square mile following paving would require a sample of 29 roads, and detecting an increase of 2 new homes per square mile would require a sample of 17 roads.

The ability of a statistical approach to detect subsequent changes in land use following paving depends on an appropriate study design and sample size. Based on our success in data collection, we feel that information could be collected on 30 paved road segments that meet the criteria used in this study. However, it is unlikely that enough information could be collected to detect an increase in development rate of one new home per square mile following paving.

Importantly, an analytical technique more powerful than a paired t-test may be able to account for concurrent variability in growth rates in other parts of Montana. For example, a study design that incorporates the use of a "control" group of road segments that are priorities for paving but have not yet been paved, may reduce the necessary sample size. Control road segments would allow for a comparison in the difference in development rates between roads that were paved versus roads that remained dirt.

The power analysis we conducted demonstrates that an expanded study is possible. In addition, a more sophisticated technique than a paired t-test may increase the likelihood of accurately quantifying small effects in the relationship between paving and land use.

Following this study, a logical next step is to use a scientific approach to investigate the relationship between road paving and land use change. Statistical evidence that demonstrates the relationship would be a unique contribution to the field of transportation planning, and extremely useful for supporting informed decisions about the costs and benefits of paving rural roads.

APPENDIX A:

Contacts for Data Collection of Paved Road Segments

Office	Title	phone	email	Data Received
County Contacts				
Beaverhead				
Richard Miller	County Road Manager	683-3781	rmiller@co.beaverhead.mt.us	Yes
Broadwater				
Dana Rauser	County Road Shop	266-3429		Yes
Carbon				
Daryl Krum	Dept of Emergency Services	446-1038		No
David Davidson	Joliet District Commissioner	446-1595		No
Doug Tucker	Bridger Dist Commissioner	446-1595		No
John Prinkki	Red Lodge District Commissioner	446-1595		No
Cascade				
Dave Sutton	Cascade Co Road & Bridge Dept	454-6913		Yes
Nadine/ Mark Peterson	Cascade Co Road & Bridge Dept	454-6913	road@co.cascade.mt.us	Yes
Deer Lodge				
Larry Sturm	County Road Supervisor	563-4072	adlcroad@in-tch.com	No
Flathead				
Juanita Nelson	Flathead Co Road Department	758-5790	jnelson@flathead.mt.gov	Yes
Rod Schmidt	Flathead Forest Service	758-3526		Yes
Gallatin				
Erin Howard	Gallatin Co Road Office	582-3250	erin.howard@gallatin.mt.gov	No
Glacier				
Bill Bandel	Glacier Co Road Dept	873-4362		Yes
Granite				
Freddie McDonald	Road Crew	288-3500		Yes
Maureen Connor	Commissioner	859-7022	mconnor@co.granite.mt.us	Yes
Ron Graham	Road Crew foreman	859-3720		Yes
Jefferson				
Joe Carter	Road Dept	225-4170	jcarter@jeffco.mt.gov	No

Lake				
Larry Ehle	Road & Bridge - Superintendent	883-7206		No
Paddy Trusler	County Commissioner	883-7204		No
Lewis & Clark				
Wayne Effertz/Dale Moore	Lewis & Clark Co Public Works Dept Roads & Bridges	447-1631		Yes
Lincoln				
Mark McCally	Libby Road Crew	293-4557		Yes
Ron Downy	Troy Road Crew	295-4420		Yes
Tim White	Eureka Road Crew	889-3702		No
Madison				
Dave Schultz	County Commissioners	843-4277		Yes
Jim Hart	County Commissioners	843-4277		Yes
Meagher				
Ray Ringer	Road Supervisor	547-3716		No
Mineral				
Jason McLees	County Road Shop	822-3560	jmclees@co.mineral.mt.us	No
Missoula				
Sean LaDue	Missoula Co Department of Public Works - Road Dept	258-4851		No
Park				
Ed Hillman	Park Co Road Dept	223-2860		No
Pondera				
John Stokes	Valier Road Shop	279-3651	pocova@3rivers.net	Yes
Powell				
Larry Renfield	Road Crew	846-2153		No
Ravalli				
David Ohnstad / Bill Meisner	Ravalli Co Road Dept	363-2733	roaddepartment@ravallicounty.mt.gov	Yes
Sanders				
Donald Kuhn	District 3 - Thompson Falls Road Dept - foreman	827-3691		No
Jon Loraas (Mark)	District 2 - Hot Springs Road Department - foreman	741-3582		No
Roger Mallery	District 1 - Plains Road Department - foreman	826-3742	pln3742@blackfoot.net	No

Silver Bow				
Sharon	Public Works - Animal Control/Roads/Bridges	497-6565		No
Stillwater				
Ken Kissler	Roads & Bridges Dept Road Superintendent	322-5335		Yes
Sweet Grass				
Randy Wordall	Road Supervisor	932-5140		No
Teton				
Linda Erickson	Teton Co Road Department	466-2671	tcrd@3rivers.net	Yes
Tom Hardin	Former Road Supervisor (retired)	467-2472		Yes
Yellowstone				
Tim Miller	Yellowstone Co Road & Bridge Department	256-6824	tmiller@co.yellowstone.mt.go	No

Montana Department of Transportation

Statewide				
Bill Cloud / Marisa Mailand	Montana Dept of Transportation	444-6114	mmailand@mt.gov	Yes

US Forest Service

Beaverhead County				
Dick Judge	Beaverhead Natl Forest	683-3900		No
Carbon-Stillwater Counties				
	Custer Natl Forest	657-6200		No
Deer Lodge County				
Dick Judge	Deerlodge Natl Forest - part of Beaverhead office	683-3900		No
Gallatin County				
Jeff Heideman	Gallatin Natl Forest - Road maintenance	587-6738		No
Lewis & Clark County				
Bob Corb	Lewis & Clark Natl Forest -	791-7737		No
Road Supervisor				
Charlie McKenna	Helena Natl Forest - Forest Engineer	449-5201	Yes	

Lincoln County

Paul Stantus	Kootenai Natl Forest - Forest Engineer	293-6211	No

Mineral County

Nancy Taylor	Lolo Natl Forest - Engineering Department	329-3729	No

Ravalli County

Rich Raines	Bitterroot Natl Forest - Engineering Dept	363-7178	Yes

Western Federal Lands Highway Division

Statewide

Bob Lale	Western Federal Lands Highway Division	619-7700	No

APPENDIX B:

Paved Road Segments for which Data was Collected, Organized by County

County Road Segment	Year of paving	Segment length (miles)
Beaverhead		
Pioneer Mtn Scenic Byway from Wise River to the Forest Service Boundary	~1985	~5
S-324	1999	5.364305
Broadwater		
Canton Lane to Delgier Rd and Delgier Rd	1991	2.5
Jack Farm Rd and Cemetery Lane	1991	1
Old Town Road starting at the intersection with Hwy 287 2 miles north of I90	1991	3
Silos Rd off Hwy 287	1991	1
Wheatland Rd starting at Hwy 287	1991	2
Cascade		
Big Sky @ Vaughn (RID)	1991	entire RID
Flood Rd. (RID)	1991	5.1
Gore Hill (RID)	1990	entire RID
Ptarmigan Acres (RID)	1991	entire RID
Sun Prairie (RID)	1980	1.3
Ulm-Vaughn, south end (RID) - this is the road from Ulm to Ulm-Pishkun	2000	4.6
Vaugn-Ulm-McIver (RID) - this is McIver Rd all the way to Vaughn-Ulm and also the Vaughn to Ulm Rd	1991	5.4
Woodland Estates (RID)	1985	2.3
Flathead		
Aero Lane	1983	1.248
Airport Road	1985	0.469
Alpine Drive	1986	0.255
Armory Road	1986	1.597
Ash Road	1989	0.59
Batavia Lane	1988	2.714
Bayou Road	1989	1.042

Berne Road	1989	2.184
Bierney Creek Road	2000	1.21
Big Horn Drive	1984	0.846
Blanchard Lake Road	1985	1.766
Braig Road	2000	0.53
Buckboard Lane	1985	0.629
Cascade Avenue	1984	0.253
Conn Road	1988	1.042
Deer Creek Road	2001	0.353
Dorothy Street	1980	0.374
Double Lake Drive	1980	0.42
Eastman Drive	1983	1.283
El Rancho Road	1986	0.704
Elk Park Road	1984	1.97
Ezy Drive	1984	0.66
Farm to Market Rd from the junction with Star Meadows Rd to Hwy 83	1987	~2
Farm to Market Rd to the south	1989-1990	ask the county
Florence Street	1980	0.325
Good Creek Rd (FS Rd 60) from Alney west for 6 miles	1984	6
Griffin Creek Rd (FS Rd # 538) from the intersection of #538 and Pleasant Valley Rd (?#543) to the intersection of #538 and #528B (this is just north of Bitterroot)	1980	12.13
Halfmoon Road	1989	2.035
Hathaway Lane	1985	0.337
Hellman Lane	1989	0.479
Highline Boulevard	1982	0.586
J P Road1986	0.795	
Meadow Lake Drive	1980	0.507
Mud Lake Road	2001	0.77
S-486 1999	7.509959	
Siderius Lane	1989	0.29
Star Meadows Road from Farm to Market Rd to the 3.35 mile mark	1987	3.35
Star Meadows Road from milepost 10.77 to 16.85	1988	6.08
Star Meadows Road from milepost 3.35 to 10.87	1984	7.52

White Birch Lane	1983	0.83
Wilson Heights	1985	0.33
Woodland Road	1987	0.506
Gallatin		
S-235 2001	1.996057	
Granite		
Black Pine	between 1980-2001	~3
Blackpine Rd near Phillipsburg	~2000 best guess	~3
Helmville Rd (Hwy 271) from Drummond to Helmville	between 1980-2001	~8
Lakeshore Dr (by Georgetown Lake)	between 1980-2001	~2
Marshall Creek (MT 348)	between 1980-2001	~10
Maxwell Rd	between 1980-2001	~2
New Chicago Rd East	between 1980-2001	2
Rock Creek from the Interstate for 11 miles	1996 or 1997 (could check records when not so busy)	11
S-271 2000	2.363607	
Jefferson		
S-399 2001	11.661226	
Lewis & Clark		
Beartooth starting at Craig Frontage Rd (old highway) north of Wolf Creek along the north side of Holter Lake	1994	5.1
Colorado Gulch Rd starting at Highway 12 west near McDonald Pass	1993	3.4
Lincoln		
ACM Road (for Anacona Mining Co) off of Hwy 2	~1995 best guess	~1.5
Blue Mtn Road starting at Pipe Crk Rd	~2000 best guess	.75
Fish Hatchery Road starting .5 mile off of Farm-to_Market Rd	~1985 best guess	.75
Granite Lake Rd starting at Snowshoe Rd	1981 or 1982	4.6
McGinnis Rd starting at Hwy 2	~1995 best guess	~ 7
road to the garbage site (dump) at Happy Inn	~ 1998 best guess	.75
Seventeen Mile Road starting at Pipe Crk Rd	~2000 best guess	.75
Sweet Mountain Road off of Farm-to-Market Road	~1994 best guess	.5
Trainers Street starting 1 block off Farm-to-Market Road	~1997-1998 best guess	.4
Upper Ford Rd - the first 2.4 miles from the junction with Hwy 508	2000	2.4

Madison		
Jeffers Road (east of Jeffers)	~1998 best guess	~2
Mill Creek (the Ruby side)	~1982 but got a new surface again in 2001	~2.5
North Meadow Creek	~1998 - best guess	~1
Rochester Rd to the bridge (in Twin Bridges district)	~ 1982 best guess	~1- 1.5
South Boulder Rd off Hwy 359 between Cardwell & Harrison	~ 1986-1988	~2
Varney Road	~1995 - an educated guess	~3
Missoula		
S-533 1999	2.695297	
Ravalli		
Lake Como Rd - .6 miles paved from Hwy 93 and then 6.1 miles of county road to beginning of FS for another .8 miles on FS road to the boat ramp at the lake	1999 (Bill Meisner Ravalli Co Rd Foreman)	7.5
Sanders		
S-556 2001	2.331559	
Silver Bow		
S-276 2000	7.367707	
Stillwater		
Brumfield Rd	1999	5.6
Cemetery Rd at Park City - from Valley Crk Intersection (just east of Hwy 10) to Sportsman's Park	2000	~2
Countryman Creek Rd from Hwy 78 to the NW - started just past Stillwater River and paved to Porter Hill	1999	3.6
S-421 1999	2.18701	
Shane Creek Rd (3 miles S of Columbus off Hwy 78)	2000	3
Springtime Rd	1999	1.5
Whitebird Creek Rd (off Hwy 78 half way between Columbus and Absarokee)	2000	2
Teton		
Secondary 431 - started at Hwy 89 to Power	~ early 90s	~20
Secondary 565 starting at Hwy 89 between Simms & Great Falls	1991	7
Secondary Hwy 220 (the northern 8 miles)	1991	~8
Teton Canyon Rd from Hwy 89 to the S. Fork Bridge	1985	1.5

ENDNOTES

[1] Hills, P., 1996. What is induced traffic. Transportation 23, 5–16; and Daniels, T., 1999. *When City and Country Collide: Managing Growth in the Metropolitan Fringe*. Island Press, Washington, DC; and Gude, P. H., A. J. Hansen, R. Rasker, and B. Maxwell. 2006. Rates and drivers of rural residential development in the Greater Yellowstone. Landscape and Urban Planning 77: 131–151.

[2] Ibid.

www.headwaterseconomics.org