Yellowstone River Wetland/ Riparian Change Detection Pilot Study

Prepared for:

The Custer County Conservation District
and
The Yellowstone River Conservation District Council

By:

Gregory M. Kudray and Thomas Schemm

Montana Natural Heritage Program
Natural Resource Information System
Montana State Library

July 2006

MONTANA Natural Heritage Program

Yellowstone River Wetland/ Riparian Change Detection Pilot Study

Prepared for:

The Custer County Conservation District
and
The Yellowstone River Conservation District Council

Agreement Number:

YRCDC011

By:

Gregory M. Kudray and Thomas Schemm

P.O. Box 201800 • 1515 East Sixth Avenue • Helena, MT 59620-1800 • 406-444-5354

This document should be cited as follows:
Kudray, Gregory, M. and Thomas Schemm. 2006. Yellowstone River Wetland/Riparian Change Detection Pilot Study. A report to the Custer County Conservation District and the Yellowstone River Conservation District Council . Montana Natural Heritage Program, Helena, Montana. 16 pp. plus appendices.

Executive Summary

Two reaches of the Yellowstone River riparian corridor were mapped using the U.S. Fish and Wildlife Service (USFWS) classification systems for wetlands and Western riparian types. We used two series of aerial photography (1950 and 2001) to map all of this area and also mapped the upstream reach A16 on two additional series (1976 and 1996). We evaluated but did not map a few photos from the earliest series available (1937 and 1938) for their suitability to map wetlands. Our primary objective was to evaluate the feasibility of mapping wetlands and tracking wetland change over time on historical aerial photography. Government Land Office (GLO) notes from the original land survey in early settlement times were also reviewed to determine if they could be used as a data source.

All photo series were suitable for mapping wetlands although the 1950 photos for the A16 reach near Columbus had been acquired during a date of very high water levels resulting in a probable under mapping of Palustrine wetlands. The 1950 photos were also of relatively poor quality compared to all other series and some vegetation classes could not always be reliably discriminated. Any future wetland change project should make sure that the dates of imagery are comparable.

The riparian corridor is extremely dynamic, as are the associated wetlands, which are created and destroyed regularly. Evaluating wetland change requires a large enough sample or total area acreage summary to be meaningful.

Created ponds have increased in both reaches but especially in the more developed reach near Glendive (D6). Wetland acreage has decreased in both reaches (-7.6%) with a greater decrease in D6 (-11%). Natural wetlands have decreased even more due to the acreage of created ponds added. The less developed A16 reach was mapped on four dates of aerial photography; wetland totals varied within about a 10% range. The Riverine type varied the most, probably due to water levels and scouring from events within a few years previous to the photo date.

Large peak flows are important in creating wetland sites. There may be more wetland change downstream than upstream since peak flows have diminished more downstream.

The GLO notes can be used to quantify early settlement riparian vegetation and compare it to current conditions but wetlands are not distinguished.

We created a crosswalk to the USFWS wetland and riparian systems from Natural Resource Conservation Service (NRCS) land use and vegetation cover classification systems used for mapping on the river. The relationship was typically complex and the NRCS minimum mapping unit is too large to identify the small wetlands often present.

ACKNOWLEDGEMENTS

We gratefully acknowledge funding and other support from the Custer County Conservation District and the Yellowstone River Conservation District Council. We also thank several others from the Technical Advisory Committee who provided support and many good ideas: Stan Danielsen, Greg Johnson, George Jordan, Eric Laux, and Burt Williams. We are grateful to Kevin Bon, National Wetland Inventory, for his quality control help. Special thanks to Jim Robinson, with his knowledge and help with historical aerial photography along the Yellowstone and especially Warren Kellogg, our project contact who assisted the project in every way.

Table of Contents

List of Tables

List of Figures

Introduction

One hundred year flood events on the Yellowstone River during 1996 and 1997 threatened human constructed features and caused channel changes and large-scale erosion. Over 100 permit applications were subsequently filed to armor or otherwise modify riverbanks. Environmental groups contested some permits. The controversy led to the authorization of a comprehensive cumulative effects study on the entire river. The federal study is led by the Corps of Engineers with the Yellowstone River Conservation District Council (YRCDC) as the local partner. The goal of the Yellowstone River Cumulative Effects Investigation is to acquire a working knowledge of the dynamics of the Yellowstone River and its associated riparian area, the last major free-flowing river in the lower forty-eight States, to accurately predict cumulative effects from natural processes and human effects, and to develop best management practices.

Several initial components of the cumulative effects study have been funded including the acquisition of bare earth Lidar (Light Detection and Ranging) digital elevation mapping, geomorphic channel classification, avian abundance and richness, land use and cover mapping and historic aerial photo coverage (see http://nris.mt.gov/yellowstone/ for data and reports). However, there has been no comprehensive work about how wetlands have changed in response to human and natural events over the last several decades and wetlands are important resources in this arid environment. Since a study of the entire river corridor is a large project and there is uncertainty about how well wetlands could be mapped on historical aerial photography, it was decided that a pilot study on two river reaches would be used to make recommendations for the techniques and materials that could be most efficiently and accurately used to complete the larger study. Our primary objective was to map wetlands on two series of aerial photography 50 years apart, evaluate the wetland/riparian change, and assess three other dates of aerial photography for their value in mapping these habitats. We also wanted to review Government Land Office (GLO) notes from the original Principal Base and Meridian survey to evaluate how useful they would be in determining early settlement vegetation patterns.

Another objective was to review the NRCS land use and vegetation cover classification systems now used in the Yellowstone River Corridor Cumulative Effects Study and create a hierarchical crosswalk with the wetland and riparian mapping types. The NRCS systems will be evaluated for usefulness in any future wetland or riparian change analysis.

Methods

Wetland and riparian areas within two Yellowstone River study reaches, A16 near Columbus, MT and D6 near Glendive, MT (Figure 1) were mapped on two dates of aerial photography: 1949(A16)/ 1951(D6) black and white (referred to in this report as 1950) and 2001 color infrared. The A16 reach was also mapped on 1976 and 1996 black and white photos. We evaluated but did not map a few photos from the earliest series available (1937 and 1938) for their suitability to map wetlands.

The wetlands were mapped with the National Wetland Inventory (NWI) system (Cowardin et al. 1979). The USFWS Western Riparian System (USFWS 1997) was used for riparian areas. Since we were not mapping the surrounding uplands we needed a boundary for mapping. The Lidar acquisition corridor, Corps of Engineers floodplain maps, and the valley bottom delineation were assessed (see http://nris.mt.gov/yellowstone for this data). The valley bottom delineation was the most ecologically comprehensive representation of the riparian corridor and was chosen as the mapping boundary.

The USFWS National Standards and Quality Components for Wetlands, Deepwater, and Related Habitat Mapping (USFWS 2004) guided the mapping techniques and Kevin Bon, the USFWS Regional Wetlands Coordinator, participated in map review and quality control. The digitized and georeferenced aerial imagery was viewed on the screen along with the Lidar digital elevation data. Wetland and riparian polygons were digitized with ESRI ArcMap software into the NWI master geodatabase clipped for the study area. Since the original NWI mapping from the 1980's had never been digitized, we obtained the aerial photographs with inked wetland delineations to use as an ancillary data source.

We evaluated two wetland/riparian change detection techniques. One was a GIS based summary of results from the total mapping dataset while the other proposed a random selection of individual wetland/riparian polygons to be followed over time. The Yellowstone riparian corridor is so dynamic that individual wetland/riparian polygons are often altered naturally over the decades considered so we concluded that the total GIS based summary would give more accurate results than the other method.

The GLO survey notes recorded general vegetation cover types at distances along the section lines they traversed. We displayed the types along section lines within some of the study area. Type distances were compared with similar types from the most current mapping.

Figure 1. Map of study reaches of the Yellowstone River.

Results and Discussion

Methodology

A primary goal of this study was to determine if wetlands could be mapped accurately from digitized historical aerial photography. Of the five time series evaluated only the 1950's series was problematic. While we could map wetlands on these photos, we found that the image quality was poorer than all other photos including the earliest photos from the late 1930's. Additionally, unlike the summer acquisition dates of the rest of the photography these photos were taken during mid-May for the A16 reach when the river level was very high. Some low wetlands were likely flooded at this time and would have been mapped as a Riverine wetland type instead of the correct type.

The dynamic nature of the riparian corridor results in a regular cycle of wetland creation and destruction. Human or natural events at a given location may destroy or create wetlands at that location and/or have impacts further downstream. Following individual wetland polygons over time will not give a good indication of wetland change. A better approach is to either look at totals from entire areas or sample at an intensity sufficient to represent the area. We felt that the System level of the classification (broad vegetation types like Forested or Emergent Vegetation) could be mapped on the historical photos with an accuracy suitable to determine wetland and wetland type change over time, although some types, like the closely related Forested and Scrub-Shrub, may need to be combined, especially on low quality photos (i.e. 1950's). Grouping all wetlands together will be the most accurate data.

Wetland and Riparian Change From 1950 to 2004

Table 1 summarizes wetland and riparian area for both reaches mapped. Differentiating some types like Forested and Scrub-Shrub on the 1950's photos was problematic. The total wetland and riparian acreage declined by 195 acres (2.4%) There was a decrease in wetland acreage of 354 acres (7.6%). The decline in natural wetlands is greater because there was an increase of 110 acres (>500%) in the Palustrine Aquatic Bed acreage due to the creation of sewage, stock, and recreational ponds. Also, high water levels in the A16 1950's photos (Table

Table 1. Wetland and riparian acreage for the A6 and D16 reaches combined.

NWI Wetland or Riparian Type	1950	2001
Palustrine Aquatic Bed	25.4	135.7
Palustrine Emergent	163.5	231.0
Palustrine Scrub - Shrub	440.5	373.8
Palustrine Forested	62.0	59.8
Palustrine Wetland Total	**691.4**	**816.4**
Riverine Flowing	2254.7	2090.3
Riverine Bank	1712.9	1398.2
Riverine Wetland Total	**3967.6**	**3488.5**
Wetlands Total	**4659.0**	**4304.9**
Riparian Forested and Shrub	2927.2	3257.6
Riparian Total	**3567.9**	**3727.4**
Wetland and Riparian Total	**8227.0**	**8032.4**

Table 2. River flow data from measuring stations closest to each mapped reach.

Photo Date	Flow at Photo Date (cfs)	High Flow in Previous 5 Years (cfs)	Deviation From Average Peak	Measuring Station
8-26-1949	2,750	98,000	+50%	Sidney
5-17-1951	11,500	54,700	+32%	Billings
9-26-1976	6,210	69,500	+68%	Billings
8-24-1996	4,350	61,900	+49%	Billings
8-2-2001	7,610	82,000	+98%	Billings
8-2-2001	1,980	85,300	+30%	Sidney

2) probably covered some Palustrine wetlands. The 479 more acres of Riverine wetland (within the channel) acres mapped in the 1950's supports the theory that water was covering some normally Palustrine wetlands in the photos.

The upstream reach A16 was mapped with four dates of aerial photography (Table 3). This relatively undeveloped reach shows the inherent variability of riparian wetlands over time (Figure 2), although total wetland acreage from all four dates is within a 10% range. While Palustrine wetland acreage was highest in 1950, the lowest amount was mapped during the next time series (1976), which also had the highest acreage of Riverine wetlands. The only clear trend from this mapping is the increase in ponds (Palustrine Aquatic Bed) with time.

The downstream reach D6 includes Glendive and shows considerable change in the wetland and riparian resource (Table 4). The total wetland and riparian area decreased by 528.3 acres (11%) with 395.2 less wetland acres (14%). Riverine bank wetlands on shores, gravel bars, and similar features showed a large decrease of 619 acres (46%). Palustrine wetlands increased by 125 acres, most of this is attributable to the 97.7 acres of increase in created ponds (Palustrine Aquatic Bed), although there were also some wetlands created in an area that was formerly riparian (Figure 3).

Table 3. Wetland and riparian acreage for the A16 reach near Columbus.

NWI Wetland or Riparian Type	1950	1976	1996	2001
Palustrine Aquatic Bed	25.4	23.8	31.0	39.0
Palustrine Wetland Total	**375.4**	**339.3**	**353.6**	**360.2**
Riverine Flowing	1149.8	934.3	1009.5	887.2
Riverine Bank	363.4	702.8	436.2	654.7
Riverine Wetland Total	**1513.3**	**1637.2**	**1445.7**	**1541.9**
Wetlands Total	**1888.7**	**1976.5**	**1799.3**	**1902.1**
Riparian Total	**1563.3**	**1818.8**	**1874.2**	**1856.0**
Wetland and Riparian Total	**3452.0**	**3795.3**	**3673.5**	**3758.1**

Table 4. Wetland and riparian acreage for the D6 reach near Glendive.

NWI Wetland or Riparian Type	1950	2001
Palustrine Aquatic Bed	0	97.7
Palustrine Wetland Total	**316**	**441**
Riverine Flowing	1104.9	1203.1
Riverine Bank	1349.5	730.9
Riverine Wetland Total	**2454.4**	**1934.1**
Wetlands Total	**2770.4**	**2375.2**
Riparian Total	**2004.6**	**1871.5**
Wetland and Riparian Total	**4775.0**	**4246.7**

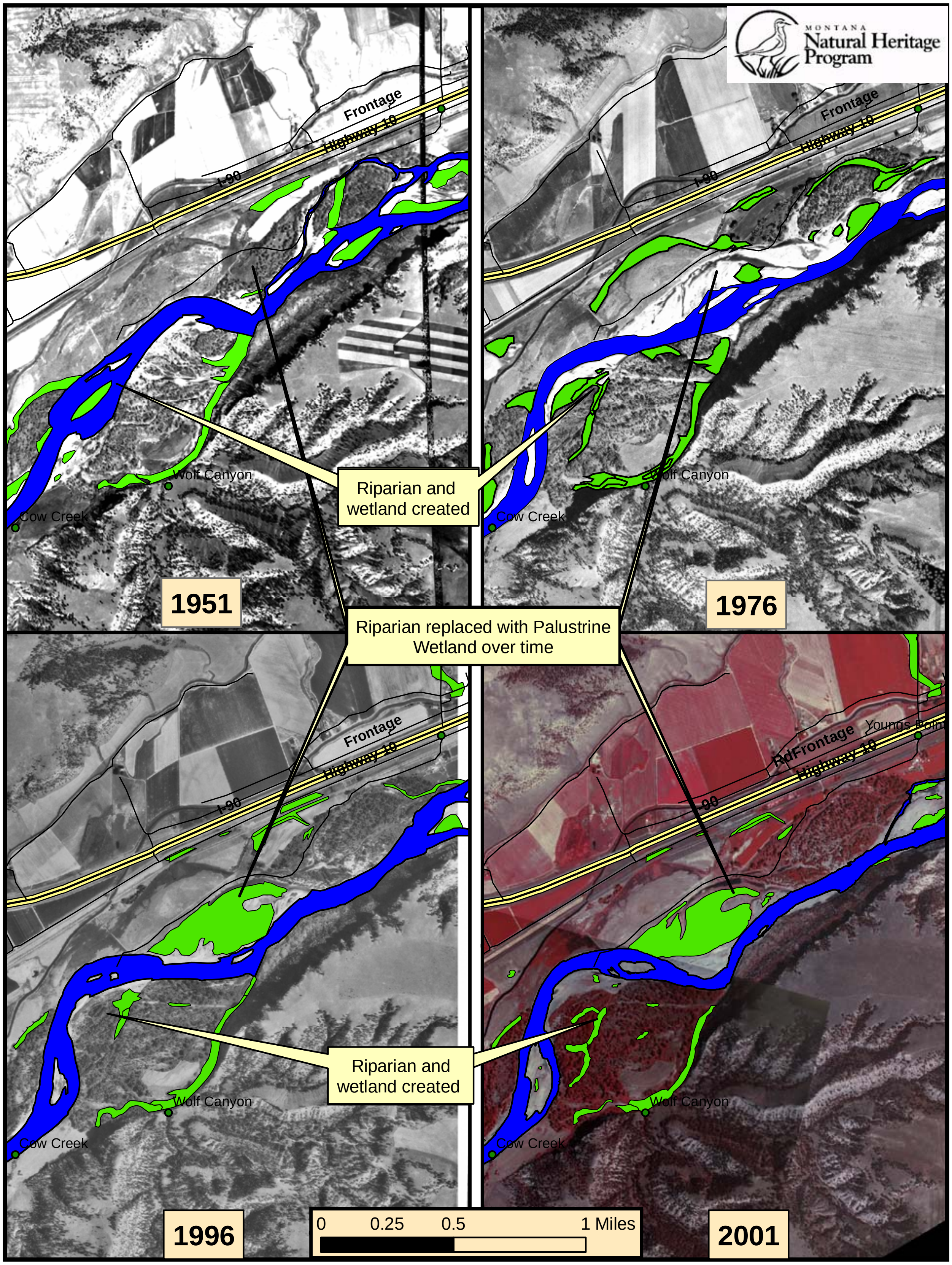

Figure 2. Habitat change in the Yellowstone River reach A16 near Columbus from 1951 to 2001.

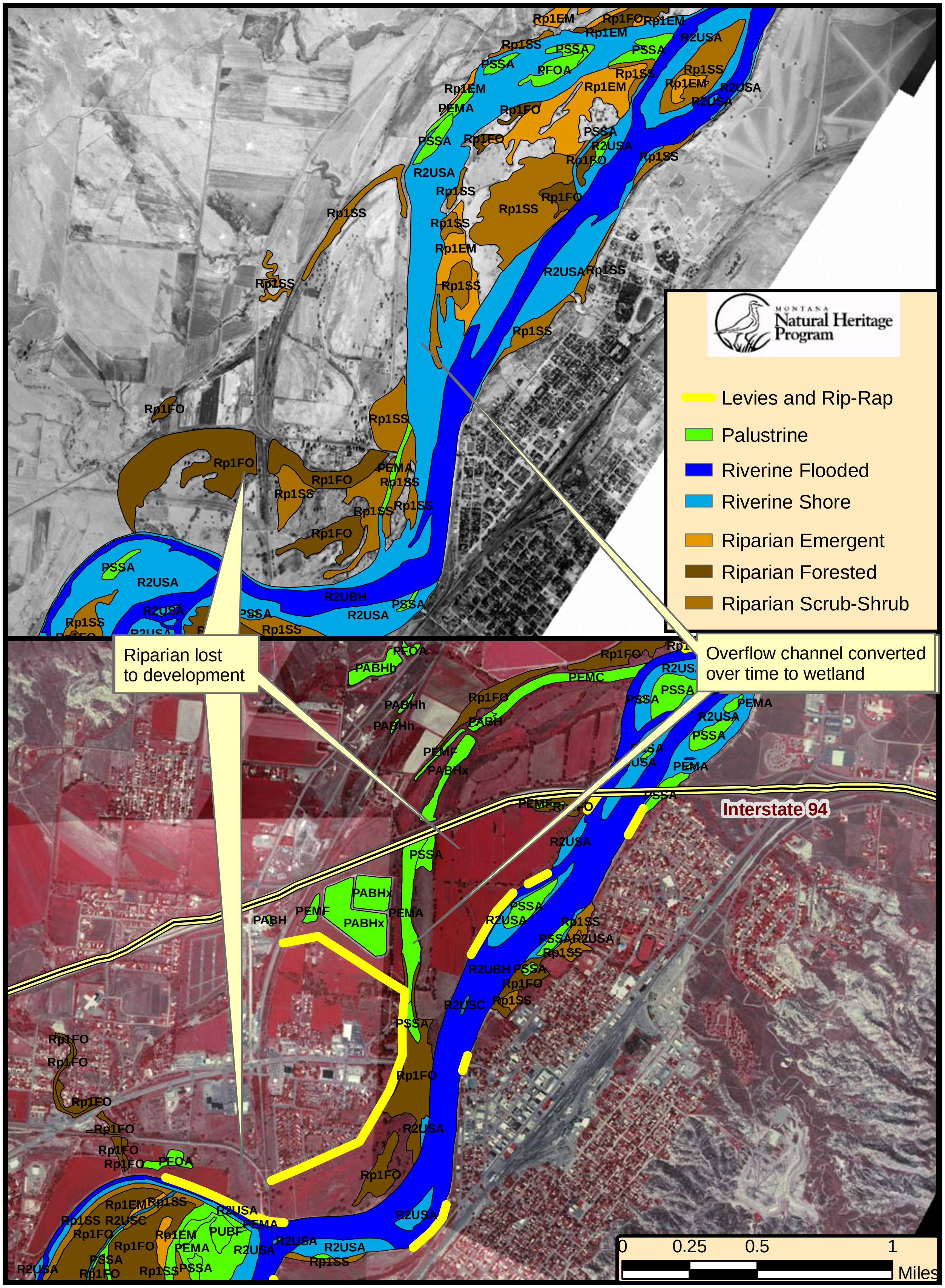

Figure 3. 1950 and 2001 mapping near Glendive.

There is little published research on riparian wetlands and how they respond to river hydrology or created structures like bridges or rip-rap. There is virtually no research on undammed rivers in arid environments like the Yellowstone River. Flood events have been recognized as critical in creating some wetlands, like willow sandbars in the well publicized large discharge of water into the Grand Canyon in Arizona (Stevens et al. 2001). However, new fluvial marshes developed with reductions in flood frequency and sediment deposition in the same area (Stevens et al. 1995). In humid areas lower peak flows and higher minimum flows results in the succession of herbaceous wetlands to wooded wetlands (Toner and Keddy 1997). High flows will scour new channels; many of our wetlands were eventually found in these locations after they aged. High flows can also destroy wetlands by filling them with new sediment. River ice scour has also been recognized as an important factor in structuring woody vegetation in Montana's riparian areas (Smith and Pearce 2000) and probably affects other wetland types too.

Created structures affect wetlands but off-site impacts downstream were impossible to determine with our limited sample. The reduction of sediment with extensive rip-rap may affect wetlands as would streamlining channels for bridges or blocking river migration with levees.

Peak stream flow in the Yellowstone River has shown a pattern of relatively little alteration near Billings (Figure 4) compared to a steady decline in peak discharge over time downstream at Sidney (Figure 5). All photo series had fairly substantial peak flow events within five years of the photo year (Table 2). Large flows and ice movement likely scour vegetation and create Riverine bank and other wetlands.

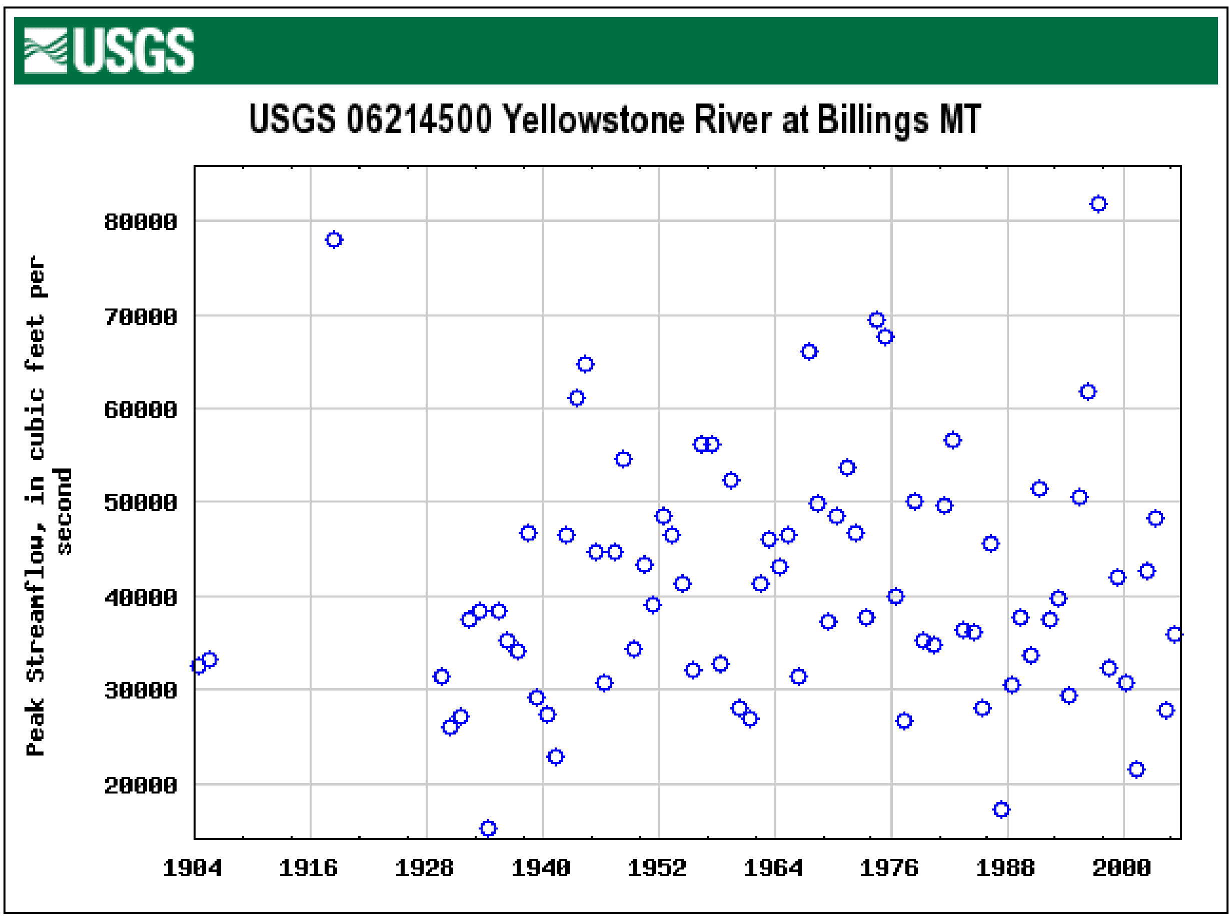

Figure 4. Annual peak Yellowstone River flows at Billings MT near study reach A16.

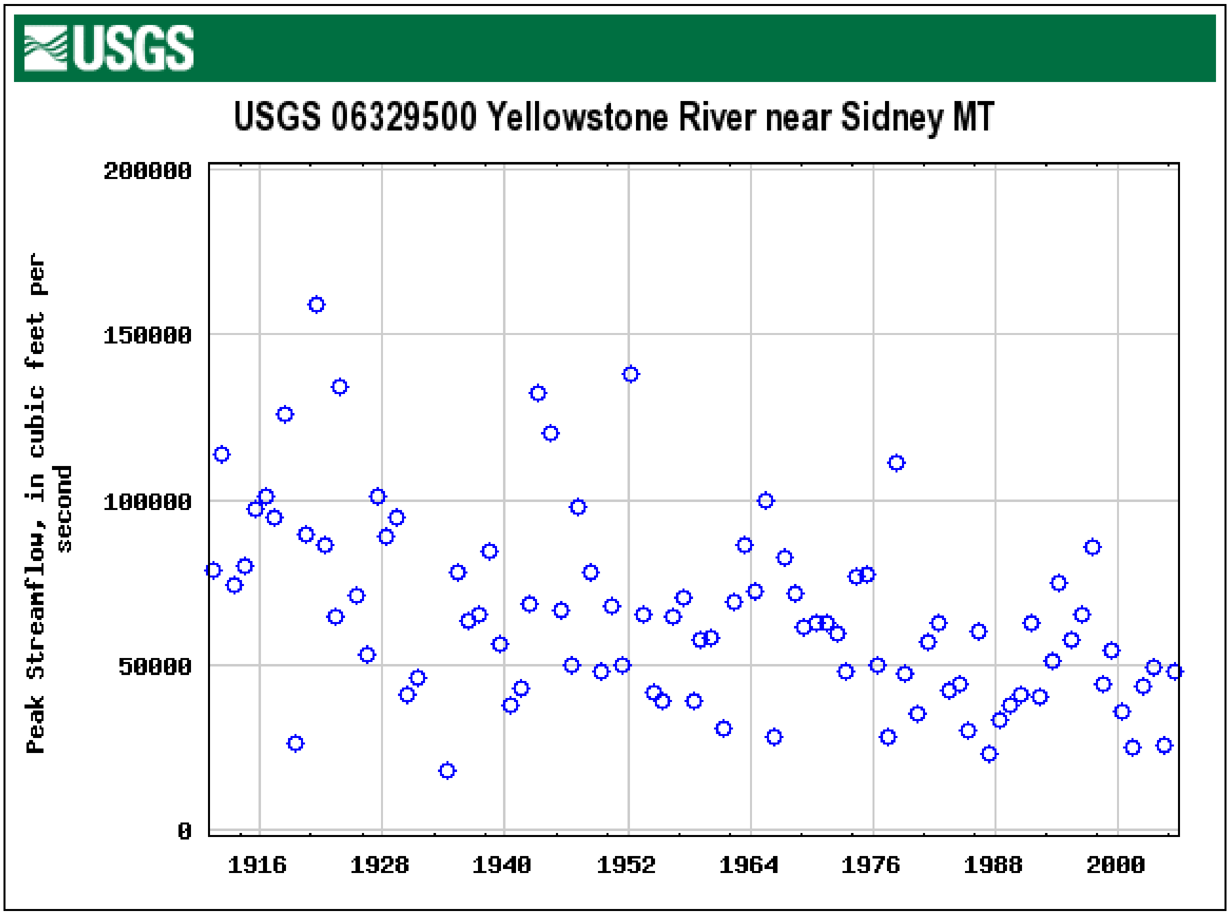

Figure 5. Annual peak Yellowstone River flows at Sydney MT near study reach D6.

Government Land Office Survey Notes Analysis

GLO surveyors recorded water and general vegetation types like "cottonwood forest" or "willow shrubs" along the section lines they established. We grouped these into types that corresponded with our mapped types and compared their respective lengths (Table 5). The water type is almost double in the GLO notes compared to our 2001 mapping, primarily due to one section line which then ran largely down the river (Figure 6). The GLO notes ranged from 1878 – 1904 and the surveys were completed during several different months. This is a relatively small sample so the results are not as important as is the fact that there is early settlement vegetation information available and that it is relatively easy to extract and compare to current conditions (although wetland types are not distinguished).

Table 5. Length (m) of vegetation types compiled from GLO survey notes and 2001 mapping.

	GLO	2001 Mapping
Shrub	670	1055
Forested	2538	3169
Water	3763	1978
Other	28805	29547

Crosswalk Between NRCS and USFWS Cover Types

Two related USFWS mapping systems, Western Riparian System (USFWS 1997) and National Wetlands Inventory (NWI) (Cowardin et al. 1979), are crosswalked with the Natural Resource Conservation Service (NRCS) land use types (Table 6) and vegetation cover types (Table 7) used in other mapping in the Yellowstone River riparian corridor. In the NWI system (Cowardin et al. 1979) wetlands are defined as:

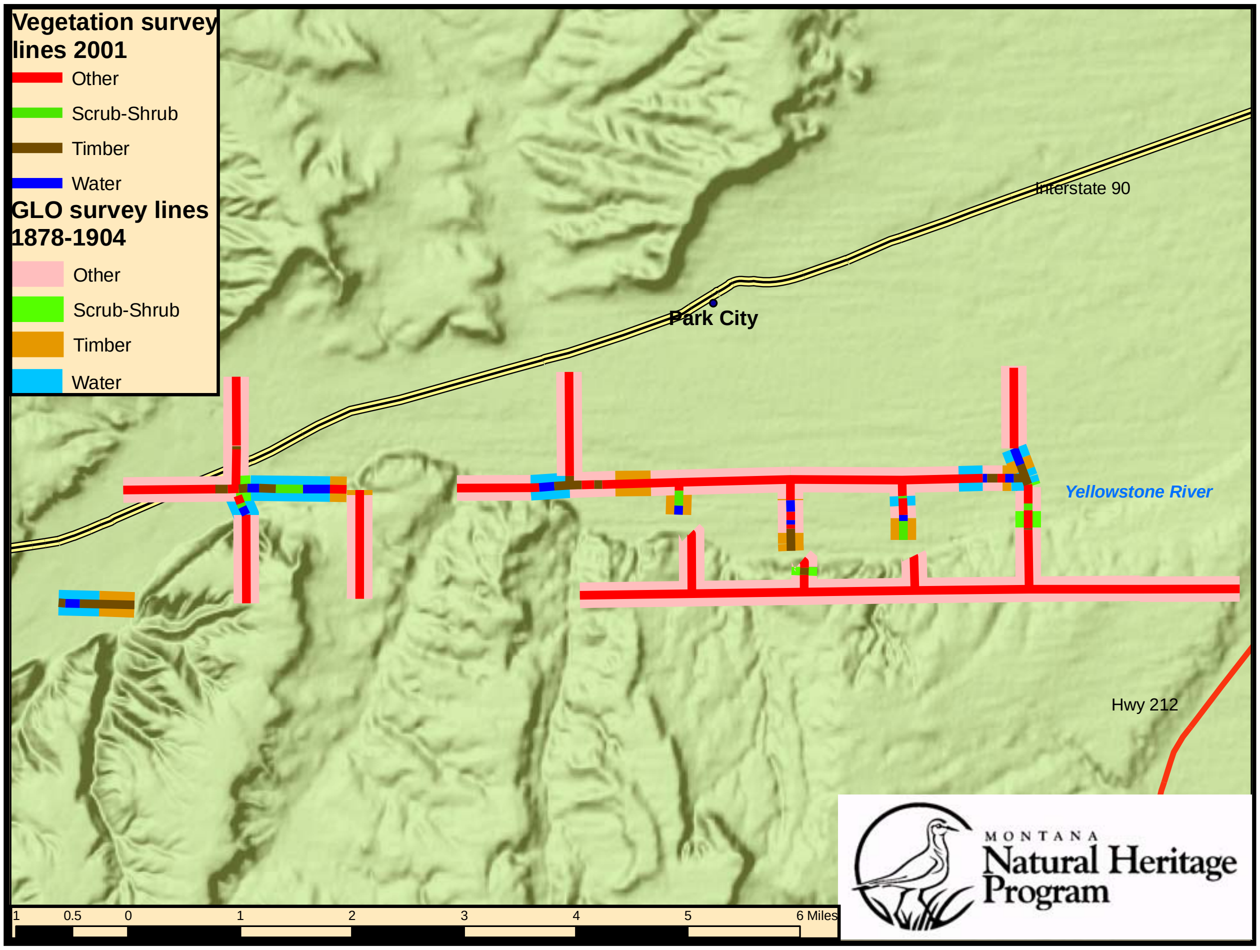

Figure 6. Section lines coded from GLO survey notes and 2001 mapping.

> "... lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes [wetland plants], (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil [does not support vegetation] and is saturated with water or covered by shallow water at some time during the growing season of each year."

The Western Riparian System (USFWS 1997) defines riparian as:

> "... plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic [flowing] and lentic [still] water bodies (rivers, streams, lakes or drainage ways). Riparian areas have one or both of the following characteristics: 1) distinctly different vegetative species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland."

By definition, riparian types are not wet enough for a long enough period of time to be classified as wetlands. True wetlands will be mapped as wetlands even if they occur within riparian areas. Therefore, many of the NRCS types used in the riparian mapping could crosswalk to either system depending on site hydrology. Within a specific NRCS type there could be substantial differences in type characteristics (e.g. vegetation composition) reflected in the range of the possible USFWS classification types. The NRCS types are broader concepts, so there will typically be several USFWS types nested within each NRCS type.

Both USFWS classification systems are hierarchical with several levels of detail that can be applied as desired. The minimum mapping standard is classification to all three of the following levels: System, Subsystem (where applicable), and Class (USFWS 2004) with hydrologic and special (i.e. beaver, farmed, excavated, etc.) modifiers often applied to NWI mapping. Subclasses can refer to more specific vegetation type (i.e. Cottonwood or Mixed Deciduous in the riparian classification) but are often beyond what can be interpreted from the aerial imagery.

Table 6. Crosswalk of NRCS land use cover types with USFWS wetland and riparian types.

<table>
<tr><th>NRCS Land Use/Cover Type:</th><th>NWI types:</th><th>Riparian types:</th></tr>
<tr><td>(Cl) Cropland - Irrigated/sub-irrigated (includes fallow, residue)</td><td rowspan="6">Generally not wetlands, although small wetlands of any type could occur within.</td><td rowspan="6">Not mapped as riparian unless there are virtually no land improvements and only grazing, then probably will be Lotic Emergent (Rp1EM).</td></tr>
<tr><td>(C2) Cropland - Non-irrigated (includes fallow, residue)</td></tr>
<tr><td>(C3) CRP (may be confused with pastureland or rangeland)</td></tr>
<tr><td>(P1) Pastureland - Irrigated/sub-irrigated</td></tr>
<tr><td>(P2) Pastureland - Non-irrigated (may be confused with CRP or rangeland)</td></tr>
<tr><td>(R) Rangeland - native (may be confused with pastureland or CRP)</td></tr>
<tr><td>(F) Forest land (>25% canopy, 10% stocking for coniferous or deciduous forest)</td><td>Must meet the 30% canopy cover limit to be mapped as forest, probably intermittently flooded (PFOJ), otherwise Scrub-Shrub (PSSJ). Most of these areas are likely not wetlands but are riparian types.</td><td>Must meet the 30% canopy cover limit to be mapped as forest (Rp1FO), otherwise Scrub-Shrub (Rp1SS).</td></tr>
<tr><td>(U) Urban Buildup (use NRI density rules)</td><td>N/A</td><td>N/A</td></tr>
<tr><td>(T) Rural Transportation (corridors of significant width) Major rural road and RR rights-of-way</td><td>N/A</td><td>N/A</td></tr>
<tr><td>(B) Barren/Disturbed land</td><td>N/A</td><td>N/A</td></tr>
</table>

Table 6. Continued.

NRCS Land Use/Cover Type:	NWI types:	Riparian types:
(Wl) Water Bodies	Palustrine, if vegetated, probably only Emergent Vegetation permanently flooded (PEMH) or aquatic bed (PABH). With <30% vegetation cover, Class would be based on bottom substrate: Unconsolidated Bottom (PUBH), Rock Bottom (PRBH), or Unknown Bottom (POWH).	Would fall under the wetland classification.
(W2) Perennial rivers/streams > 66 feet wide	Riverine Upper and Lower Perennial with Unconsolidated Bottom (R2UBH, R3UBH) or Aquatic Bed (R2ABH, R3UBH) the most common Classes. Subclass either Vegetated or based on substrate (e.g. sand).	Would fall under the wetland classification.
(Ol) Other Rural Land (not cropland or urban build-up)	N/A	N/A
(O2) All other land not as above (describe in notes)	Could be anything.	Could be anything.

Table 7. Crosswalk of NRCS vegetation cover types with USFWS wetland and riparian types.

NRCS Type:	NWI types:	Riparian types:
(t) Closed canopy tall woody: Mixed Deciduous Tree > 25% canopy and > 4 meters tall, single stemmed	Palustrine Forested (PFO), temporarily flooded water regime is the most common (PFOA), Broad-Leaved Deciduous Subclass (PFOA1)	Riparian Lotic Forested (Rp1FO), Deciduous Subclass (Rp1FO6)
(s) Closed canopy short woody: Mixed Deciduous Shrub >25% canopy and < 4 meters tall, multi-stemmed	Palustrine Scrub - Shrub (PSS), temporarily or seasonally flooded water regime are the most common (PSSA or PSSC), Broad-Leaved Deciduous Subclass (PSSA1 or PSSC1)	Riparian Lotic Scrub - Shrub (Rp1SS), Deciduous Subclass (Rp1FO6)
(rl) Open canopy tall woody: Mixed Deciduous Tree 5-25% canopy and > 4 meters tall, single stemmed (p1) Open canopy short woody: Mixed Deciduous Shrub 5-25% canopy and < 4 meters tall, multi-stemmed (p2) Open canopy short woody: Semi-Deciduous Shrub 5-25% canopy and < 4 meters tall, multi-stemmed	If trees and shrubs are more than 30% canopy cover together then this type would be Palustrine Scrub – Shrub (PSS), if not then typed for the dominant Class below the tree canopy, probably Palustrine Emergent (PEM). Temporarily flooded water regime is the most common (PSSA), Broad-Leaved Deciduous Subclass (PSSA1)	If trees and shrubs are more than 30% canopy cover together then this type would be a Riparian Lotic Scrub – Shrub (Rp1SS), Deciduous Subclass (Rp1SS6), if not then probably Riparian Lotic Emergent (Rp1EM).
(r2) Open canopy tall woody: Mixed Coniferous Tree 5-25% canopy and > 4 meters tall, single stemmed	If trees and shrubs are more than 30% canopy cover together then this type would classify as a Palustrine Scrub – Shrub (PSS), if not then probably Palustrine Emergent (PEM) or other dominant Class below the tree canopy. Temporarily flooded water regime would be the most common (PSSA), Needle-Leaved Evergreen Subclass (PSSA3)	If trees and shrubs are more than 30% canopy cover together then this type would classify as a Riparian Lotic Scrub – Shrub (Rp1SS), Deciduous (Rp1SS6), Evergreen (Rp1SS7) or Mixed (Rp1SS8) Subclass, if not then probably Riparian Lotic Emergent (Rp1EM).
(h1) Herbaceous/Graminoid, mixed: actively growing - wet, <5% woody canopy	Palustrine Emergent (PEM), Water regime is most commonly temporarily (PEMA), seasonally (PEMC), or semi-permanently flooded (PEMF). Persistent (PEMA1) or Nonpersistent (PEMA2) vegetation Subclass	This type is probably all wetland.

Table 7. Continued.

NRCS Type:	NWI types:	Riparian types:
(h2) Herbaceous/Graminoid, mixed: non-actively growing - dry, < 5% woody canopy (h3) Herbaceous/Graminoid Complex: (h1) + (h2), < 5% woody canopy	Palustrine Emergent (PEM), Water regime would be most commonly temporarily (PEMA). Persistent (PEMA1) Subclass.	Riparian Lotic Emergent (Rp1EM)
(c1) Crop cover (tilled row and close-grown crops, fallow, residue, idle) (c2) Crop cover (perennial, not tilled); hayland	If vegetated wetland then Palustrine Emergent with Farmed modifier (PEMf), Water regime would probably be temporarily (PEMAf).	Not mapped as riparian unless there are virtually no land improvements and only light grazing.
(a) Artificial cover (build-up, commercial, paved areas, etc)	These would not be wetlands.	Would not meet the riparian definition – must be vegetated.
(b) Barren (flood deposits, saline areas, pits, mines, disturbed areas)	If these are wetlands then most would probably be Palustrine Unconsolidated Shore with a temporarily (PUSA), seasonally (PUSC), or semi-permanently (PUSF) flooded water regime. Subclass either Vegetated or based on substrate (e.g. sand). There could possibly be other classes depending on the specific circumstances.	Would not meet the riparian definition – must be vegetated.
(w) Water (includes exposed low-water riverwash in primary channel)	If within the river channel then Riverine Lower Perennial with Unconsolidated Shore (R2US), Unconsolidated Bottom (R2UB), or Aquatic Bed (R2AB) the most common Classes. Subclass either Vegetated or based on substrate (e.g. sand). The exposed riverwash (if large enough to map) would be Palustrine Unconsolidated Shore with a seasonally (PUSC), or semi-permanently (PUSF) flooded water regime. Subclass either Vegetated or based on substrate (e.g. sand).	Would fall under the wetland classification.

CONCLUSIONS AND RECOMMENDATIONS

The five series examined (1930's, 1950's. 1970's, 1990's and 2001) were generally acceptable for wetland mapping, however, the 1950's photos had issues with quality and timing. The quality was significantly lower than all the other series, probably resulting in lower accuracy, especially with accurately assigning vegetation types. A more significant issue was the mid-May acquisition of the A16 reach compared to the late summer timing of all other photo series. The associated high water levels in A16 may have covered some low Palustrine wetlands. Water levels were especially high even for this date and magnified the problem. Any future wetland change project should make sure that the dates of imagery are comparable.

Most wetlands are within the riparian corridor: primarily 1) within the channel (Riverine System), 2) close to the channel (Palustrine System), or 3) in old channels or oxbows (Palustrine System). The riparian corridor is extremely dynamic, as are the associated wetlands. Few wetlands persist longer than a few decades; many are quite ephemeral and may persist only a few years. Wetland type within an individual site may also change quickly. Wetland change is best viewed as total acreage amounts in broad classes over the time period considered instead of tracking individual wetland areas.

Even with the problems in the baseline 1950 imagery there were a few clear trends apparent. Created ponds have increased in both reaches but especially in the more developed reach near Glendive (D6). Wetland acreage has decreased in both reaches with a greater decrease in D6. The less developed A16 reach was mapped on four dates of aerial photography; wetland totals varied within about a 10% range. The Riverine type varied the most, probably due to water levels and scouring from events within a few years previous to the photo date. Large peak flows are important in creating wetland sites. There may be more wetland change downstream than upstream since peak flows have diminished more downstream.

The Government Land Office survey field notes can be used to compare riparian vegetation composition from early settlement times to current conditions although wetland types are not distinguished.

The NRCS land use and cover classification systems were crosswalked to USFWS wetland and riparian types. Some had a simple relationship but most NRCS types could be one of many USFWS types. The NRCS mapping also has a several acre minimum mapping unit, which is too large to identify the often small wetlands areas.

References Cited

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. FWS/OBS-79/31.

Smith, D.G. and C.M. Pearce. 2000. River Ice and Its Role in Limiting Woodland Development on a Sandy Braid-Plain, Mile River, Montana. *Wetlands* Vol. 20(2) pp. 232-250.

Stevens, Lawrence E., Schmidt, John C., Ayers, Tina J., Brown, Bryan T. 1995: Flow Regulation, Geomorphology, and Colorado River Marsh Development in the Grand Canyon, Arizona. *Ecological Applications*: Vol. 5, No. 4, pp. 1025–1039

Stevens, Lawrence E., Ayers, Tina J., Bennett, Jeffery B., Christensen, Kerry, Kearsley, Michael J. C., Meretsky, Vicky J., Phillips, Arthur M., Parnell, Roderic A., Spence, John, Sogge, Mark K., Springer, Abraham E., Wegner, David L. 2001: Planned Flooding And Colorado River Riparian Trade-Offs Downstream From Glen Canyon Dam, Arizona**.** *Ecological Applications*: Vol. 11, No. 3, pp. 701–710

Toner, M. and P. Keddy. 1997: River Hydrology And Riparian Wetlands: A Predictive Model For Ecological Assembly. *Ecological Applications*: Vol. 7, No. 1, pp. 236–246

U.S. Fish and Wildlife Service. 1997. A System for Mapping Riparian Areas in the Western United States. U.S. Department of the Interior, Fish and Wildlife Service, Lakewood, CO. 15 p.

U.S. Fish and Wildlife Service. 2004. National Standards and Quality Components For Wetlands, Deepwater and Related Habitat Mapping. U.S. Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 18 pp.