Draft Final Report
Historic Watershed Land Use Assessment of the Upper Yellowstone River Valley

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Introduction:

The Governor's Upper Yellowstone River Task Force was interested in land use changes over time as a gauge of cumulative effects for the Upper Yellowstone River basin. This project is a follow up to the work of Harrison and Potter (2001) that used satellite imagery to assess land cover change. Due to quality of imagery from the 1970s relative to imagery from the 1990s, they were unable to map the watershed at a level of detail required to assess land use change that occurred along the Upper Yellowstone River. The goal of this study was to map portions of the Upper Yellowstone River basin, focusing on private and public lands adjacent to the river, as well as map into the foothills for the years 1948, 1979, and 1998.

Objectives:

1. Map land use/cover for three years, 1948/49, 1979, and 1998, in four sample areas along the Upper Yellowstone River with a focus on agricultural and rural residential land uses.
2. Characterize historical land use change by identifying areas where change has occurred, the types of change that have occurred, and their relationship to the Yellowstone River.
3. Map house locations for three years, 1948/49, 1979, and 1998, in four sample areas along the Upper Yellowstone River.
4. Characterize home location in relation to land use/cover and the Yellowstone River.

Methods:

Study Areas:

Four study areas along the Upper Yellowstone River were selected that centered on the river and extended into the foothills (Figure 1). These areas were chosen as examples of the braided, moderately confined, and confined river reaches. These areas provided optimal overlap for other studies directed by the Task Force. The Mission Creek study area includes the braided reach type in the vicinity of the Shields River and Mission Creek confluences with the Yellowstone River. The Pine Creek study area, also considered a braided river reach includes Pine Creek and Suce Creek confluences with the Yellowstone River. The Emigrant study area considered a moderately confined river reach, centers on the town of Emigrant and includes Mill Creek and Big Creek confluences. The Corwin Springs study area includes the confined river reach centered on the town of Corwin Springs. Three of the study areas are approximately 25 square

miles in area. The Emigrant area was used for a previous study and is approximately 100 square miles.

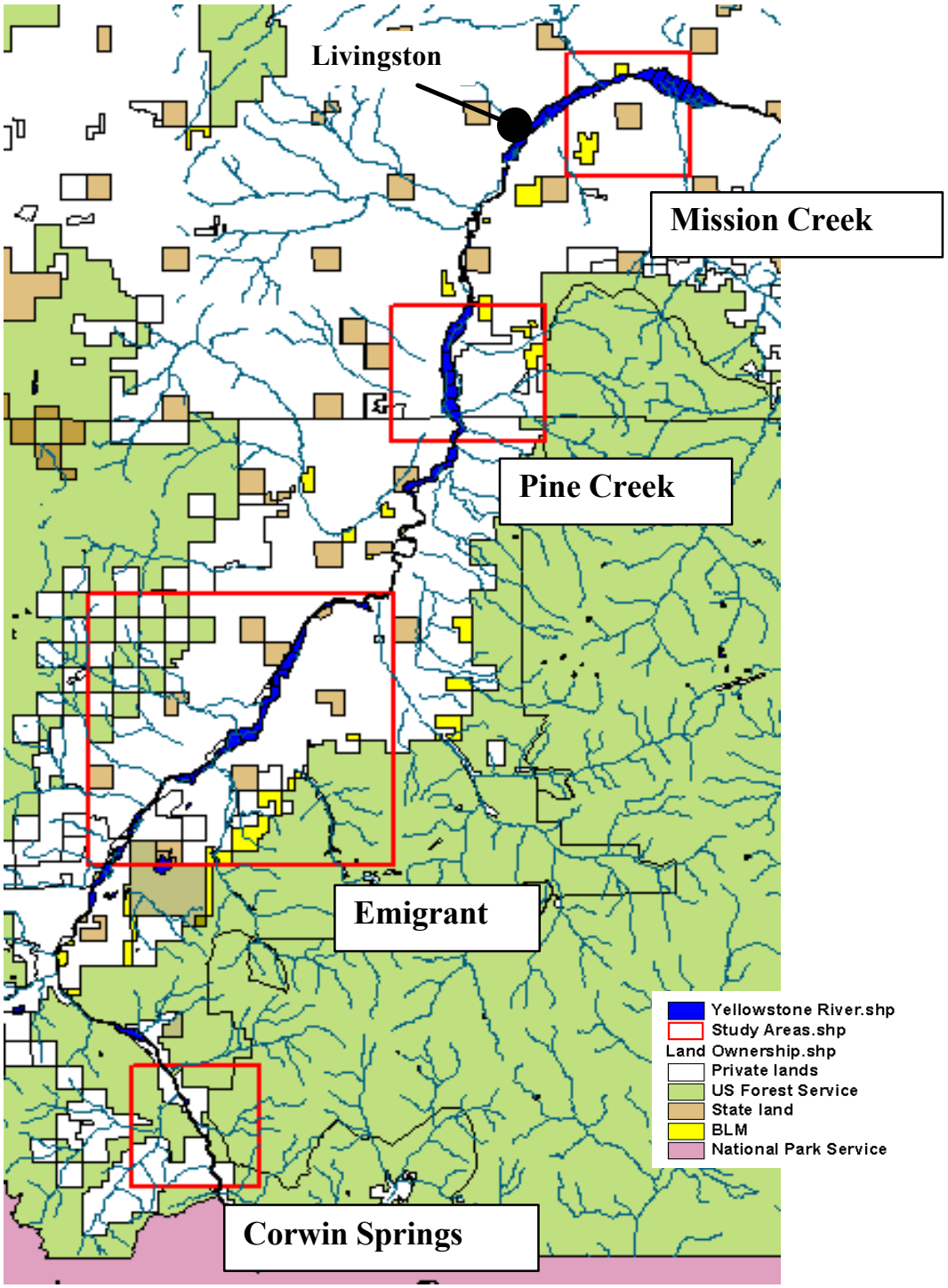

Figure1. Study areas along the Upper Yellowstone River

Photo Interpretation:

Aerial photos were obtained for the years 1948/49 from the Task Force and were georectified by Positive Systems. The 1979 photos were obtained from Park County USDA Service Center and were georectified at Montana State University. The 1998 photos were obtained from the web at the Montana Natural Resource Information System as digital ortho quarter-quads (DOQQ) and were actually a mix of 1997, 1998 and 1999 photos, with the majority being 1998. For the Corwin Springs area the DOQQs were dated 1991, therefore we obtained and georectified 1998 U.S.Geological Survey aerial photos for this area.

Aerial photos were georectified as close as possible to the DOQQs, and we tried to be within 20 meters of specific locations on the DOQQs. Due to photo quality, coverage and computer programs available, as well as time allotment, this was not always possible. We had full photo coverage for 1998. The 1979 photo coverage was lacking at high elevations in the northwestern and southeastern corners of the Corwin Springs study area. The 1948/49 coverage was incomplete for all the study areas.

Land use/cover was mapped in ArcView at the 1:10,000-scale or, in many cases, even finer scales. We mapped land use/cover types on the 1998 photos first and then went back in time to insure that polygon boundaries lined up appropriately. Polygons were created and classified using the classification scheme developed by Harrison and Potter (2001) (Table 1). All of the study areas have complete land use/cover maps (215 square miles) for the year 1998, and partial maps for 1979 and 1948. However, for evaluation of land use change, the land area that was included in the analysis was reduced to the coverage available in the 1948/49 photos (175 square miles).

Using ArcView, land use polygons for different years were intersected and the resulting polygon coverage depicted the type of change, the area of change, and the location of change that has occurred. This information was displayed visually and spatially.

Houses were mapped as a separate point layer in ArcView using the photos. All structures were mapped and classified as houses that had visible driveways. During the fall of 2002, house and trailer home locations were verified by driving around the four study areas. Barns, outbuildings, abandoned homes, and businesses were removed from the data. Due to time constraints and extent of study areas, individual landowners were not contacted to gain permission for access on private roads marked as ”no trespassing”. Therefore, a small portion of home sites could not be verified visually and inferences were made to determine number of homes along these roads. In these cases, the number of mail boxes were counted and estimated to be the number of homes along private roads. Home sites that were not confirmed visually were recorded as unverified in the data. Also new homes were mapped and recorded as occurring in 2002.

Table 1. Land cover classifications used in the "Satellite-Based Land Cover Map for the Upper Yellowstone River Watershed, Montana and Wyoming" completed in 2001. Additional categories reflecting more specific use were added to provide a finer scale of classification for the current work described in this report (4-digit code numbers). In addition, our work did not include Urban designations. Instead, inhabited houses were created as a separate layer of points.

I Urban
1101 Farm (house with out buildings)
1103 Commercial Areas or Structures
1106 Airport

II Agriculture
2020 Center Pivots
2021 Irrigated Hay
2022 Dry land Annual Crop
2023 Dry land Hay
2024 Irrigated Annual Crop

III Grasslands
3000 Moist Grassland
3150 Grassland/ Dry land Pasture
3170 Grassland with Sagebrush

IV Shrub Lands
3400 Juniper with deciduous shrubs and minor component pine
3350 Sagebrush (>20% canopy)

V Forest Lands
4000 Low Density Coniferous Forest
4200 High Density Coniferous Forest
4300 Streams with mixed Deciduous/ Coniferous Forest
4500 Cut over forest

VI Water
5000 Water (Yellowstone river and gravel bars, lakes and ponds)

VII Riparian
6120 Deciduous Trees (cottonwood/willow juniper under-story possible)
6130 Shrub Riparian (young cottonwoods, willow)
6160 Riparian meadow/ bottomland pasture
6190 Broadleaf Trees on Ditch Lines

VIII Barren Lands
7300 Rock, Rock Outcrop
7500 Gravel Pits, Disturbed

IX Alpine
8100 Alpine (treeless)

Results:

Land Use/Cover Mapping

In the Mission Creek study area, 264 acres of dry grassland changed to juniper (Figure 2). This is a common successional change that is likely due to fire suppression. 421 acres of grassland also changed into commercial land use, i.e. the Livingston airport.

In the Pine Creek study area, 566 acres of agricultural lands changed to dry grasslands (Figure 3). Some areas previously irrigated now appear to be idle with no active agriculture. In addition, 374 acres of riparian has changed into agricultural lands. Juniper dominated areas have changed to coniferous forest. As juniper shrub classified area transitioned into a more spatially consistent canopy it was classified as low density conifer forest. This appears to be common throughout the study area, in which junipers appear first, followed by limber pine and Douglas fir.

In the Emigrant study area, 2538 acres of dry grassland changed into agricultural lands (irrigated hay, irrigated crops, and center pivots) (Figure 4). 371 acres of dry grasslands changed into juniper. 320 acres of dry grasslands and 527 acres of shrub lands have changed in forested lands. 170 acres of riparian land has changed to agricultural lands.

In the Corwin Springs area, 451 acres of dry grasslands changed into shrub lands (sagebrush and juniper) (Figure 5). 202 acres of shrub lands changed into forested lands.

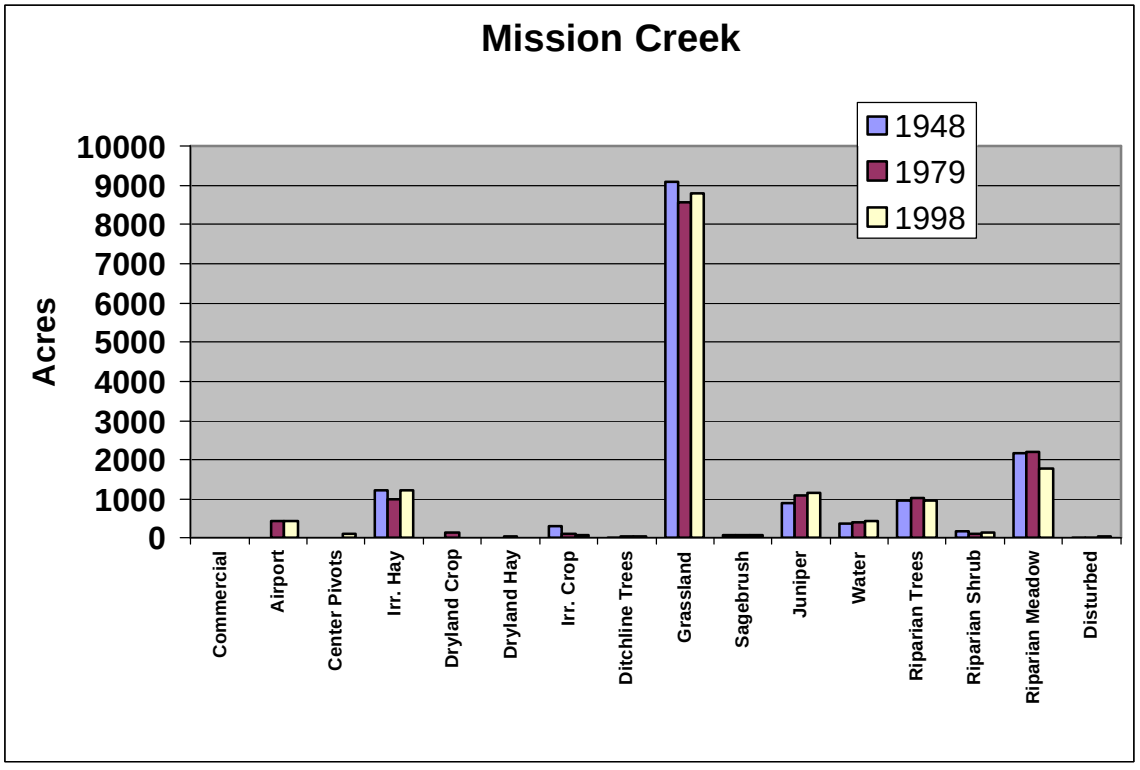

Figure 2. Acres of land in each land use/cover type in 1948, 1979, and 1998 in the Mission Creek sample area.

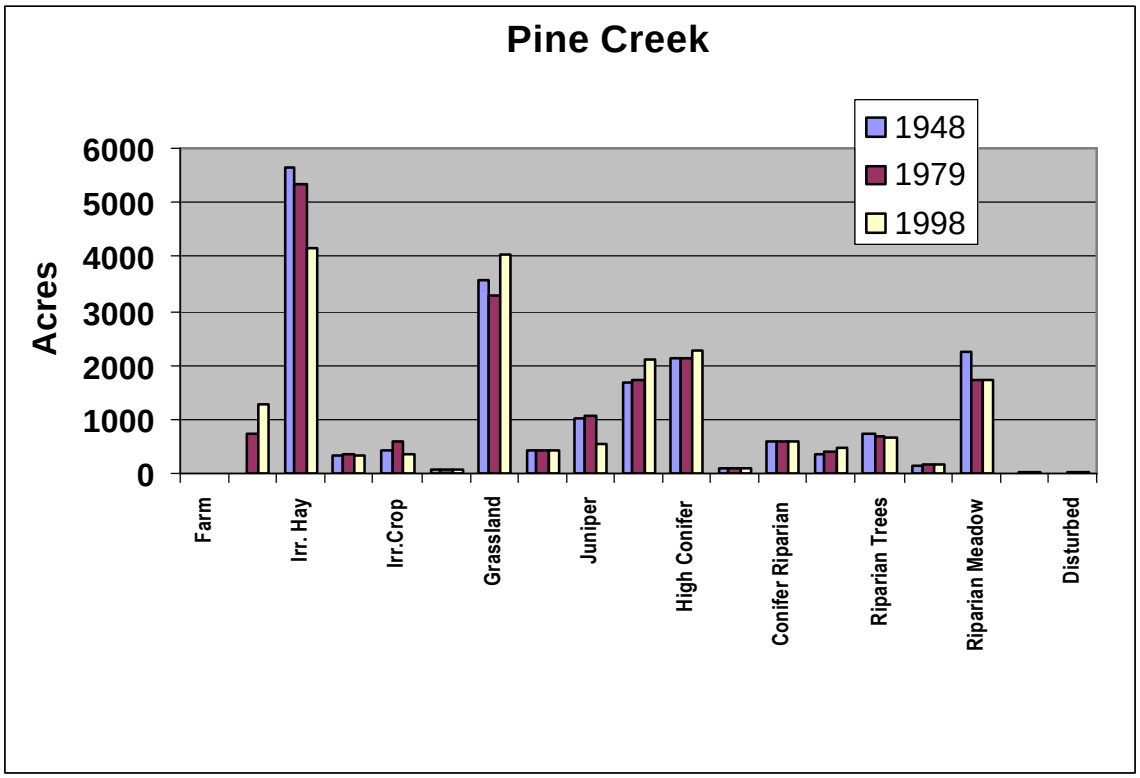

Figure 3. Acres of land in each land use/cover type in 1948, 1979, and 1998 in the Pine Creek sample area.

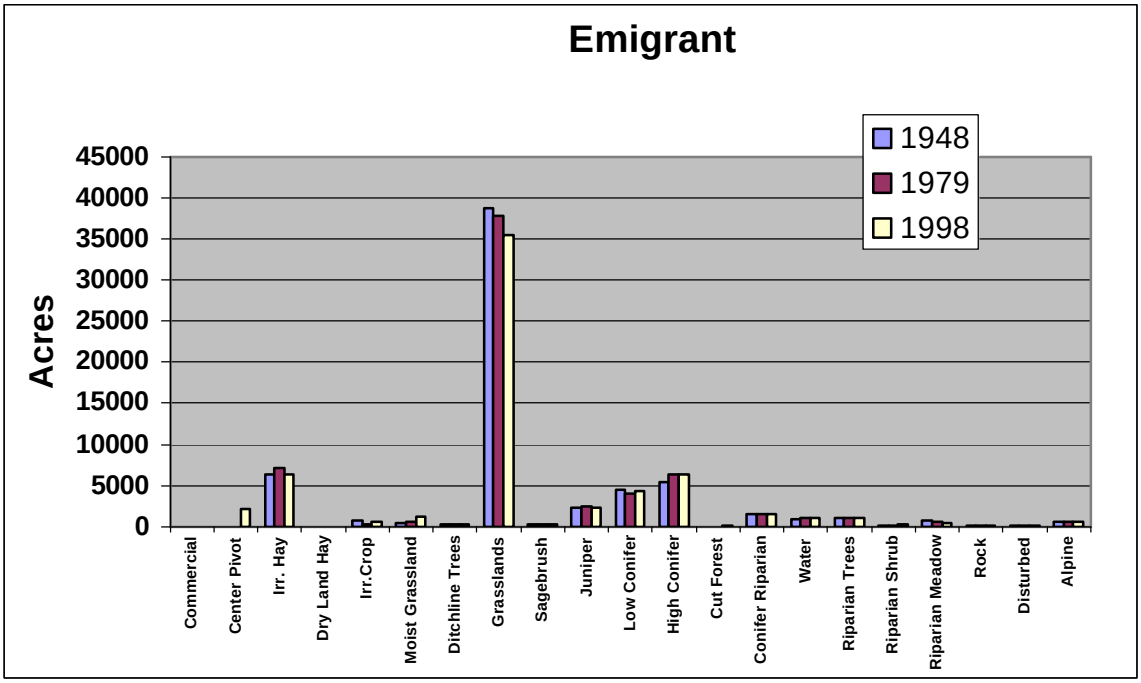

Figure 4. Acres of land in each land use/cover type in 1948, 1979, and 1998 in the Emigrant sample area.

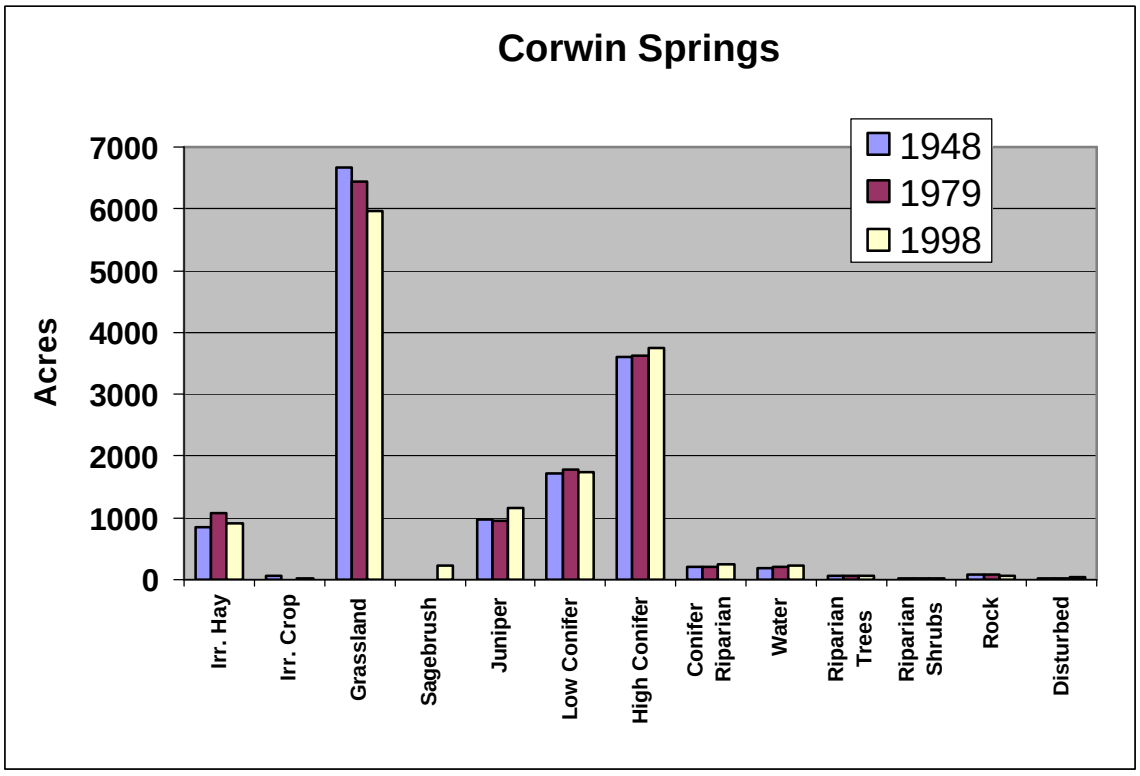

Figure 5. Acres of land in each land use/cover type in 1948, 1979, and 1998 in the Corwin Springs sample area.

In an effort to look at over all changes of non-forested classifications, land use classifications were grouped. Irrigated crop, irrigated hay, center pivots, moist meadow, dry-land hay and ditch lines were grouped as Agricultural lands. Riparian trees, riparian shrubs, meadows, open water and forested secondary streams were grouped as Riparian. Grasslands and grasslands with a minor component of sagebrush (<20%canopy cover) were grouped. Juniper and sagebrush types were grouped as Shrub lands. Of the land classified as Agriculture in 1948, eighty percent of that land remained in agriculture in 1998. For Riparian lands eighty seven percent of the area remained as riparian. For the Grasslands classification, eighty nine percent of the grassland was still grassland in 1998. Eighty two percent of the shrub lands remained as shrub lands in 1998. Agricultural lands increased by 2,406 acres, Riparian lands decreased by 868 acres, Grasslands decreased by 3,745 acres and Shrub lands increased by 146 acres. Other classifications not in the grouped data changed as follows: commercial lands increased by 445 acres (airport), forest increased by 1,477 acres, and disturbed land increased by 80 acres.

Trends were looked at across all four sample areas separately (Figure 6). The graphs demonstrate that some areas increased or decreased for a specific land use but no land use was consistently increasing or decreasing. For example, looking at agricultural land use, Pine Creek area increased in 1979, but decreased in 1998; in the Emigrant area it increased for both time periods; in the Mission Creek area agricultural land decreased and then increased. The data suggests that along the upper Yellowstone River there are no consistent trends in land-use change trends occurring for the entire basin.

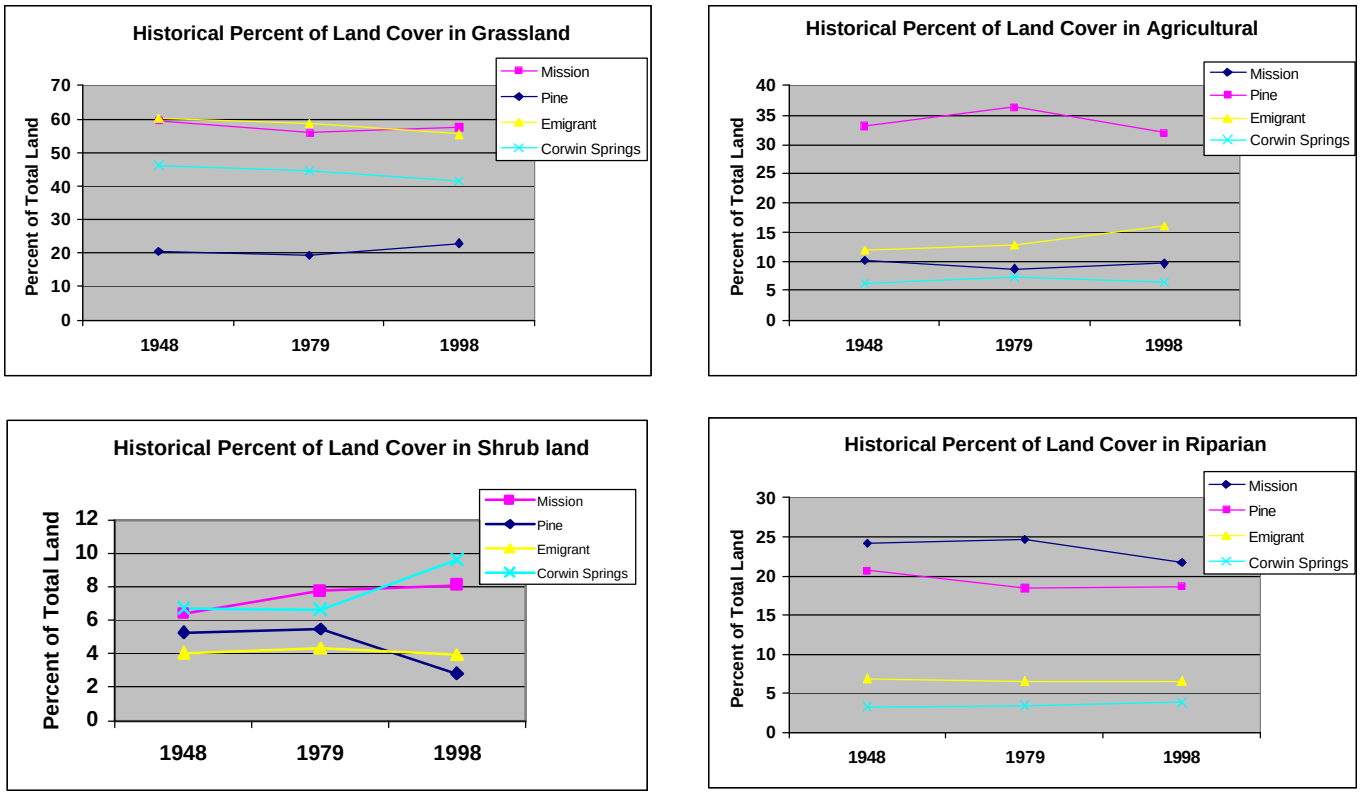

Figure 6. Trends in specific (grouped) land use/cover types over time in each sample area.

House Locations

Home site locations were mapped from aerial photographs for the three years (1948, 1979 and 1998), and were verified in the fall of 2002 for the 1998 layer. New 2002 houses were also mapped. Permission was not obtained for access to private roads, thus home sites that were not visually verified are recorded as such in the data layer.

The number of homes for each study area are listed in Table 2. The total number of homes increased 99 percent between the year 1948 and 1979. For the years 1979 to 1998 the number of homes increased 229 percent, the percent increase from 1948 to 1998 is 555 percent. The Emigrant study area has the largest percent increase in homes, while the Pine Creek study area has the least percent increase in homes.

Home sites were attributed to land use/cover classification. In 1948, the majority of home sites were in agricultural and riparian lands in the Mission Creek and Pine Creek study areas (Figure 7). The majority of home sites in the Emigrant and Corwin Springs study areas were located on the agricultural land and grasslands in 1948. In 1998, the majority of the home sites were in agricultural lands, grasslands, and riparian lands for the Mission Creek and Pine Creek study areas (Figure 8). However, in the Emigrant and Corwin Springs study areas in 1998, the majority of the homes were again in the agricultural lands and grasslands cover types.

Table 2. Number of home sites in each sample area, density of homes, and percent increase in homes for each time period. *N/A means "not available".					
Study Area	Year	Number of homes recorded using photos	Number of homes per section of land (640 acres)	Percent increase of homes	Number of 1998 homes ground truthed in 2002
Mission Creek	1948	19	0.8	N/A*	N/A*
	1979	30	1.3	58	N/A*
	1998	76	3.2	153	72
Pine Creek	1948	49	1.6	N/A*	N/A*
	1979	90	3.0	84	N/A*
	1998	153	5.0	70	146
Emigrant	1948	63	0.6	N/A*	N/A*
	1979	130	1.3	106	N/A*
	1998	589	5.9	353	319
Corwin Springs	1948	17	0.8	N/A*	N/A*
	1979	45	2.0	165	N/A*
	1998	152	6.7	238	144

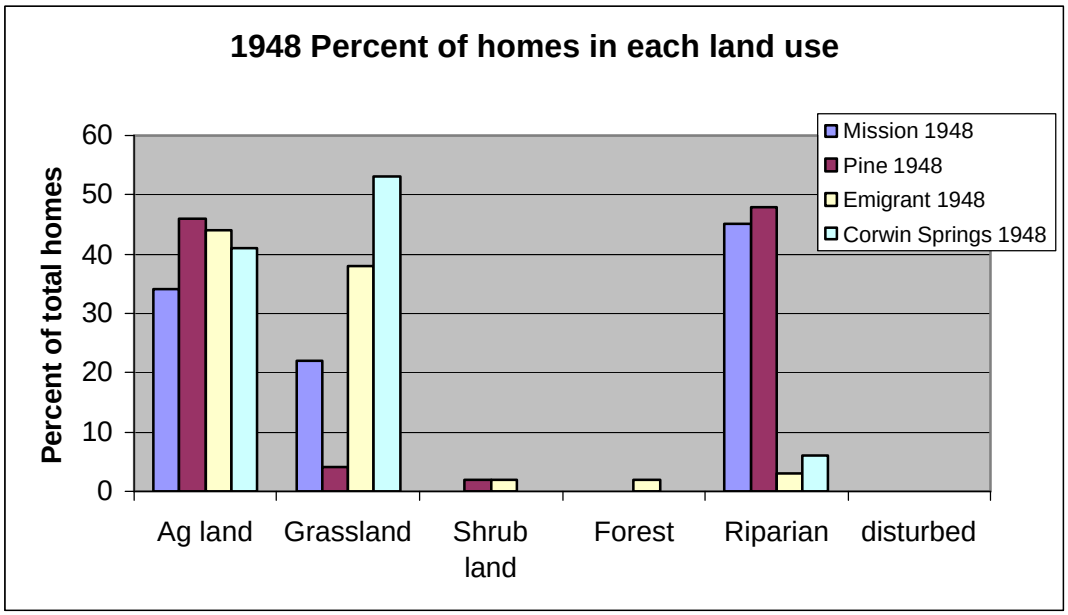

Figure 7. Percent of homes in each land use/cover type in 1948 in each sample area.

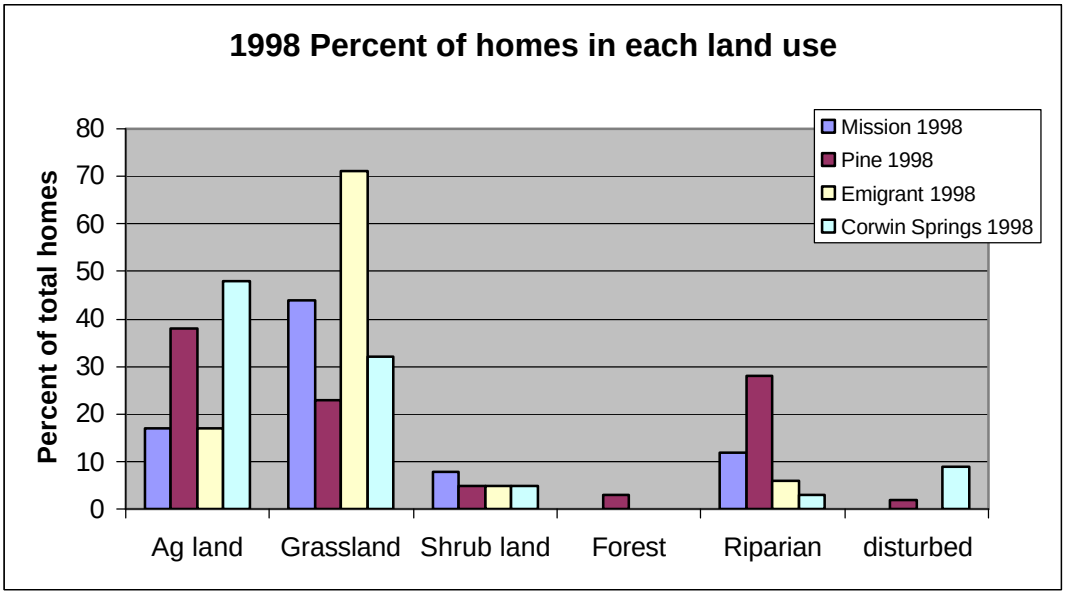

Figure 8. Percent of homes in each land use/cover type in 1998 in each sample area.

Percent of homes in each land type are then compared to the availability of the land type to determine if land use types are being selected as preferred home sites. If percent of home sites in each land use equal the availability of the land use, then home site location would be random. However, within our study areas along the Yellowstone River, home site locations are not random and specific land use types are preferred in each study area. In the Mission Creek study area, home sites were over represented in the agriculture and riparian land uses, and under represented in the grassland type (Figure 9). In the Pine Creek study area, home sites were over represented in the agricultural, grassland, and

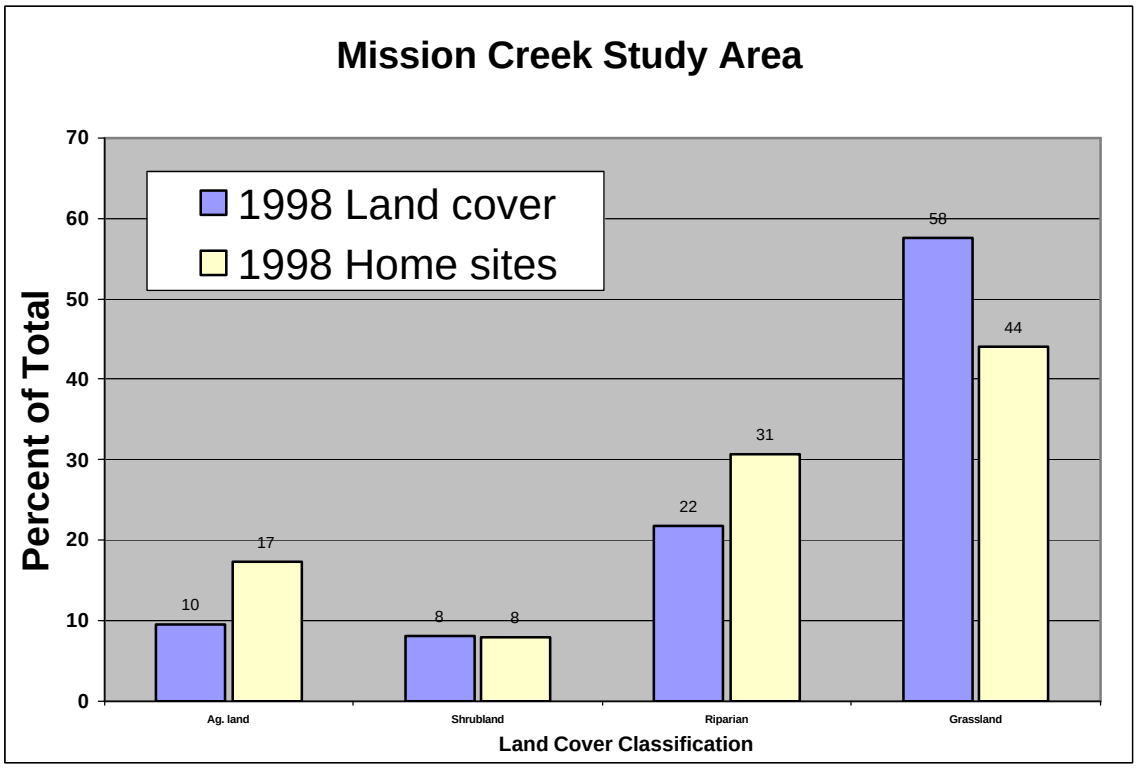

Figure 9. Percent of area and homes in each land use/cover type where homes occurred in 1998 in the Mission Creek sample area.

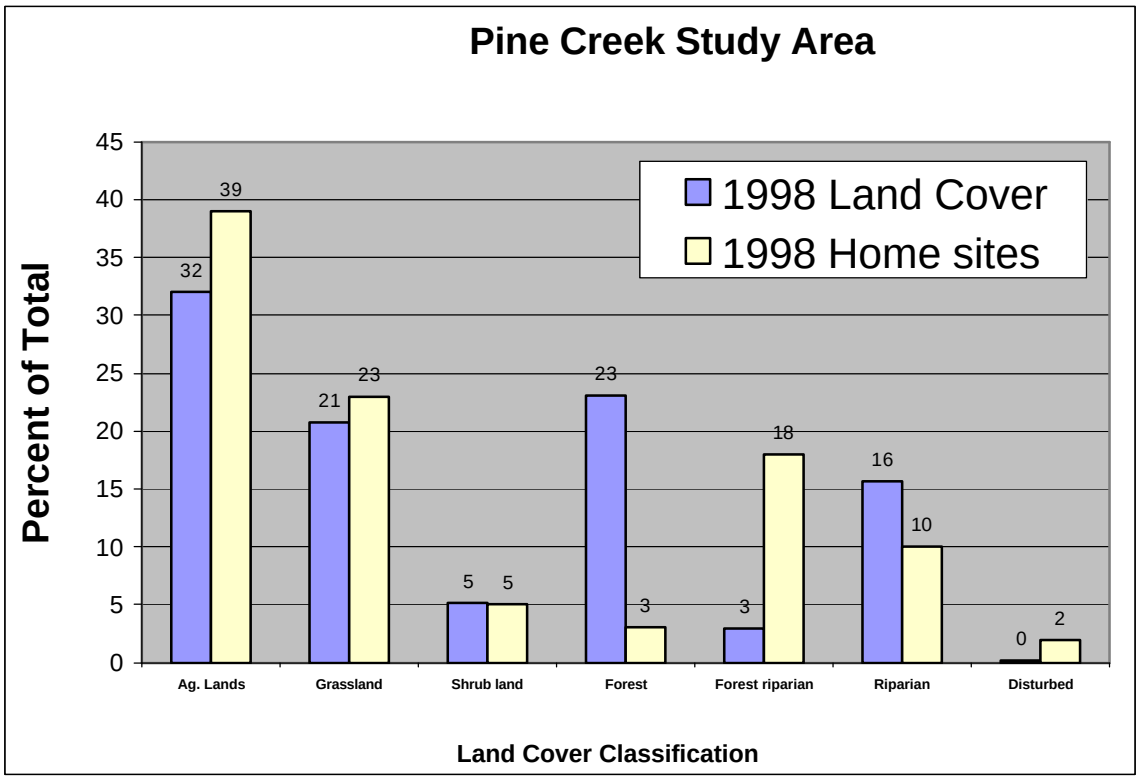

Figure 10. Percent of area and homes in each land use/cover type where homes occurred in 1998 in the Pine Creek sample area.

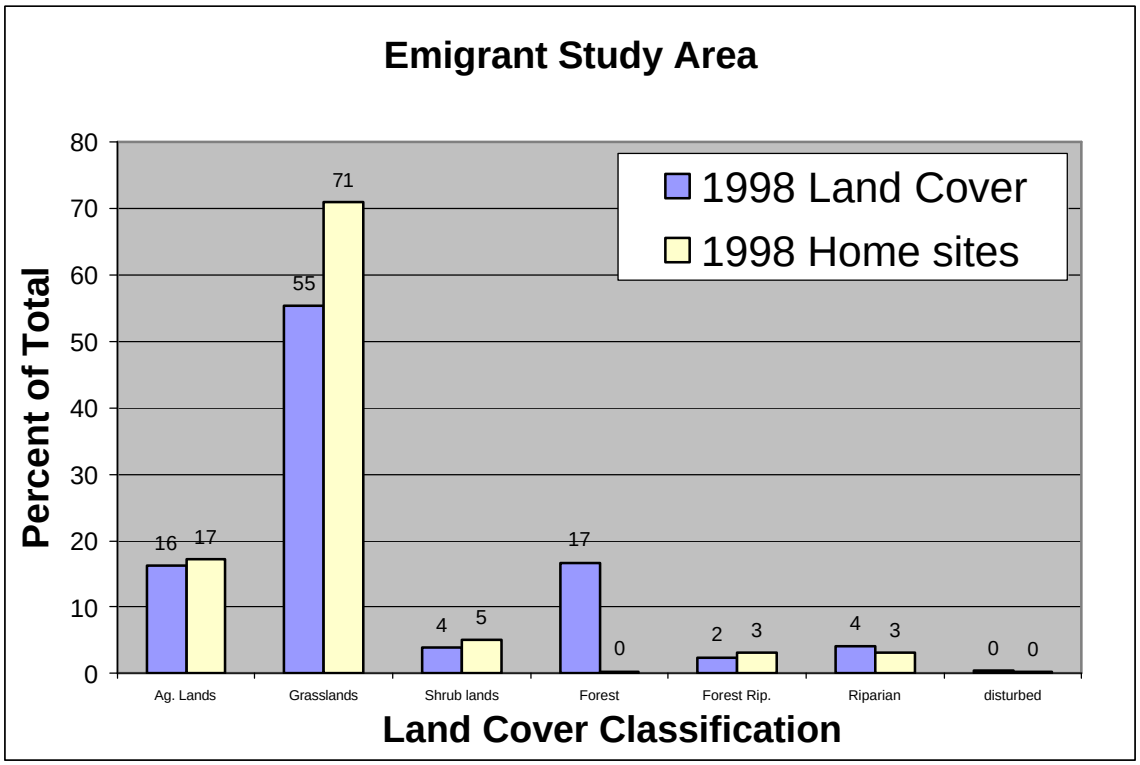

Figure 11. Percent of area and homes in each land use/cover type where homes occurred in 1998 in the Emigrant sample area.

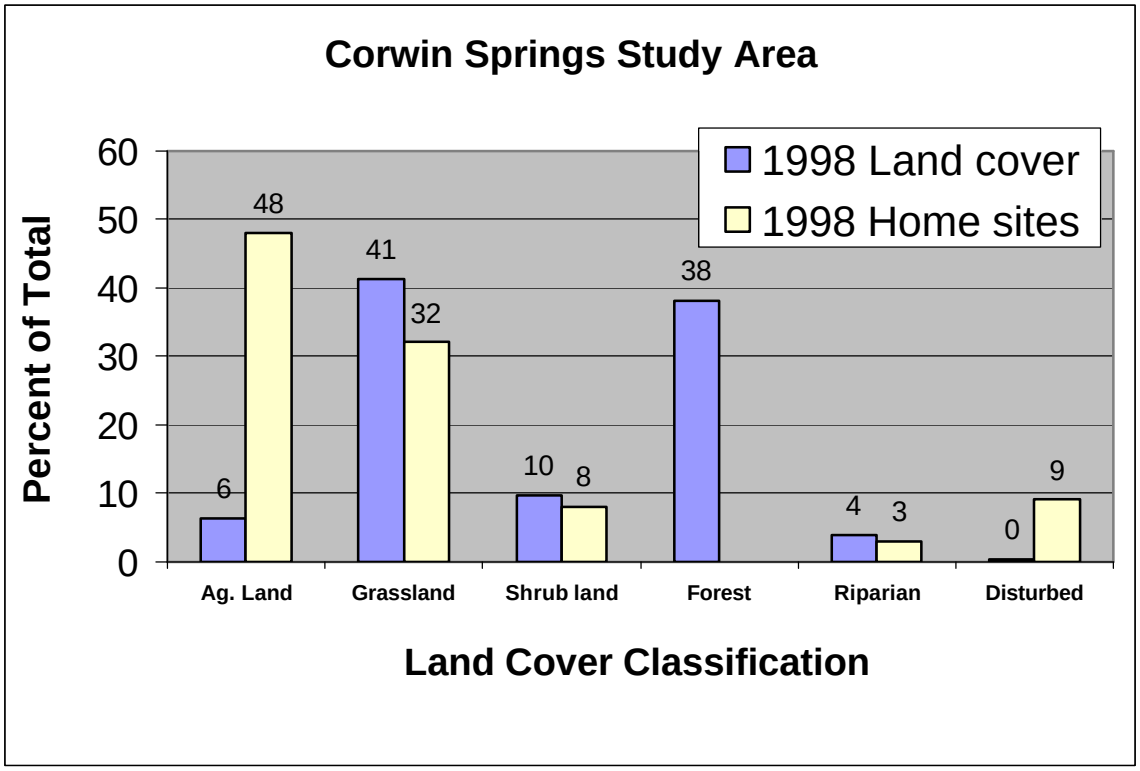

Figure 12. Percent of area and homes in each land use/cover type where homes occurred in 1998 in the Corwin Springs sample area.

forested riparian land use (Figure 10). In the Emigrant study area homes were over represented in the grassland land use (Figure 11). In the Corwin Springs study area homes are over represented in the agricultural land use (Figure 12).

Home sites were summarized by their distance to the Yellowstone River 100 year floodplain (maps created by the U.S. Army Corps of Engineers and USGS-WRD in 2003, in review) and riparian zone study maps created by Mike Merigliano (Figure 13).

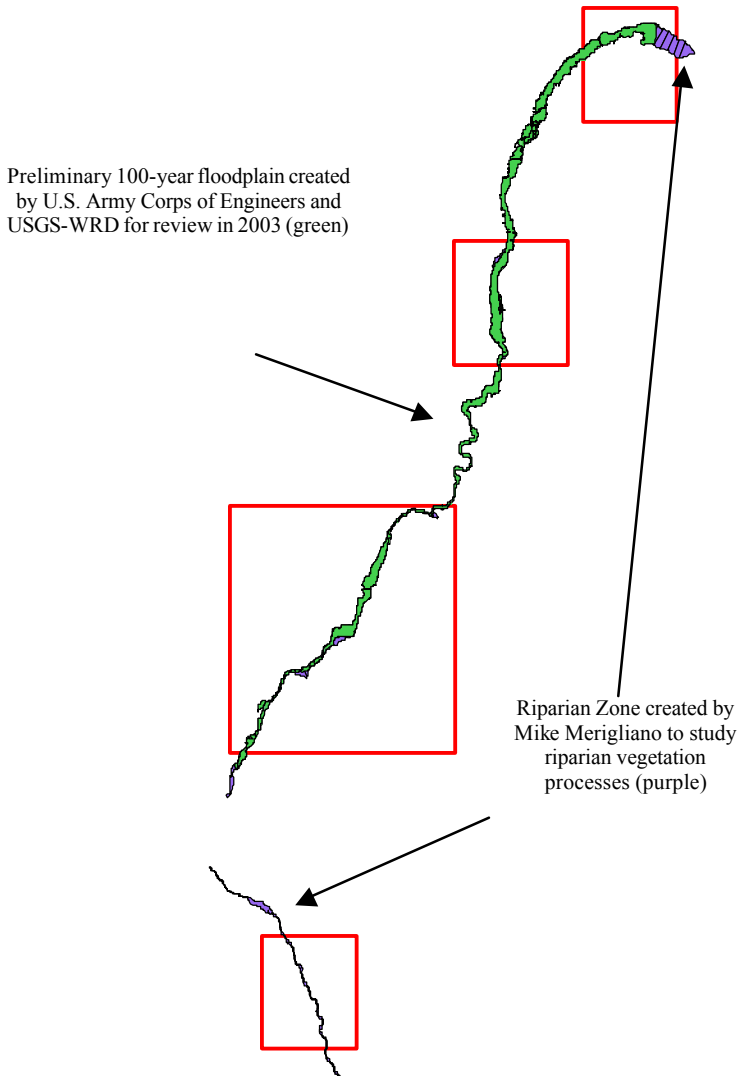

Figure 13. Study Polygons created by U.S. Army Corps of Engineers and Mike Merigliano used as the 100 year floodplain in this study.

Using the study maps, 17 homes were located within the 100-year floodplain and an additional 121 homes were located within 100 meters from the 100-year floodplain (Figure 14). In the Mission Creek study area, six homes were within the 100-year floodplain as it is currently mapped. Three homes were in the flood plain in Pine Creek study area, eight homes in the Emigrant study area, and zero in the Corwin Springs study area.

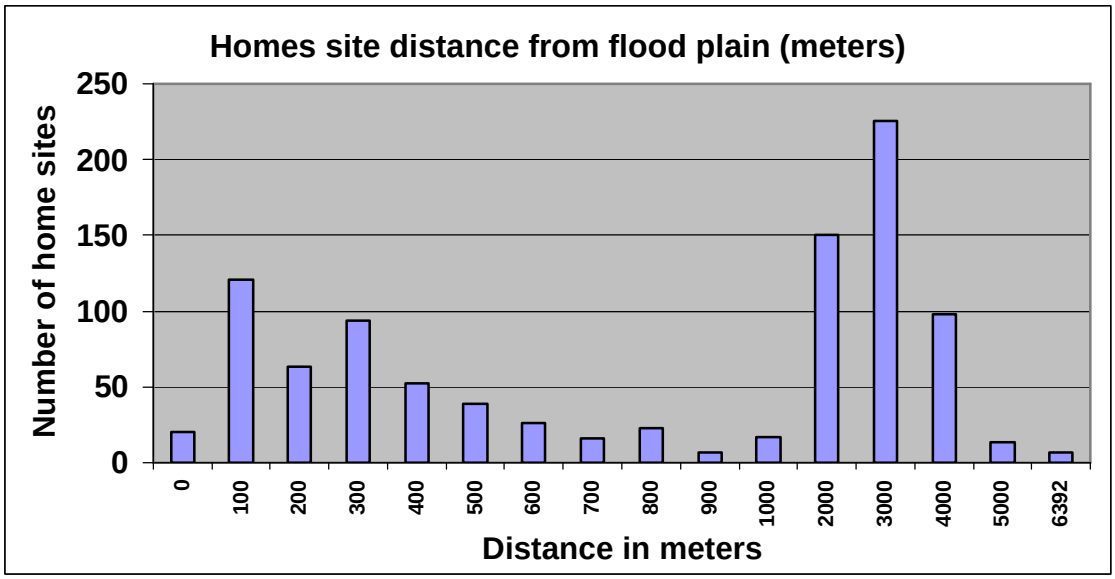

Figure 14. Frequency of home sites at distances from the Yellowstone River flood plain across all sample areas in 1998.

Land use cover types did not include individual home sites. In an effort to begin to understand the impact of homes on land use and the environment in general, we assigned an area to each home site point so that houses could assume a spatial signature equivalent to other land use/cover types. Considerations for how to assign an area to each house is dependent on the land use/cover type where the house is placed, what elements of the landscape or environment may be impacted, and dispersal rates of organisms that may cause an impact. For example, if a house is placed in agricultural land it is likely to be a source of weeds, which can impact production. Dispersal distances and rates vary tremendously with different weed species and mechanisms of dispersal (wind, water, animals, etc.), but 1 meter to 2,000 meters per year encompasses a large proportion of the range measured for agricultural weeds (Cousens and Mortimer, 1995). This ignores some extremely high rates of dispersal (2.5 kilometers per day) reported along rivers (Gray, 1960) that may be relevant in the Yellowstone Valley.

Research has been conducted to determine zones of ecological influence from homes (Hansen et al, 2002; Odell et al, 2003; Theobald et al, 1997). The zone of influence is largely based on dispersal distances of animals that accompany humans

(pets) and their impacts on native animal species (birds and mammals) (Odell and Knight, 2001). Taking into account the range of distances of influence reported in the literature (100 meters to 6,000 meters) and those associated with weeds and agricultural production, we selected a conservative sized zone of influence, 100 meters (7.76 acres) to assign area to our house points identified in the sample areas (Figure 15). We selected a distance creating an area of influence only to demonstrate how houses may be assigned a spatial signature. The Task Force may want to select a different sized area of influence as they determine their priorities.

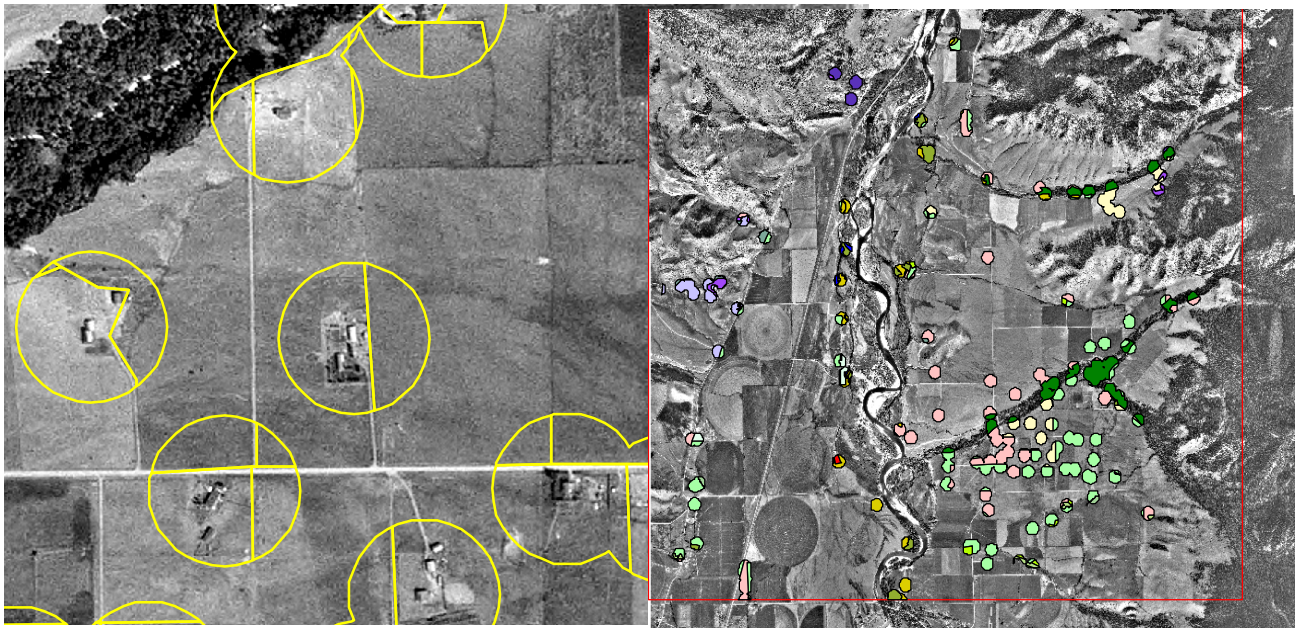

Figure 15. Aerial photos indicating 100-meter radius zones of influence around house site points (left) and 100-meter radius house site zones of influence colored to show intersection with different land use/cover types (right).

When using the 100-meter radius to define residential land use, the land use types reduced the most by home sites were agricultural, grassland, and riparian land use types (Figure 16). Agricultural lands were reduced by 1,404 acres, grasslands by 2,684 acres, and riparian by 846 acres. Shrub land was reduced by 264 acres, forested land by 107 acres, and disturbed land by 32 acres. Residential land use accounted for 5,337 total acres in the four study areas. Residential impact zone makes up 4.7 percent of the total acreage in all four study areas.

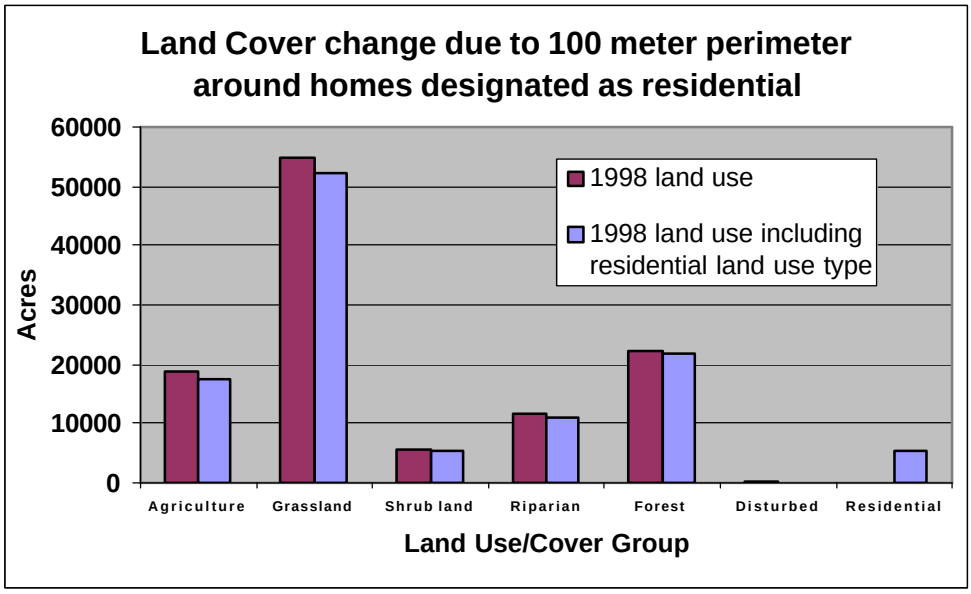

Figure 16. Percent reduction in land use/cover types due to homes built between 1948 and 1998 across all of the sample areas.

Summary

There has not been significant or consistent shifts in land use /cover for the four study areas in the Upper Yellowstone River Basin between the years 1948 and 1998. Land use classifications were grouped into agriculture, grassland, shrub lands and riparian. Of the land classified as agriculture in 1948, 80 percent of that land remained in agriculture in 1998. For riparian lands, 87 percent of the area remained as riparian. For the grasslands classification, 89 percent of the grasslands still remained in grasslands by 1998. Eighty two percent of the shrub lands remained as shrub lands in 1998. Agricultural lands increased by 2,406 acres, riparian lands decreased by 868 acres, grasslands decreased by 3,745 acres, and shrub lands increased by 146 acres. Other classifications not in the grouped data changed as follows: commercial lands increased by 445 acres (airport), forest increased by 1,477 acres, and disturbed land increased by 80 acres.

The number of homes have increased by 555 percent in the last 50 years. The total number of homes increased 99 percent between the years 1948 and 1979. For the years 1979 to 1998, the number of homes increased 229 percent. The Emigrant area demonstrated the largest percent increase in homes, while the Pine Creek study area had the lowest percent increase in homes. Using the study maps created by the U.S. Army Corps of Engineers and USGS-WRD in 2003 and riparian zone study map created by

Mike Merigliano, 17 homes were found to be located within the 100-year floodplain and an additional 121 homes were located within 100 meters of the 100-year floodplain.

In this study, home sites were not mapped as a land use classification and they did not have acreage. However, with the dramatic increase in homes along the Yellowstone River, it is important to place homes on the map and relate their presence to the landscape. Therefore for this study, an impact zone with a 100-meter radius or approximately 7.76 acres was created around a home and used to evaluate land use change due to residential housing. In all four study areas, there was a reduction in agricultural, grassland, and riparian land use types due to the home site impact zone. Residential impact zone covered 4.6 percent of the landscape when all four sites are combined.

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