FUNCTIONAL ASSESSMENT OF THE MANCOS RIVER WATERSHED:

MANCOS VALLEY AND ADJACENT AREAS

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All photographs are by the author unless otherwise noted.

SUMMARY

This report examines the functional condition and ecological health of the Mancos River watershed, Montezuma County, in southwestern Colorado. The Mancos River originates in the western flanks of the La Plata Mountains, and flows south and west until it joins the San Juan River in northwestern New Mexico. The river can be divided on the basis of hydrogeomorphology and ecology into five general sections. First, the high elevation and high gradient reaches of the various tributaries that eventually combine to form the main Mancos River, including the East, Middle and West Mancos Rivers, and Chicken Creek. Second, the middle elevation reaches of the four main tributaries, which are lower gradient and which run through canyons that incise the plateaus at the base of the peaks. Third, the section of the river that flows through the Mancos Valley, which is relatively flat and used for irrigated agriculture. Fourth, the reaches in Mancos Canyon, where the river runs in a deep canyon between several large mesas, including Mesa Verde. And fifth, the lower section of the river from the mouth of Mancos Canyon to the confluence with the San Juan River, where the river is low gradient and flows through flat desert scrubland country. This report focuses primarily upon the reaches in the Mancos Valley (section 3), since this is where there have been the most human impacts upon the stream/riparian system. Additional surveys were taken for comparison upstream from Mancos Valley along the main tributaries (section 2), and also downstream, in Mancos Canyon at the Mesa Verde National Park/Ute Mountain Ute Indian Reservation border (section 4). Preliminary fieldwork and flyovers indicated that there have been relatively few human impacts in the high elevation reaches of the upstream tributaries, and practical considerations prevented the collection of data along the downstream reaches within the Ute Mountain Ute Indian Reservation.

The condition of each reach was measured using the protocol described in the ***User's Guide for the Rapid Assessment of the Functional Condition of Stream-Riparian Ecosystems in the American Southwest*** (Stacey et al. 2006). This protocol examines five functional components of the stream-riparian ecosystem that provide important benefits to humans and to aquatic and terrestrial wildlife: 1) non-chemical water quality and indicators of nutrient pollution in the stream, 2) stream channel and flood plain morphology, including the ability of the system to limit erosion and withstand flooding without damage, 3) the presence of habitat for native fish and other aquatic species, 4) riparian vegetation structure and composition, including the occurrence and dominance of non-native species, and 5) suitability of the riparian zone as habitat for terrestrial wildlife, including threatened or endangered species. Within each category, the RSRA evaluates between two and seven variables that reflect the overall functional condition and health of the stream-riparian ecosystem. Quantitative measurements made in the field are used to assign scores to each variable, ranging from "1" (completely non-functional); to "5" (what would be expected to be found in a system that is completely functional and that has not impacted by prior human activities). Mean scores are then calculated for each functional category, and for all categories combined, to measure the overall condition of that particular reach. The goal of this project was therefore to determine at each survey location which components of the ecosystem were functioning either well or poorly at the present time, when compared to what would be found in an unimpacted system of similar ecological and geomorphological characteristics. This information can be used as a guide to determine whether restoration programs might be needed to help improve the health of the river, as well as reaches where further action might not be necessary, depending upon the needs of the local community. The surveys also serve as a baseline description that can be used to objectively monitor the impact of any restoration program and/or change in land management practices that are undertaken on that particular reach or section of the river.

The Mancos River watershed has been occupied by Native Americans for many thousands of years, and there has been extensive development and modification of the river for irrigated agriculture in the

Mancos Valley since the late 1870's. We conducted seventeen surveys at different locations spaced regularly throughout the valley and on the major tributaries. Each reach that was surveyed exhibited a specific set of characteristics that was unique to that particular part of the river, and these surveys should be consulted when considering future management or restoration plans for that reach. However, because we sampled many different reaches within the study area, we were able to detect geographic trends and patterns in the surveys that are useful in describing the overall condition of the Mancos River in the study area, and that will help provide a guide to restoration planning for this watershed in the future.

We found that despite the long history of intensive human use, many aspects of the stream-riparian ecosystem of the Mancos River in the Mancos Valley and the surrounding areas are currently in good or very good functional condition, especially when compared to similar sized river systems elsewhere in the American Southwest. Water quality in the watershed as measured by the RSRA protocol was generally good, although there was a relatively high amount of algae in the lower Valley that suggests that there may be some nutrient loading into the river from agricultural run-off in this area. There was little active bank erosion or channel downcutting in the main river or the major tributaries. Mud Creek was the primary exception to this pattern, where there was considerable current erosion. Fine sediment deposition on the channel bottom of the main river and the major tributaries was limited, except in the lower Valley, where there may be a lack of regular scouring flows that would remove normal sediment loads. The diversity of aquatic macroinvertebrate within the river was mostly excellent, except again in the most downstream reaches. The presence of a good macroinvertbrate fauna was another indicator of good water quality and a lack of heavy sedimentation. Aquatic insects also serve as key source of food for native fish, including trout. The riparian vegetation in the flood plain adjacent to the river was generally abundant and vigorous in most reaches. Although there was an absence of dense shrubs and tall trees in the reaches that have historically been used as pastures for livestock grazing, new seedling recruitment for most riparian woody species was very good throughout the Valley. The presence of seedlings indicates that the woody component of the riparian system has the potential to recover rapidly in the future. When this happens, dense shrubs and trees along the stream banks will create additional shading and will reduce evaporation and current water loss from the river channel. It will also provide more and better habitat for wildlife species. Finally, there were very few non-native or exotic shrubs and trees, such as saltcedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*), in most of the reaches, except in a few locations in the lower part of the Valley. The lack of invasion of the riparian zone by exotic woody plants is exceptional for river systems like the Mancos in the American southwest. The removal of the non-native species at the few sites where they now occur, such as has already been conducted by Mesa Verde National Park, should be effective in stopping further encroachment in the future.

The RSRA surveys also revealed several challenges to maintaining and potentially improving the stream riparian ecosystem in the Mancos Valley and the surrounding areas. First, the levees that line one or both banks in many reaches in the middle and upper part of the valley have isolated the river from its historic flood plain, and they have stopped the important natural processes such as regular over-bank flooding into the flood plain in these reaches. The levees also reduce the quality of the Mancos River as habitat for native fish, because they have prevented the development of important channel and bank structural features needed by the fish, including underbank cover, and frequent deep water pools and riffles. Instead, where there are levees, the channel is uniformly wide and shallow, with steep, cobble-lined, banks. The addition of woody debris to the river in these reaches could result in a significant improvement in fish habitat, and thereby increase the overall ability of the Mancos River to support a healthy and large fish population.

Second, it appears that much of the moisture that has created the vigorous riparian plant community that occurs within the historic flood plain in the Mancos Valley is the result of leakage from unlined irrigation ditches that run throughout the valley, and does not derive primarily from the river itself. A key challenge to sustain the overall long-term healthy condition of the Mancos River will be to find ways to

maintain the current wet meadows and moist soil conditions of the riparian zone, as the methods for water delivery change within the Valley. And third, the results of the surveys suggest that the impact of native ungulate species that are now feeding on the young woody vegetation in the riparian zone is significant, particularly near the town of Mancos. This problem, which exists in many other communities in the United States, appears to be increasing, as the numbers of natural predators decline near rural communities. Because browsing on the growing tips of shrubs and small trees will eventual kill the plants, it is likely that unless this issue is addressed, the presence of large numbers of mule deer (*Odocoileus hemionus*), and potentially elk (*Cervus canadensis*), will prevent the recovery of the woody vegetation in the riparian zone. This may occur even as domestic livestock are progressively excluded from the same riparian areas.

FUNCTIONAL ASSESSMENT OF THE MANCOS RIVER WATERSHED:

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INTRODUCTION

Description of the Mancos River Watershed

The Mancos River originates in the western flanks of the La Plata Mountains, a western subrange of the San Juan Mountains in southwestern Colorado. It then flows southwest through the Mancos Valley and Mancos Canyon, until it joins the San Juan River in northwestern New Mexico (Figure 1). The river is 185 km or 116 miles in length, including the major upstream tributaries, and drains an area of approximately 2075 km^2 (800 $miles^2$). The Mancos River watershed is part of the Colorado Plateau geologic region, and is often divided into two main parts: an upper watershed of approximately 527 km^2 (203 $miles^2$) that includes Mancos Valley and the surrounding mountains, and a lower area that begins in Mancos Canyon at the confluence Weber Creek, and drains the mesa and desert lowland country of Mesa Verde National Park, the Ute Mountain Ute Indian Reservation, and the surrounding regions. Four main tributaries begin among the ridges and peaks of the upper watershed (the highest are Hesperus Mountain and Lavender Peak, at 4033 meters (13,232 feet) and 4036 meters (13,240 feet) respectively). They are the East, Middle and West Mancos Rivers, and Chicken Creek. A fifth major tributary, Mud Creek, drains the lower elevation regions in the northwestern part of the upper watershed. In the lower watershed, numerous small side canyons and ephemeral washes enter the river as it moves through Mancos Canyon. The river then flows through relatively flat desert county until it enters the San Juan River. Navajo Wash forms the only major drainage system that joins the river in the lower watershed, and it includes the area north of the Mancos River and between the mesa country to the east and Sleeping Ute Mountain to the west (Figure 1). Mean annual precipitation in the overall watershed ranges from over 100 centimeters (40 inches) at the highest elevations in the mountains to less than 20 centimeters (8 inches) where the Mancos River enters the San Juan River.

The Mancos River travels through almost all of the major vegetation life zones found in the Colorado Plateau region, including Alpine Tundra, Sub-alpine Coniferous Forests, Spruce-Fir Forests, Mixed-Conifer Forests, Ponderosa Pine Forests, Piñon-Juniper Forests, Plains-Mesa Grasslands and Savannah (now primarily converted to agriculture), and Desert Scrublands. As a result, the biological diversity of both the aquatic and terrestrial riparian communities across the entire watershed is high.

Hydrogeomorphic sections. For the purposes of conducting the Rapid Stream-Riparian Assessment (RSRA) surveys, we used an initial overflight of the entire watershed and subsequent field work to identify five major sections of the river that vary significantly in terms of their hydrology, geomorphology and ecological communities. Examples of these sections are given in Figure 2. Because the stream-riparian ecosystem would be expected to exhibit different characteristics in each of these sections, the functional condition of an individual reach in each section was scaled during the RSRA

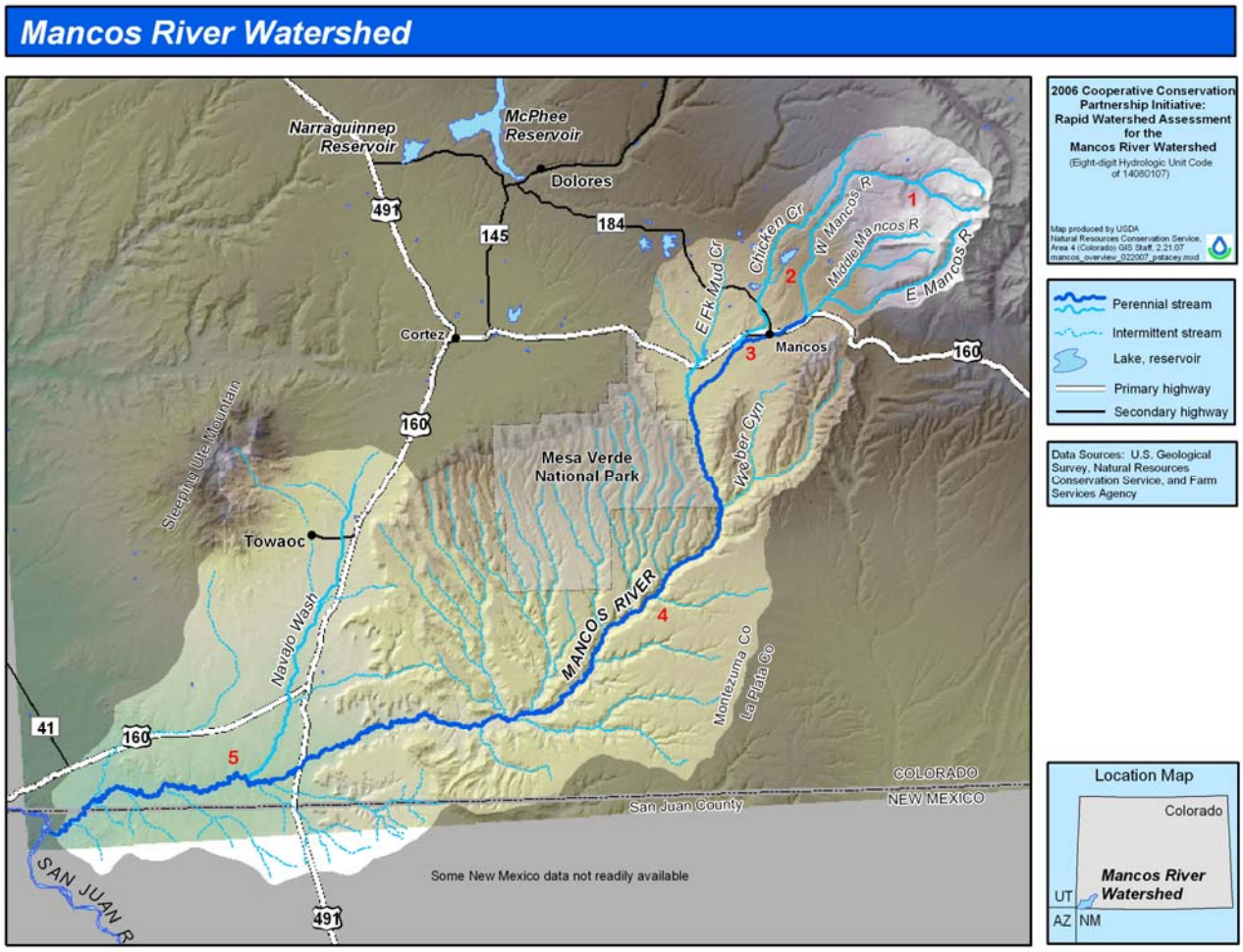

Figure 1. Overview map of the Mancos Watershed. The red numbers refer to the different hydrogeomorphological and ecological sections of the river as described in the text (*Map by Marianna Young, NRCS*).

surveys to reference conditions that would be typical or expected of an unaltered or unimpacted reach in that section.

1. High elevation reaches in the mountains, generally above 2900 meters (9500 feet; see Figure 2A). The streams here are small, straight, narrow and high gradient. The banks and channel bottom are typically either bedrock or comprised of boulders and other material from nearby rock formations. The surrounding vegetation is characteristic of southern Rocky Mountain alpine tundra, sub-alpine, and spruce-fir forests (for descriptions of typical southwestern and Colorado Plateau plant communities in this region, see, for example, Dick-Peddie 1993). Common riparian trees and shrubs in this section include various willows (*Salix spp.*) and aspen (*Populus tremuloides*).

2. Upper plateau and canyon reaches, generally between 2300-2900 meters (7500-9500 feet; Figure 2B). The major tributaries of the Mancos in this section form deep canyons that cut through relatively flat plateaus. The canyon walls are steep, often forming cliffs, and the bottoms are relatively flat. The canyons progressively widen as one moves further downstream. The stream channel tends to be deeper than in reaches further upstream, and the bottom and banks are comprised primarily of cobble and larger material that has been washed downstream from the mountains. In some cases, the channel also exhibits

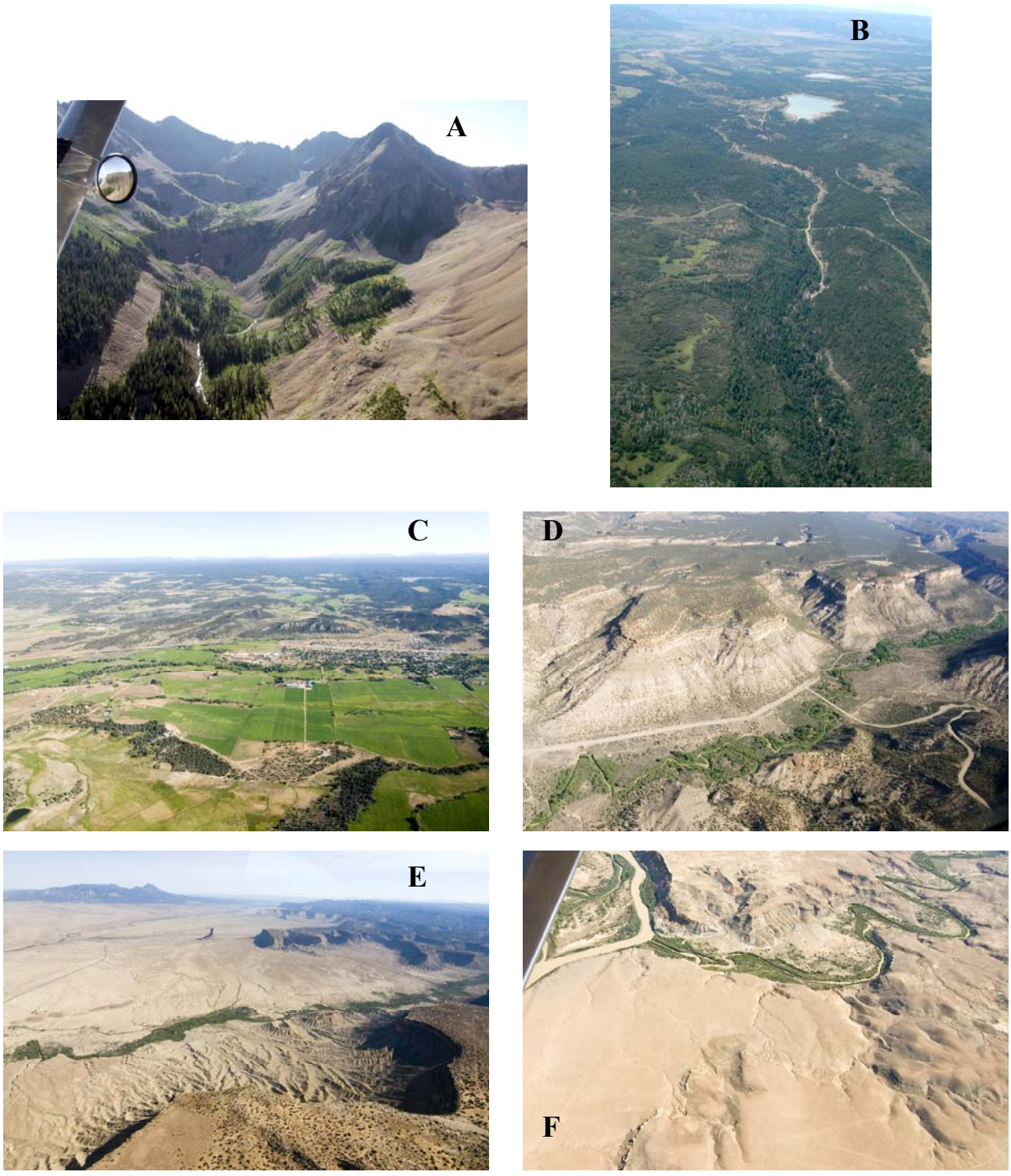

Figure 2. Illustrations of the different hydrogeomorphological and ecological sections of the Mancos River used for this study (see text for details). A. High Elevation reaches: Beginning of the East Mancos River in the La Plata Mountains. B. Upper Plateau and Canyon reaches: West Mancos River canyon and the Jackson Gulch Reservoir diversion. The Mancos Valley is in background (*Photo by Pete Cruser*). C. Mancos Valley reaches: agricultural fields and the town of Mancos. D. Lower Mesa and Canyon reaches: Mancos Canyon, on the Ute Mountain Ute Indian Reservation. E. Low Elevation reaches: mouth of Mancos Canyon. Sleeping Ute Mountain is at left in background and Mesa Verde is at right. F. Confluence of Mancos and San Juan Rivers.

limited meanders. The surrounding vegetation is primarily southern Rocky Mountain mixed conifer and Douglas fir (*Pseudotsuga menziesii*) forests at the higher elevations, and ponderosa pine (*Pinus ponderosa*) at the lower elevations, although many different species of conifer occur together within the canyons themselves. Riparian species include willows, aspen, and narrow-leaf cottonwood (*Populus angustifolia*). There are also large aspen stands on the plateaus above the canyons in this section.

3. Mancos Valley reaches, generally between 2000-2300 meters (6500-7500 feet; Figure 2C). The Mancos Valley is relatively flat and the river in this section has a medium gradient. The flood plain is relatively wide, particularly in the middle sections of the Valley. Most of the reaches in this section have been channelized, and many have small levees along one or both banks. Remnant fluvial landforms in the flood plain indicate that there were originally numerous meanders in the past prior to channelization. The bottom of the channel is primarily medium to large cobble that has been washed down from the surrounding mountains; because the cobble "armors" the bottom there has been little downcutting of the river in this section. In a few areas, particularly in the lower parts of the valley, the channel rests on bedrock, including the Mancos Shale formation. The surrounding soils in the valley are composed primarily of gravels and alluvial deposits. The Valley is used at the present time primarily for agriculture, although the number of houses in the town of Mancos and elsewhere is rapidly increasing. The original vegetation was probably primarily piñon-juniper woodland (*Pinus edulis* and *Juniperus spp*.) with scattered native grasslands. Riparian vegetation in this section includes narrowleaf and Freemont (*P. fremontii*) cottonwoods. There are numerous willows and a few buffaloberry (*Shepherdia argentea*) in the lower parts of the valley, but most of the native riparian shrub community that would be expected to occur at this elevation is absent.

4. Lower mesa and canyon reaches, between 1615-2000 meters (5300-6500 feet; Figure 2D). This section consists of Mancos Canyon. Numerous small side canyons and ephemeral washes enter the river from the surrounding mesas. We only conducted one survey in this section, at the boundary between Mesa Verde National Park and the Ute Mountain Ute Indian Reservation. The gradient at that site was relatively low, and the channel was wide and shallow, with considerable sediment and only small cobbles on the bottom. The river banks consisted primarily of fine and medium sediments, and there was considerable meandering of the channel within the flood plain. Native riparian vegetation included willows and Fremont cottonwood, and junipers were common on the side of the canyon. The conditions at the survey site are probably typical of most of Mancos Canyon. The Park had undertaken a program to remove saltcedar from the floodplain in this area; however this exotic species appeared from the overflight to be common in the rest of the Canyon.

5. Lower elevation reaches, from 1400-1615 meters (4600-6500 feet; Figures 2E and F). This section is between the mouth of Mancos Canyon and the confluence with the San Juan River. No surveys were conducted in this section. The river has a low gradient, and the channel is wide and shallow, with a number of meanders. Most of the banks consist either of exposed bedrock or fine sediments, including wind-blown sand. The surrounding vegetation is Great Basin desert shrub. The primary riparian vegetation appears to be willows and saltcedar, although this was not confirmed with field surveys.

Major human uses and impacts. Native Americans have used most of the Mancos River watershed for agriculture, hunting and fishing, and various other purposes for many thousands of years. At the present time, most human activities are focused in the upper parts of the watershed. Intensive settlement and the modification of the Mancos River and its tributaries for irrigated agriculture began around 1876, and major water delivery systems and several small water storage reservoirs had been established by the 1890s. The US Bureau of Reclamation estimated that in 1994 approximately 14,900 acres in the Valley and surrounding areas were used for agricultural production, including alfalfa, grasses and small grains. At that time, 11,700 acres were irrigated: 9900 acres by flood irrigation and 1800 acres with sprinklers (USBR 1994, cited in Yochum 2004). To deliver water to the fields, there are approximately 46 water

diversions on both the main Mancos River and on its tributaries. There are also several large storage reservoirs that are located above Mancos Valley itself, including Jackson Gulch and Weber reservoirs. Annual diversions from the Mancos River and its tributaries in the upper watershed were estimated by the Colorado Department of Natural Resources (Colorado Decision Support System 2001) to range between 14,600 acre feet and 67,000 acre feet per year for the period between 1974 and 2000, with an average of 42,100 acre feet per year.

Additional human impacts in the upper parts of the watershed include livestock grazing, limited aspen timber harvests on the higher elevation plateaus, recreation, a few small roads along portions of several tributaries, and historic mining at higher elevations on the East Mancos (no mines are known to be active at present). The town of Mancos is situated directly on the Mancos River below where the major tributaries join together at the head of Mancos Valley. In recent years there also has been considerable new home construction in previously agricultural areas, as the population in the upper watershed has increased. A number of these homes are directly adjacent to the river or its tributaries.

The lower part of the Mancos River watershed is largely undeveloped. Primary human use and impacts at the present time appears to be livestock grazing, as well as a road that runs along portions of the river itself in the lower part of Mancos Canyon.

Hydrograph. A major impact that human activities like water diversions for agriculture and domestic water use can have on stream-riparian ecosystems is to change both the amount and timing of the water that moves through the river downstream from the diversion point(s). The pattern of stream flow past a specific spot is called a hydrograph. We are not aware of any detailed quantitative records of the amount of water that flowed in the Mancos River prior to the first water diversions. It is therefore impossible to know exactly what the original hydrograph would have looked like at various reaches within this watershed. However, it is likely that the Mancos River exhibited the same general flow pattern as does many other streams and rivers in the American southwest. Most precipitation in this region falls either during the winter, primarily as snow in mountains, or during the summer monsoon or rainy season, which usually takes place between July and October. This precipitation pattern leads to two peaks in the annual amount of water flow: a large increase in the spring, with the snow melt and runoff from the mountains, and a secondary peak that results from the summer rains. At other periods, and depending on the overall size of the watershed above a particular reach, flows tend to be much smaller. In some streams, and during some dry years, the amount of water in a particular reach may even fall to zero in the smaller area watersheds. Figure 3 is a hydrograph from the West Mancos River, above the town of Mancos, for the year 1939. These data were collected prior to the completion of the Jackson Gulch Reservoir project, which diverts water from the West Mancos and then stores it in the reservoir for subsequent release during the irrigation season. The hydrograph in Figure 3 shows the two peaks in stream flow (spring and late summer) discussed above, as well as the low flow periods over the winter and mid-summer. Most of the plants and animals that live in stream-riparian ecosystems in the American southwest are adapted to a lesser or greater extent to this type of water-flow pattern, although of course the aquatic system itself is very sensitive to periods when there is no stream flow whatever.

Without further detailed analysis, it is impossible to know what the overall impact of the irrigation removals and water storage reservoirs has been on the stream-riparian ecosystems within the study area. The primary effect of the diversions is to decrease the total amount of water in reaches downstream whenever the diversion is active. A secondary effect, from the storage reservoir part of the irrigation system, is to decrease the annual variance in water flow. Part of the spring run off is captured by the reservoir, which then decreases the natural peak of water flow during that time. This stored water is then released throughout the summer, increasing the amount of water in at least parts of the river over what would normally be present (above any diversion of that water into irrigation ditches). It is impossible to tell how much of the hydrograph pattern in Figure 3 has been altered due to the combined effects of water

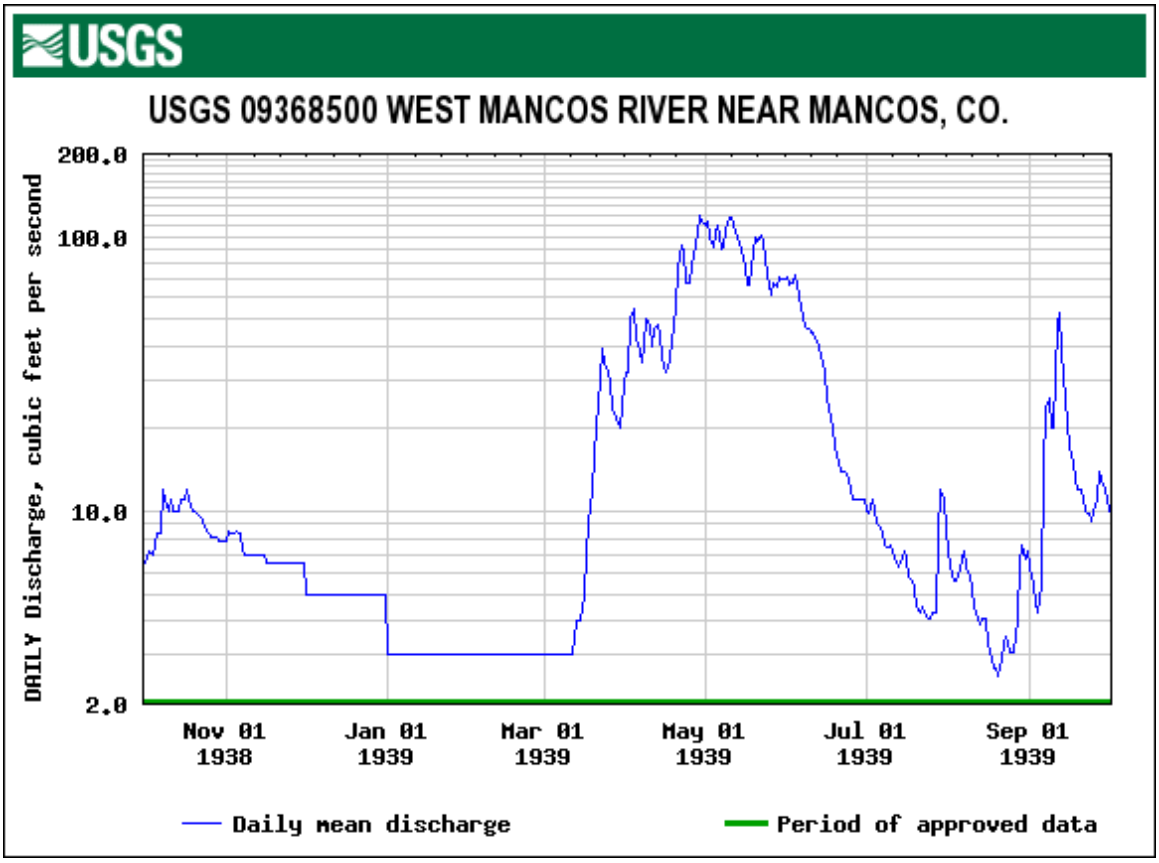

Figure 3. Hydrograph from the West Mancos River in 1939, prior to the construction of Jackson Gulch Reservoir, which was completed in 1949. The hydrograph shows an annual pattern in stream flow levels typical of many streams and small rivers in the southwest, with the highest flows during the spring snow melt, and a secondary peak during the summer rainy season. Low flows occur during the winter months, and during mid to late summer before the summer rains. The watershed area of the West Mancos River that feeds into the measured water flow location in this figure is 42 square miles, and has an average discharge of 27,490 acre feet per year (USBR, 2007).

storage and diversion. However, overall, these factors are likely to have the following impacts: 1) reduce the peak amount of water that flows in downstream reaches, particularly the scouring flows and overbank flooding that often occur during the spring run-off, and 2) reduce the total amount of water that flows in the furthest downstream reaches during the water diversion/irrigation season, although this might be balanced to some extent in some reaches by water releases and irrigation ditch return flows during the period of low precipitation in the early summer. The Mancos watershed, particularly the upper part, is relatively small; whether or not any of the reaches in Mancos Valley and surrounding areas ever went totally dry before the development of intensive irrigation remains problematic.

Salinity. Much of the middle and lower sections of the upper Mancos River watershed (upper plateau and canyon, and Mancos Valley, sections) is underlain by salt bearing formations that include Mancos Shale and Dakota Sandstone. There has been considerable leaching of the salts from exposed beds of these formations, and the impact of the salts that are then transported downstream by the Mancos River on the overall salinity of the San Juan and Colorado River basin system has been the subject of considerable study (e.g., Yochum 2004). An examination of the possible effects of high salt loads in the Mancos River on the overall functioning of the stream-riparian ecosystem was beyond the scope of this study. However, we did not observe any obvious direct effects of this factor in any of the reaches examined.

METHODS

The Rapid Stream-Riparian Assessment (RSRA) Method

The RSRA protocol (Stacey *et al*. 2006) was developed to provide a mechanism to objectively determine the functional condition of both the aquatic and riparian components of small and medium sized streams and rivers in the American Southwest and in other similar arid and semi-arid regions. It provides a standardized method to evaluate the existing conditions along a particular reach of the river, to determine which components of the stream-riparian ecosystem differ from what would be expected within the reach under geomorphicly similar but unimpacted reference conditions, and to create a yardstick to objectively monitor any future changes within the system that result either from active restoration programs or from allowing the system to follow its current trajectory under existing management programs. Because the protocol can be completed in a relatively short time and does not require specialized and expensive equipment, it is possible to efficiently survey a number of different reaches within a particular watershed. This then can provide an understanding of both the variation in conditions within a particular watershed, as well as any trends that might exist as one moves through the watershed that might indicate cumulative impacts of various activities upon the stream-riparian ecosystem. The RSRA method thus provides an effective tool to assess the current overall health of a river system at the level of the entire watershed.

The RSRA utilizes a primarily qualitative assessment based on quantitative measurements made in the field. It focuses upon five functional components of the stream-riparian ecosystem that provide important benefits to humans and wildlife, and which, on public lands, are often the subject of government regulation and standards. These components are: 1) non-chemical water quality and pollution, 2) stream channel and flood plain morphology and the ability of the system to limit erosion and withstand flooding without damage, 3) the presence of habitat for native fish and other aquatic species, 4) vegetation structure and composition, including the occurrence and relative dominance of exotic or non-native species, and 5) suitability as habitat for terrestrial wildlife, including threatened or endangered species.

Within each of these areas, the RSRA evaluates between two and seven variables which reflect the overall function and health of the stream-riparian ecosystem. Each variable and the basis for its inclusion in the protocol are briefly summarized in Table 1. Variables are measured either along the entire study reach (usually around 1 kilometer in length, depending on local conditions) or along 200 meter sample transects. Each variable is then assigned a score from “1" to “5", using predefined scoring levels that can be scaled to the individual geomorphic and ecological conditions of that particular reach. A score of “1" would indicate that the ecosystem is highly impacted and non-functional for that variable, while the other extreme, a score of “5", would indicate the system is healthy and is functioning in a way that would be found in a reference stream that has not been impacted by human activities. A complete description of the variables and the methods used to collect and score them is contained in Stacey *et al.*, 2006).

Assumptions and Limitations of the RSRA Method. In interpreting the results of a RSRA survey, several features of the protocol should be kept in mind. First, the protocol considers features or variables that not only indicate the ability of the system to provide specific functions, but ones that also reflect important ecological processes within the stream-riparian system. For example, the fish habitat section includes a measure of the relative amount of undercut banks along the reach. Undercut banks not only provide important habitat and hiding cover for fish and other aquatic species, but their presence along a reach indicates that the banks themselves are well vegetated, and that there is sufficient root mass from vegetation to allow the development of the hour-glass shape channel cross-section that is typical of most healthy stream systems. The presence of this channel shape would in turn indicate that the fluvial

Table 1: RSRA indicator variables and the reasons for including them in the protocol.

CATEGORY AND VARIABLE	JUSTIFICATION FOR INCLUSION IN THE RSRA ASSESSMENT
Water Quality: **Algal growth**	Dense algal growth may indicate nutrient enrichment and other types of pollution which may result in decreased dissolved oxygen in the water column and affect invertebrates and the ability of fish to spawn.
Water Quality: **Channel shading and solar exposure**	Solar exposure affects stream temperature and productivity. Decreased streambank vegetation cover, increased channel width, and reduced stream depth increases exposure, raises water temperatures and impacts aquatic life. Native trout usually require cool stream temperatures.
Hydrogeomorphology: **Floodplain connection and inundation frequency**	Channels that are deeply downcut or incised result in a reduced frequency of overbank flooding into the adjacent flood plain during peak runoff or stream flows. The absence of flooding lowers water tables, reduces nutrient availability in the floodplain, decreases plant germination, growth and survivorship, and may lead to the loss of riparian vegetation and the invasion of upland species.
Hydrogeomorphology: Vertical bank stability	Steep and unstable vertical banks dominate many southwestern streams, limiting the physical dynamics of aquatic ecosystems and increasing erosion and sediment loads through sloughing off of soils during high flow events. Steep banks may limit wildlife access to water.
Hydrogeomorphology: **Hydraulic habitat diversity**	Fish and aquatic invertebrate diversity and population health is related to habitat diversity. Features such as oxbows, side channels, sand bars, gravel/cobble bars, riffles, and pools can provide habitat for different species or for the different life stages of a single species.
Hydrogeomorphology: **Riparian area soil integrity**	Riparian soils reflect existing stream flow dynamics (e.g., flooding), management practices, and vegetation. It affects potential vegetation dynamics and species composition, as well as wildlife habitat distribution and quality.
Hydrogeomorphology: **Beaver activity**	Beavers are keystone species in riparian systems because they modify geomorphology and vegetation, and reduce variance in water flows and the frequency of floods. Beaver dams and adjacent wet meadows provide important fish and plant nursery habitat.
Fish/Aquatic Habitat Qualifier: **Loss of perennial flows**	Fish and most aquatic invertebrates require perennial or constant flows to survive. Streams that were originally perennial but are now ephemeral no longer provide habitat for these species unless there are refuges that never dry out (e.g., permanent pools).
Fish/Aquatic Habitat: **Pool distribution**	Fish use pools, with reduced current velocity and deep water, to rest, feed and hide from predators. Many species use gravel-bottomed riffles to lay their eggs. The number, size, distribution, and quality of pools, and pool to riffle ratios indicate the quality of fish habitat. 1:1 pools to riffle ratios are generally considered to be optimum.
Fish/Aquatic Habitat: **Underbank cover**	Underbank cover is an important component of good fish habitat, used for resting and protection from predators. A number of aquatic invertebrates also use these areas. Underbank cover usually occurs with vigorous vegetative riparian growth, dense root masses, and stable soil conditions.
Fish/Aquatic Habitat: **Cobble embeddedness**	Low levels of gravel and boulder embeddedness on the channel bottom increase benthic productivity and fish production. The filling of interstitial spaces between rocks with silt, sand, and organic material reduces habitat suitability for feeding, nursery cover, and spawning (egg to fry survival) by limiting space and macroinvertebrate production. Increased embeddedness often reflects increased sediment loads and altered water flow patterns.
Fish/Aquatic Habitat: **Diversity of aquatic invertebrates**	The density and composition of aquatic invertebrates are strong indicators of stream health, including temperature stresses, oxygen levels, nutrients, pollutants, and sediment loads. Larvae and adult macroinvertebrates provide critical food for fish and other invertebrate and vertebrate species in stream-riparian ecosystems.

Table 1: Continued from the previous page.

CATEGORY AND VARIABLE	JUSTIFICATION FOR INCLUSION IN THE RSRA ASSESSMENT
Fish/Aquatic Habitat: **Large woody debris**	The amount, composition, distribution and condition of large woody debris (LWD) in the stream channel and along the banks provides important fish habitat for nursery cover, feeding, and protective cover. Streams with adequate LWD generally have greater habitat diversity, a natural meandering shape and greater resistance against high water events.
Fish/Aquatic Habitat: **Overbank cover and terrestrial invertebrate habitat**	Overhanging terrestrial vegetation is essential for fish production and survival, providing shade, bank protection from high flows, sediment filtering, and input of organic matter. Overbank cover also is important for terrestrial insect input (drop) into streams, which is a key source of food for fish.
Riparian vegetation: **Plant community cover and structural diversity**	High cover and structural diversity of riparian vegetation generally indicates healthy and productive plant communities, high plant species diversity and provides direct and secondary food resources, cover, and breeding habitat for wildlife. This affects avian breeding and foraging patterns in particular. Good structural diversity can also reduce flood impacts along banks.
Riparian vegetation: **Dominant shrub and tree demography (recruitment and age distribution)**	The distribution of size and age classes of native dominant species indicates recruitment success, ecosystem sustainability, and wildlife and fish habitat availability. When one or more age classes of the dominant species are missing, it indicates that something has interrupted the natural process of reproduction and individual plant replacement. In time, this may lead to the complete loss of the species in the area as older individuals die off and are not replaced by younger plants.
Riparian vegetation: **Non-native herbaceous and woody plant cover**	Non-native plant species profoundly influence ecosystem structure, productivity, habitat quality, and processes (e.g., fire frequency, intensity). Strong dominance by non-native plants may eliminate key attributes of wildlife habitat quality, and may limit ungulate and livestock use.
Riparian vegetation: **Mammalian herbivory impacts on ground cover**	Ungulate herbivores can affect riparian soils, ground cover, and general ecosystem condition. Utilization levels >10% in riparian zones retard vegetation replacement and recovery. Moderate and higher levels of grazing almost always increase soil compaction and erosion.
Riparian vegetation: **Mammalian herbivory impacts on shrubs and small trees**	Ungulate herbivores can affect recruitment of woody shrub and trees by clipping or browsing the growing tips of the branches. Continued high levels of utilization lead to the death of the plant and over time can cause the loss of all shrubs and trees in a local area.
Terrestrial Wildlife Habitat: **Riparian shrub and tree canopy cover and connectivity**	Riparian shrubs and trees often grow in dense patches that provide food, thermal cover, predator protection and nesting or breeding habitat for terrestrial wildlife, including many invertebrates, amphibians, reptiles, birds and mammals. These patches are often absent in riparian areas that have been heavily utilized by livestock and other ungulates, or that have been damaged by other human activities. As a result, many native wildlife species may no longer be able to survive in the area. Patches of dense vegetation, both native and exotic, also plays a key role in trapping sediment during periods of over-bank flow.
Terrestrial Wildlife Habitat: **Fluvial habitat diversity**	Natural processes create a diversity of fluvial landforms, including terraces, bars, oxbows, wet marshes and fluvial marshes, which provide habitats for different species of terrestrial wildlife. Conversely, in a highly degraded system with extensive erosion and downcutting, there may be only a single fluvial form: a straight and single-depth channel and steep banks without vegetation.

processes of erosion and deposition along that reach are in relative equilibrium. Thus, when interpreting the surveys, the results of all indicators should be considered together. This will facilitate deciding which parts of the ecosystem within the study reach may be most out of balance with natural processes, and therefore which of those parts may be the most important or the most suitable for future restoration efforts.

Second, in order to increase the number of survey sites that can be sampled, the protocol uses variables that can be measured rapidly in the field and that do not require specialized equipment. More detailed and extensive methods have been developed for several of the individual indicators included in this protocol. Many of these analyses may take one or more days to complete, just for that single variable. However, should any of the individual components of the reach be found to be particularly problematic or non-functional using the RSRA protocol, then the more specialized methods can be used during subsequent visits to the site in order to collect additional quantitative information on that particular variable.

Third, the RSRA protocol measures only the current condition of the ecosystem. It does not base its scores upon some hypothesized future state or successional trend within the reach, as is done with several other riparian assessment methods (e.g., the BLM's Proper Functioning Condition assessment). The RSRA method addresses the ability of the ecosystem to provide some important function at the present time, and not whether it would be likely to do so at some point in the future, if current trends or management practices on the reach continue. This approach is used because stream-riparian systems are highly dynamic and they are often subject to disturbances (e.g., large floods) that can alter successional trends and make predictions of future conditions on an individual reach highly problematic.

By evaluating only current conditions, this protocol can be used as a powerful tool for monitoring and measuring future changes in the functional status of the system. For example, if a reach is rated as in poor condition with respect to a particular set of parameters, reevaluating the system using the identical protocol in subsequent years gives one the ability to measure the effectiveness of any management change or active restoration program and to undertake corrections if the restoration actions are found to be not producing the desired changes. This type of adaptive management approach can be extremely difficult if the evaluation and monitoring measures are based primarily upon the expectations of some future, rather than current, condition.

Fourth, the protocol incorporates a quantitative, five level, scale in order to assign a score to each of the variables examined. Many of the other riparian assessment systems are based upon dichotomous categories, such as "functional/non-functional", or "yes/no", and they can be subjective and difficult to repeat in the same way from one year to the next, or when conducted by different observers. In addition, dichotomous scoring systems often are not able to provide sufficient insight into the ecological processes that may be affecting the ability of the system to provide (or not provide) desired functions that would indicate whether active restoration efforts might be necessary. The RSRA scoring levels were based upon a review of existing assessment and monitoring protocols, extensive external peer-reviews, and the individual research experiences of all of the authors. A scale is used for each variable.

While individual variables during a survey may receive extreme scores of "1" or "5", it is highly unlikely that all of the scores for a functional category, or that the overall mean score for a particular reach, will receive these outermost ratings. It is therefore important when interpreting the results of the RSRA surveys that all scores be viewed together. For example, most of the scores in one functional category (e.g., fish and aquatic habitat) may be high, but one other variable may be low. In terms of restoration planning, this means that a relatively simple action to correct that one deficiency in the system could have large future impacts. Such actions would then be high priority, since the cost to benefit ratio would be high. Alternatively, low scores in some categories may be difficult to correct without extensive

and expensive restoration actions (e.g., a lack of flood plain connectivity due to channel entrenchment or a widespread levee system). In these situations it may be more appropriate to focus upon other restoration actions, such as re-vegetating the banks and/or reintroducing beavers, which will eventually alter the shape of the channel and thereby indirectly help resolve the problem. By simultaneously examining a number of different features of the stream-riparian ecosystem in each of several different functional categories, it is possible to obtain both an overall picture of the current health of the stream or river in that reach, as well as the specific areas where restoration programs may be particularly effective.

RESULTS

INDIVIDUAL ASSESSMENT SITE DESCRIPTIONS

Survey Site Selection

The specific locations where the RSRA surveys were conducted were chosen on the basis of preliminary field reconnaissance, aerial overflight of the watershed, and in consultation with personnel of the Mancos Conservation District. As discussed above, the initial field work indicated that the high altitude sections of the tributaries of the main stem of Mancos River (the East, Middle and West Mancos Rivers) showed only minor direct impacts from past or current human activities. These consisted primarily of historic hard-rock mining activity on the East Mancos, and several small dirt roads along limited sections of the stream in the Middle and West Mancos tributaries. In the upper canyon and plateau region, there have been limited aspen harvests on the top of the plateaus. However, there were no obvious visible impacts from these activities on the streams in the adjacent canyons since the sides of the canyons in this section are very steep and have not been harvested. As is detailed below, however, there have been channel and floodplain modifications resulting from construction of numerous water diversion structures in both the Middle and West Mancos Rivers.

As a result of these preliminary observations, we decided to concentrate the majority of the assessments within the Mancos Valley itself. This part of the watershed is where a) there has been the most past and present human activity that could potentially affect the stream-riparian ecosystem, b) the benefit provided by the Mancos River to the human community from irrigated agriculture and other factors such as tourism, recreation and quality of life, are the greatest, and c) any restoration program undertaken in the future is likely to have the most direct and indirect positive impacts on the system. To provide context for the assessments in the Valley, we also surveyed additional sites as follows. 1) To determine the local impacts of major water diversions to feed the numerous water storage reservoirs in the region, we assessed the functional condition of the West Mancos River above and below the Jackson Gulch Reservoir inlet diversion and canal. 2) To examine the condition of the major tributaries of the main Mancos River before they enter the Valley, we assessed: a) the East Mancos River where it joins the Middle Mancos, and just upstream from the first agricultural (ranch) pastures, b) the Middle Mancos just above the Weber Reservoir diversion, and c) the West Mancos in the canyon just above where it begins to widen and enter the Valley. 3) We also examined two other primary tributaries that enter the Mancos within the Valley proper, to determine if their input might affect the main stem of the River. These were Chicken Creek, surveyed near where it joins the Mancos near the town of Mancos, and Mud Creek, where we sampled an area of agricultural use west of the town of Mancos. 4) Finally, we assessed the condition of the Mancos downstream of Mancos Valley. This survey was located within Mancos Canyon at the mouth of Weber Canyon, and just above the border of Mesa Verde National Park and the Ute Mountain Ute Indian Reservation. We were unable to conduct additional surveys further downstream on the Mancos River within the Ute Mountain Reservation. The locations of the surveys are shown in Figure 4.

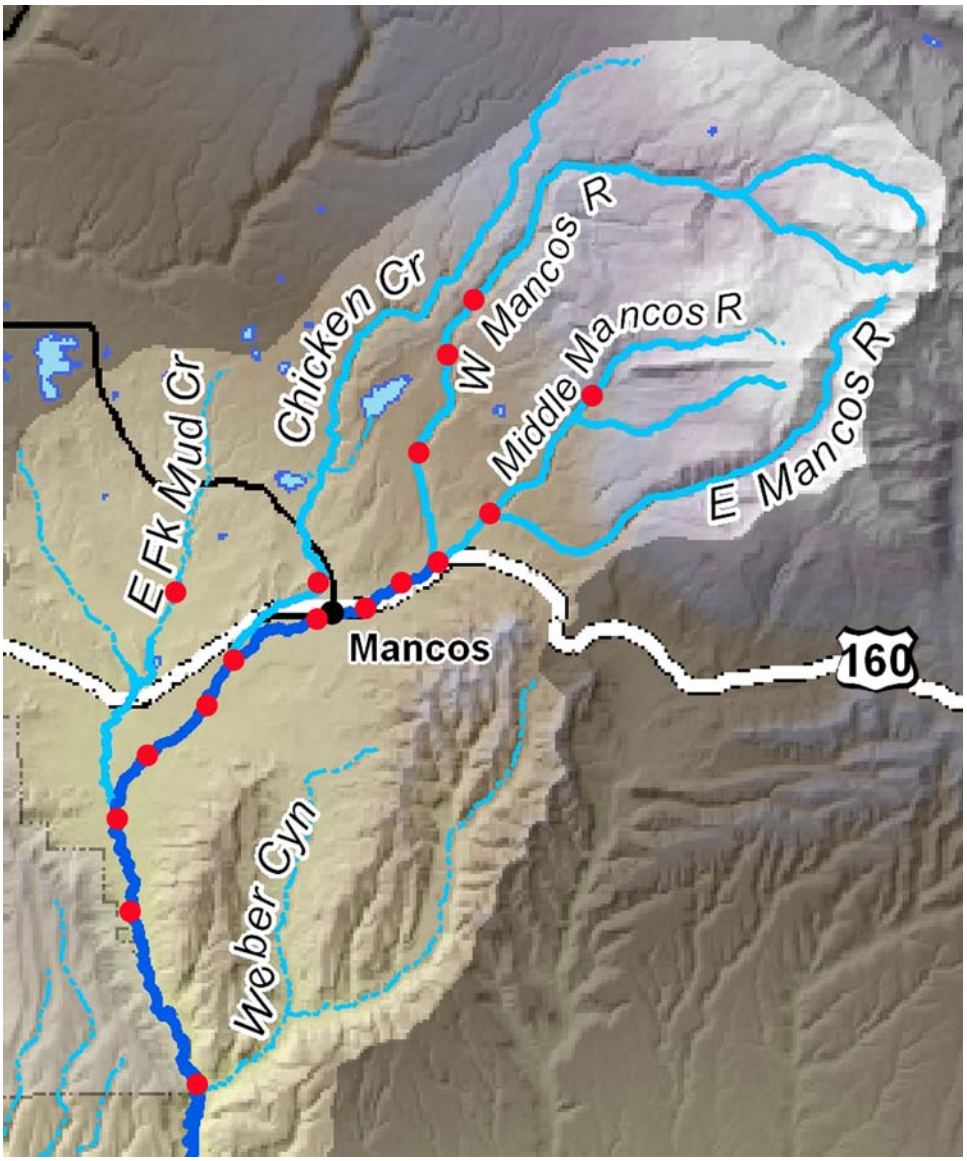

Figure 4. Location of RSRA surveys (red dots) in the Mancos Valley and surrounding areas.

Site Descriptions and Narrative of Findings

Table 2 presents the results of the assessments in tabular form. The field evaluation forms should be consulted in any interpretation of the results of the surveys. The reader should also refer to the RSRA User's Guide for a detailed description of how the data were collected in order to interpret the meaning of the assessment scores. The field forms and reference photos form a permanent record of the current condition of each reach, and therefore can be used to monitor future changes in the stream-riparian ecosystem, either as a result of any active restoration efforts, or from maintaining current management regimes for that reach.

	Survey Descriptors				Reach Coordinates			
Number	River	Reach	Field Survey Date	Elevation (Upstream end of reach, in meters)	Start UTM (E)	Start UTM (N)	Stop UTM (E)	Stop UTM (N)
1	East Mancos	Reddert Ranch Reach	6/17/2006 and 7/23/2006	2279	12 S 0745007 E	4139352 N	12 S 0744884 E	4139412 N
2	Middle Mancos	Weber Resevoir Inlet Diversion Reach	7/23/2006	2562	12 S 0748322 E	4143240 N	12 S 0747991 E	4142941 N
3	West Mancos	Above Mesa Verde Diversion Reach	7/19/2006	2544	12 S 0746479 E	4149234 N	12 S 0746439 E	4149062 N
4	West Mancos	Below Jackson Gulch Resevoir Diversion Reach	7/19/2006	2431	12 S 0744389 E	4146042 N	12 S 0744412 E	4145873 N
5	West Mancos	Colyer Ranch Reach	7/7/2006	2310	12 S 0742993 E	4141784 N	12 S 0742781 E	4141359 N
6	West Mancos	Above Weber Diversion Reach	7/22/2006	2226	12 S 0743245 E	4138086 N	12 S 0743201 E	4137849 N
7	Mancos	Below Ratliff Diversion Reach	7/22/2006	2199	12 S 0742596 E	4137425 N	12 S 0742217 E	4137209 N
8	Mancos	Redwood/Black Reach	7/12/2006	2171	12 S 0740942 E	4136453 N	12 S 0740759 E	4136456 N
9	Mancos	Excelsior/Sewage Plant Reach	7/8/2006	2112	12 S 0738984 E	4135964 N	12 S 0738512 E	4135937 N
10	Mancos	Road J Bridge Reach	7/9/2006	2068	12 S 0737005 E	4134791 N	12 S 0736667 E	4134310 N
11	Mancos	Lazy F/W Ranch Reach	7/11/2006	2055	12 S 0736366 E	4133877 N	12 S 0736257 E	4133467 N
12	Mancos	Perry Ranch Reach	6/18/2006 and 7/12/2006	2021	12 S 0734427 E	4132055 N	12 S 0734342 E	4131818 N
13	Mancos	Soussanna Ranch Reach	7/10/2006	1999	12 S 0733603 E	4130540 N	12 S 0733570 E	4130172 N
14	Mancos	Mitchell Ranch Reach	7/18/2006	1952	12 S 0734048 E	4127867 N	12 S 0734066 E	4127329 N
15	Mancos	Mesa Verde NP/Ute Border Reach	7/21/2006	1880	12 S 0736039 E	4122345 N	12 S 0736112 E	4122124 N
16	Chicken Creek	Valley Inn Reach	7/18/2006	2133	12 S 0739466 E	4136951 N	12 S 0739844 E	4137156 N
17	Mud Creek	Mud Creek Ranch Reach	7/20/2006	2058	12 S 0735537 E	4137587 N	12 S 0735538 E	4137444 N

Table 2. Summary of the results of the assessment surveys of the reaches on the Mancos River and tributaries. Description of sites.

		Water Quality			Hydrogeomorphology					
Reach	Overall Score	Algal Growth	Channel Shading	Water Quality Mean Score	Floodplain Connection	Vertical Bank Stability	Hydraulic Habitat Diversity	Riparian Area Soil Integrity	Beaver Activity	Hydrogeo-morphology Mean Score
Reddert Ranch Reach	3.8	3	5	4	2	5	5	5	2	3.8
Weber Resevoir Inlet Diversion Reach	4.8	5	5	5	5	5	5	4	4	4.6
Above Mesa Verde Diversion Reach	4.1	5	3	4	1	5	4	5	1	3.2
Below Jackson Gulch Resevoir Diversion Reach	3.6	5	2	3.5	1	5	3	5	1	3
Colyer Ranch Reach	3.4	2	4	3	1	5	5	3	1	3
Above Weber Diversion Reach	3.2	2	4	3	1	5	3	1	1	2.2
Below Ratliff Diversion Reach	3.6	1	4	2.5	1	5	3	5	1	3
Redwood/Black Reach	3.1	3	2	2.5	1	5	2	5	1	2.8
Excelsior/Sewage Plant Reach	3.3	2	2	2	1	4	4	4	1	2.8
Road J Bridge Reach	2.9	3	2	2.5	1	5	3	4	1	2.8
Lazy F/W Ranch Reach	2.3	1	2	1.5	1	3	3	1	1	1.8
Perry Ranch Reach	2.4	1	2	1.5	1	3	2	1	1	1.6
Soussanna Ranch Reach	2.5	1	1	1	1	4	4	5	1	3
Mitchell Ranch Reach	2.5	1	2	1.5	1	5	2	5	1	2.8
Mesa Verde NP/Ute Border Reach	2.8	1	2	1.5	1	5	2	3	1	2.4
Valley Inn Reach	3	1	2	1.5	1	4	4	5	4	3.6
Mud Creek Ranch Reach	2.2	n/a	2	2	1	4	2	2	1	2

Table 2 (continued). Scores for Water Quality and Hydrogeomorphology.

Reach	Pool Distribution	Underbank Cover	Cobble Embedded-ness	Aquatic Macro-invertebrate Diversity	Large Woody Debris	Overbank Cover	Fish/Aquatic Habitat Mean Score
Fish/Aquatic Habitat							
Reddert Ranch Reach	5	5	5	1	5	5	4.3
Weber Resevoir Inlet Diversion Reach	5	5	5	5	5	5	5
Above Mesa Verde Diversion Reach	4	2	5	5	5	5	4.3
Below Jackson Gulch Resevoir Diversion Reach	2	2	4	5	2	4	3.2
Colyer Ranch Reach	4	3	4	5	5	5	4.3
Above Weber Diversion Reach	1	3	5	5	5	5	4
Below Ratliff Diversion Reach	3	3	5	5	3	5	4
Redwood/Black Reach	2	2	4	5	2	5	3.3
Excelsior/Sewage Plant Reach	4	3	3	5	5	5	4.2
Road J Bridge Reach	1	2	3	5	4	2	2.8
Lazy F/W Ranch Reach	3	2	2	5	2	3	2.8
Perry Ranch Reach	2	2	3	5	3	2	2.8
Soussanna Ranch Reach	4	2	1	5	1	5	3.2
Mitchell Ranch Reach	3	2	2	1	1	3	2
Mesa Verde NP/Ute Border Reach	5	2	1	1	1	5	2.5
Valley Inn Reach	5	4	3	5	3	5	4.2
Mud Creek Ranch Reach	4	3	3	1	1	5	2.8

Table 2 (continued). Scores for Fish Habitat.

Reach	Riparian Vegetation											
	Lower Riparian Zone Plant Cover	LRZ Ground Cover (%)	LRZ Shrub Cover (%)	LRZ Middle Canopy Cover (%)	LRZ Upper Canopy Cover (%)	Upper Riparian Zone Plant Cover	URZ Ground Cover (%)	URZ Shrub Cover (%)	URZ Middle Canopy Cover (%)	URZ Upper Canopy Cover (%)	Shrub Demography & Recruitment	Tree Demography & Recruitment
Reddert Ranch Reach	3	---	---	---	---	3	---	---	---	---	4	5
Weber Resevoir Inlet Diversion Reach	4	62%	80%	64%	34%	4	90%	78%	58%	40%	5	5
Above Mesa Verde Diversion Reach	3	57%	73%	45%	9%	4	81%	62%	58%	28%	4	5
Below Jackson Gulch Resevoir Diversion Reach	4	53%	90%	67%	36%	4	80%	86%	54%	66%	4	5
Colyer Ranch Reach	3	36%	52%	30%	28%	4	77%	58%	35%	34%	5	4
Above Weber Diversion Reach	3	67%	42%	25%	65%	4	88%	57%	43%	70%	5	5
Below Ratliff Diversion Reach	3	56%	36%	36%	36%	4	88%	43%	42%	43%	5	5
Redwood/Black Reach	3	61%	84%	24%	6%	4	77%	90%	41%	13%	4	5
Excelsior/Sewage Plant Reach	3	86%	43%	22%	10%	4	94%	33%	38%	42%	5	5
Road J Bridge Reach	3	63%	42%	15%	3%	4	25%	44%	68%	69%	5	5
Lazy F/W Ranch Reach	2	67%	11%	9%	9%	3	79%	14%	17%	23%	4	4
Perry Ranch Reach	2	---	---	---	---	3	---	---	---	---	5	4
Soussanna Ranch Reach	2	68%	6%	0%	0%	3	92%	18%	0%	0%	3	3
Mitchell Ranch Reach	3	49%	50%	0%	0%	3	77%	48%	0%	0%	4	4
Mesa Verde NP/Ute Border Reach	3	33%	74%	0%	0%	3	56%	71%	2%	0%	5	5
Valley Inn Reach	3	89%	27%	2%	2%	3	94%	13%	1%	0%	4	2
Mud Creek Ranch Reach	3	59%	67%	1%	0%	2	52%	33%	3%	0%	4	2

Table 2 (continued). Scores for Riparian Vegetation.

						Terrestrial Wildlife Habitat				
Reach	Non-native Herbaceous Plant Species	Non-native Woody Plant Species	Mammalian Herbivory on Ground Cover	Mammalian Herbivory on Shrubs and Small Trees	Riparian Vegetation Mean Score	Shrub Patch Density	Middle Canopy Patch Density	Upper Canopy Patch Density	Fluvial Habitat Diversity	Terrestrial Wildlife Habitat Mean Score
Reddert Ranch Reach	2	5	5	3	3.8	2	4	4	3	3.3
Weber Resevoir Inlet Diversion Reach	5	5	5	5	4.8	4	5	4	5	4.5
Above Mesa Verde Diversion Reach	5	5	5	5	4.5	4	4	5	4	4.3
Below Jackson Gulch Resevoir Diversion Reach	5	5	5	5	4.6	4	4	5	1	3.5
Colyer Ranch Reach	5	5	3	1	3.8	4	2	3	3	3
Above Weber Diversion Reach	3	5	2	3	3.8	2	3	4	3	3
Below Ratliff Diversion Reach	5	5	5	4	4.5	3	4	5	3	3.8
Redwood/Black Reach	3	5	5	3	4	5	4	2	1	3
Excelsior/Sewage Plant Reach	2	5	3	2	3.6	2	4	4	5	3.8
Road J Bridge Reach	2	4	2	2	3.4	3	3	3	2	2.8
Lazy F/W Ranch Reach	2	5	2	1	2.9	2	2	2	3	2.3
Perry Ranch Reach	3	5	5	1	3.5	2	3	3	2	2.5
Soussanna Ranch Reach	5	2	2	1	2.6	2	1	2	5	2.5
Mitchell Ranch Reach	1	5	5	5	3.8	4	2	3	1	2.5
Mesa Verde NP/Ute Border Reach	2	5	5	5	4.1	5	3	2	3	3.3
Valley Inn Reach	5	4	5	1	3.4	1	2	1	5	2.3
Mud Creek Ranch Reach	1	4	3	3	2.8	2	1	1	2	1.5

Table 2 (continued). Scores for Riparian Vegetation and Terrestrial Wildlife Habitat

In order to facilitate the interpretation of the scores assigned in the field in the site descriptions below, the following terminology is used to describe the current relative ecological condition of a particular RSRA assessment variable: a score of “5" is termed “excellent”; “4" is termed “very good”; “3" is termed “good”; “2" is termed “fair”; and “1" is termed “poor”. However, the original quantitative scores (Table 2) should be used for across site comparisons, as well as for all future monitoring purposes.

A. Canyon and Plateau Sites

1. East Mancos River, Reddert Ranch Reach

Location of beginning of reach: 12 S 0745007 East, 4139352 North
Elevation: 2402 meters (7879 feet)
References Photos: Figure 5 A, B
Aerial Location Photo: Figure 6

Overall Score: 3.8

Individual Area Scores:

Water Quality Mean Score: 4.0
- Algal Growth: 3
- Channel Shading: 5

Hydrogeomorphology Mean Score: 3.8
- Floodplain Connection: 2
- Vertical Bank Stability: 5
- Hydraulic Habitat Diversity: 5
- Riparian Area Soil Integrity: 5
- Beaver Activity: 2

Fish/Aquatic Habitat Mean Score: 4.3
- Pool Distribution: 5
- Underbank Cover: 5
- Cobble Embeddedness: 5
- Aquatic Macroinvertebrate Diversity: 1
- Large Woody Debris: 5
- Overbank Cover: 5

Riparian Vegetation Mean Score: 3.8
- Lower Riparian Zone Plant Cover: 3
- Upper Riparian Zone Plant Cover: 3
- Shrub Demography and Recruitment: 4
- Tree Demography and Recruitment: 5
- Non-native Herbaceous Plant Species: 2
- Non-native Woody Plant Species: 5
- Mammalian Herbivory on Ground Cover: 5
- Mammalian Herbivory on Shrubs and Small Trees: 3

Terrestrial Wildlife Habitat Mean Score: 3.3
- Shrub Patch Density: 2
- Mid-canopy Patch Density: 4
- Upper Canopy Patch Density: 4
- Fluvial Habitat Diversity: 3

Figure 5. Reference Photos for the upstream and downstream ends of the Reddert Ranch Reach, East Mancos River.

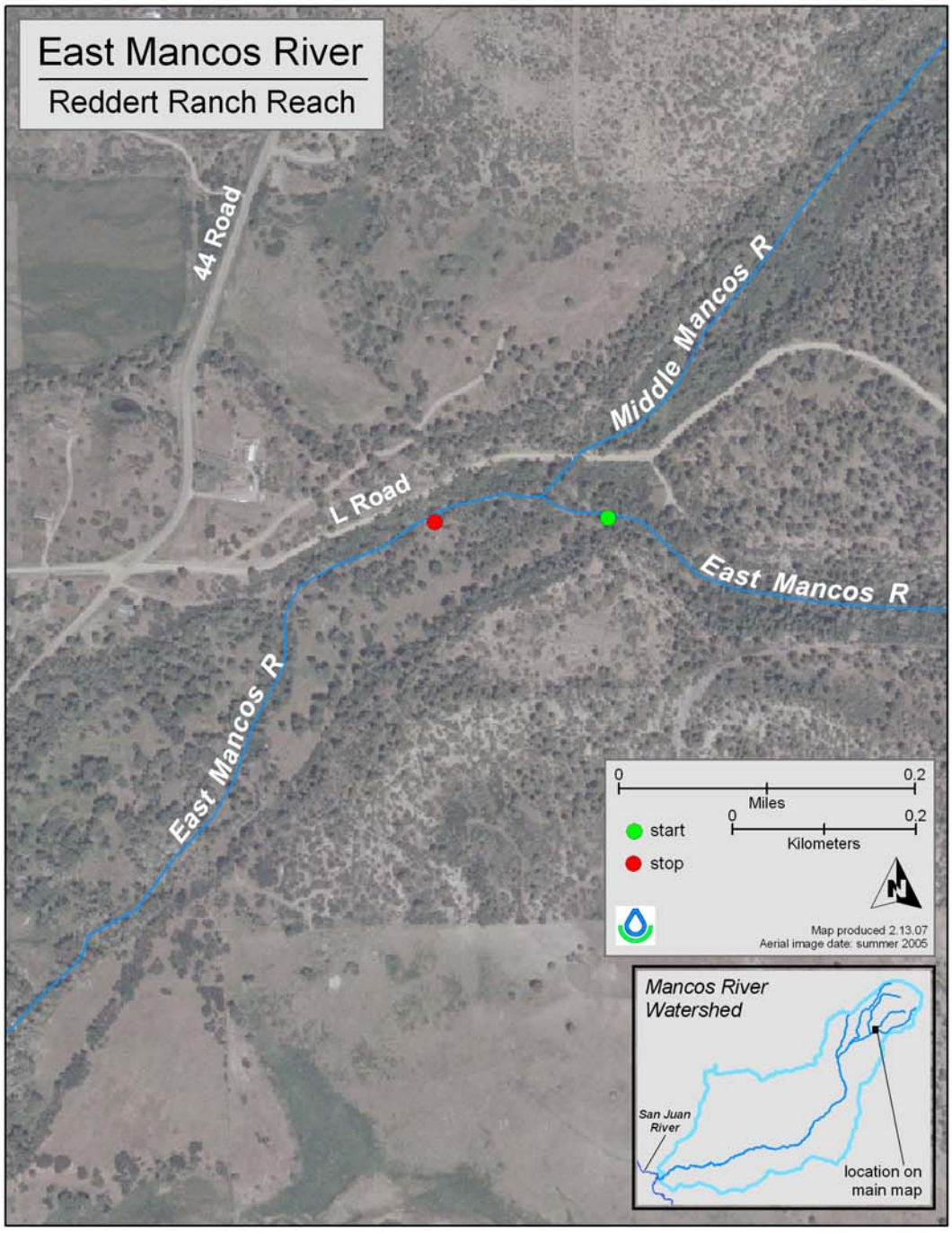

Figure 6. Aerial photo showing the location of the Reddert Ranch Reach, East Mancos River (*photo compiled by Marianna Young*). Note: the location of the river channel in this photo and the subsequent photos is based upon data collected prior to the 2005 date of the photo, and may not represent the current position of this feature.

The Reddert Ranch reach is located on the East Mancos River, where it joins the Middle Mancos River, and just as it emerges from a small canyon and enters the Mancos Valley proper. The reach is medium gradient. It is located on an old ranch, and was historically grazed but does not appear to be used at present. There is a road on the north side of the stream channel, mostly above the stream on the adjacent hillside.

The reach is generally in good to excellent condition, with some exceptions. Nonchemical Water Quality was good, with the expected amount of algae, and with dense overhanging vegetation providing good solar shading. Hydrogeomorphology was generally very good, although the channel was incised more than what would be expected, suggesting that there have been high flow events in the past that have produced some downcutting. There appears to be little active erosion at present. There are no beavers in the assessment reach, but there is an active colony just across the road at the mouth of the Middle Mancos. It is likely these beavers will colonize the area in the near future, if not removed by humans.

Fish/Aquatic Habitat was uniformly excellent, with the exception that there was no macroinvertebrate fauna found in the stream. In addition, no fish were observed during the assessment, despite the fact that this is excellent habitat, and that fish are found in the Middle Mancos where it joins the East Mancos. This indicates that there is probably something in the water that is killing the insects, and this should be examined in greater detail by more detailed chemical studies (see also note to West Mancos-Weber Diversion assessment, below).

Riparian Vegetation and Terrestrial Wildlife Habitat was generally good to very good. There was a lack of shrub cover in much of the reach. This may be due to the heavy browsing levels that were observed on shrubs and small trees. There was little evidence of current livestock use, which suggests that most browsing at present is from mule deer and elk.

Non-native herbaceous plant cover was high, but there were no non-native shrubs or trees found in the reach.

2. Middle Mancos River, Weber Reservoir Inlet Diversion Reach

Location of beginning of reach: 12 S 0748322 East, 4143240 North
Elevation: 2562 meters (8400 feet)
References Photos: Figure 7. A, B
Aerial Location Photo: Figure 8

Overall Score: 4.8

Individual Area Scores:

Water Quality Mean Score: 4.8
- Algal Growth: 5
- Channel Shading: 5

Hydrogeomorphology Mean Score: 4.6
- Floodplain Connection: 5
- Vertical Bank Stability: 5
- Hydraulic Habitat Diversity: 5
- Riparian Area Soil Integrity: 4
- Beaver Activity: 4

Fish/Aquatic Habitat Mean Score: 5.0
- Pool Distribution: 5
- Underbank Cover: 5

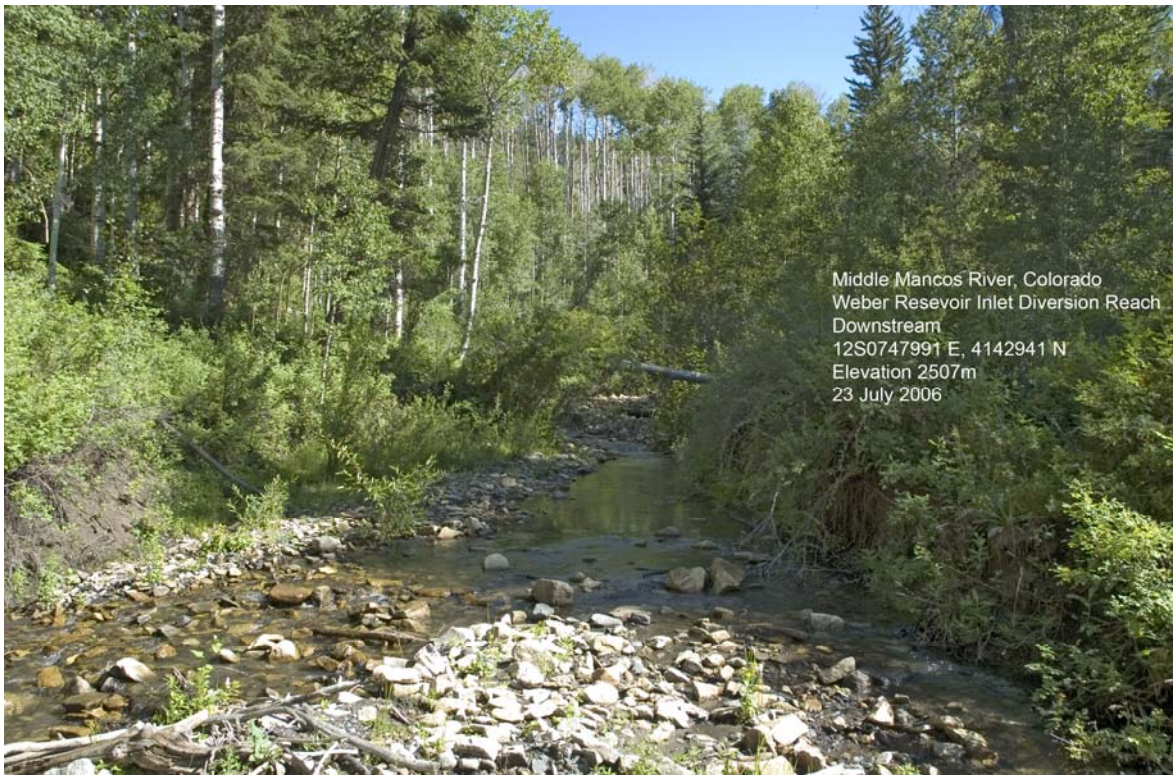

Figure 7. References Photos for the Weber Reservoir Inlet Diversion Reach, Middle Mancos River.

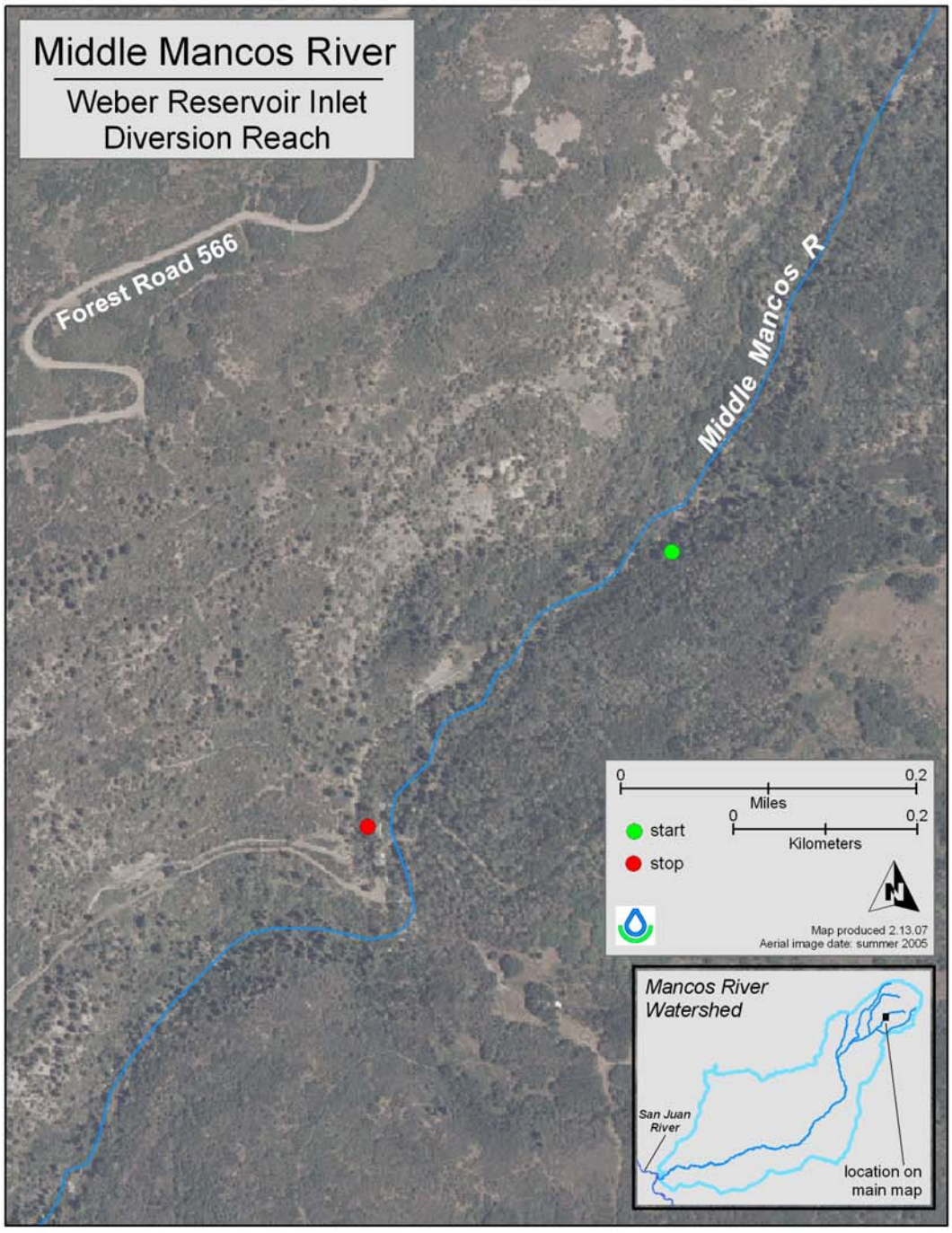

Figure 8. Aerial photo showing the location of the Weber Reservoir Inlet Diversion Reach, Middle Mancos River (*photo compiled by Marianna Young*).

Cobble Embeddedness: 5
Aquatic Macroinvertebrate Diversity: 5
Large Woody Debris: 5
Overbank Cover: 5

Riparian Vegetation Mean Score: 4.8

Lower Riparian Zone Plant Cover: 4
Upper Riparian Zone Plant Cover: 4
Shrub Demography and Recruitment: 5
Tree Demography and Recruitment: 5
Non-native Herbaceous Plant Species: 5
Non-native Woody Plant Species: 5
Mammalian Herbivory on Ground Cover: 5
Mammalian Herbivory on Shrubs and Small Trees: 5

Terrestrial Wildlife Habitat Mean Score: 4.5

Shrub Patch Density: 4
Mid-canopy Patch Density: 5
Upper Canopy Patch Density: 4
Fluvial Habitat Diversity: 5

The stream here is relatively small and has a medium to high gradient. It is located just below the diversion for Weber Reservoir, although at the time of the survey no water was being removed from the stream. It is surrounded by aspen and spruce-fir forests. There are some impacts from the construction of the diversion and ditch, but these are minor. There is a small jeep road just downstream from the lower end of the reach. There is also limited livestock grazing, but this appears to have minimal impact. Almost all features were rated as very good or excellent, and geomorphicly consistent. Fish, possibly native cut-throat trout, were seen in the reach. It is excellent habitat for native trout. There are beaver dams just upstream from the area surveyed. Riparian vegetation recruitment is good, and there are almost no non-native plants (no non-native shrubs or trees were observed). There is some incision of the channel, but this is geomorphicly consistent for streams with this high gradient.

This reach is in excellent condition overall and can serve as a reference reach for similar size and gradient streams in this elevation range in the Mancos Watershed.

3. West Mancos River, Above Mesa Verde Pipeline Diversion

Location of beginning of reach: 12 S 0746479 East, 4149234 North
Elevation: 2526 meters (8285 feet)
References Photos: Figure 9 A, B
Aerial Location Photo: Figure 10

Overall Score: 4.1

Individual Area Scores:

Water Quality Mean Score: 4.1

Algal Growth: 5
Channel Shading: 3

Hydrogeomorphology Mean Score: 3.2

Floodplain Connection: 1
Vertical Bank Stability: 5
Hydraulic Habitat Diversity: 4

Figure 9. Reference Photos for the Above Mesa Verde Diversion Reach, West Mancos River.

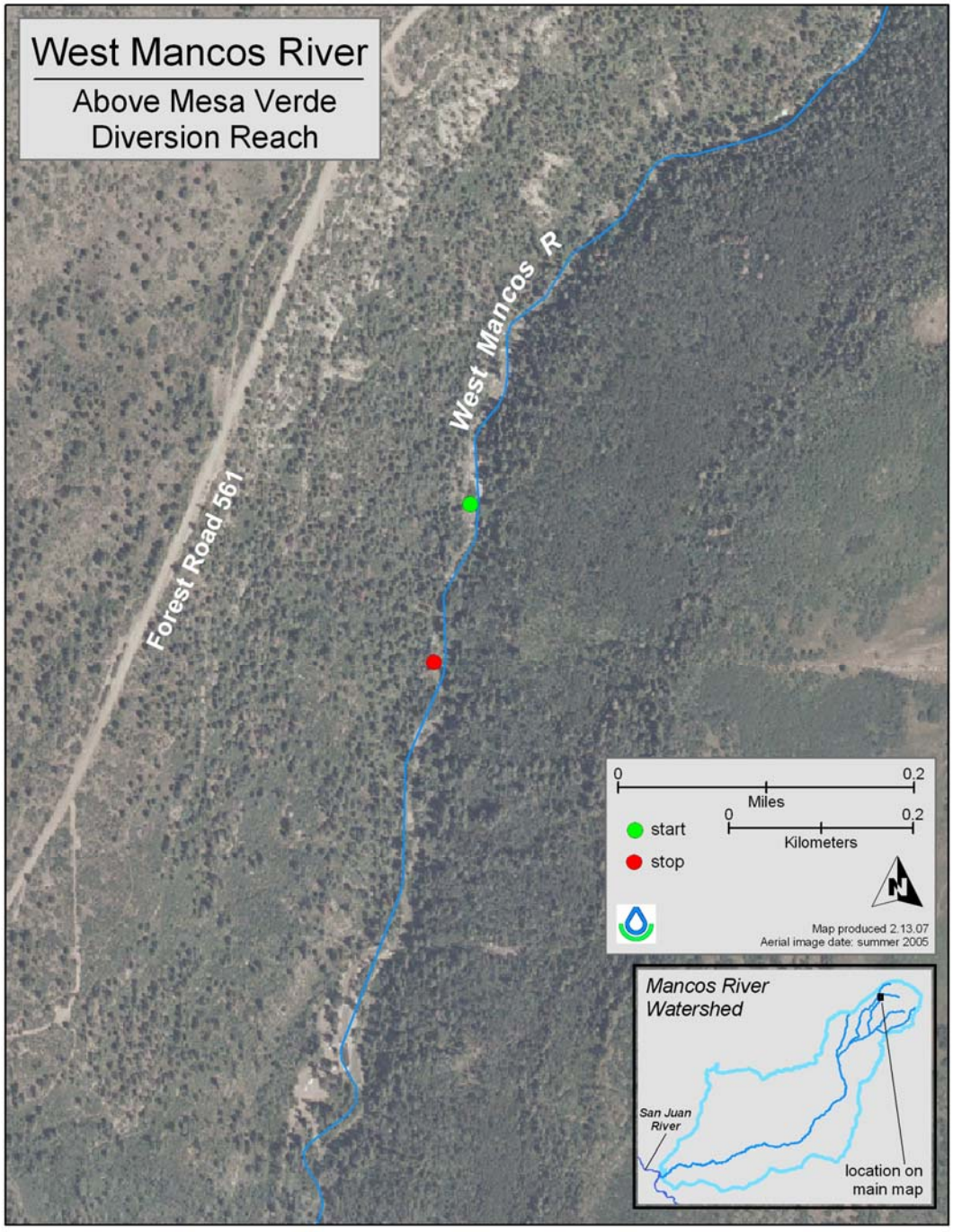

Figure 10. Aerial photo showing the location of the Above Mesa Verde Diversion Reach, West Mancos River (*photo compiled by Marianna Young*).

Riparian Area Soil Integrity: 5
Beaver Activity: 1

Fish/Aquatic Habitat Mean Score: 4.3

Pool Distribution: 4
Underbank Cover: 2
Cobble Embeddedness: 5
Aquatic Macroinvertebrate Diversity: 5
Large Woody Debris: 5
Overbank Cover: 5

Riparian Vegetation Mean Score: 4.5

Lower Riparian Zone Plant Cover: 3
Upper Riparian Zone Plant Cover: 4
Shrub Demography and Recruitment: 4
Tree Demography and Recruitment: 5
Non-native Herbaceous Plant Species: 5
Non-native Woody Plant Species: 5
Mammalian Herbivory on Ground Cover: 5
Mammalian Herbivory on Shrubs and Small Trees: 5

Terrestrial Wildlife Habitat Mean Score: 4.3

Shrub Patch Density: 4
Mid-canopy Patch Density: 4
Upper Canopy Patch Density: 5
Fluvial Habitat Diversity: 4

This is a medium gradient reach, located within the West Mancos canyon above the major water diversions (Mesa Verde Pipeline and Jackson Gulch Reservoir Inlet Canal). It is surrounded by aspen and pine Forests, and there are a number of old and very large cottonwoods in the floodplain. There are few human impacts on the reach, with the exception of a small road, which is located in the floodplain but is usually away from the stream channel.

Nonchemical Water Quality was good, although there was only moderate stream shading. This probably has only a minor impact on water temperatures, given the elevation of the stream and its gradient. Hydrogeomorphology was generally very good to excellent, except that the channel is isolated from the floodplain. The reason for this is not clear. There are no levees along the stream channel as is observed further downstream. This situation may be due to past episodes of heavy livestock grazing combined with exceptionally high flow events, but this remains speculation. There were no beavers on the reach. Their presence would have a significant positive impact on the ecosystem.

Fish/Aquatic Habitat was generally excellent. Notable was the large amount of woody debris in the stream channel; this debris was mostly absent below the diversions. Riparian Vegetation was mostly very good to excellent, with the exception of a lack of vegetation along the banks in the lower riparian zone. The effects of the cobble-lined banks was also reflected in the low floodplain connection score (hydrogeomorphology) and low underbank cover score (fish/aquatic habitat). Few non-native grasses and forbs, and no non-native shrubs and trees, were recorded. Mammalian grazing and browsing impacts were very limited. Terrestrial Wildlife Habitat was very good, including the presence of well developed patches in all structural layers (shrub, mid-canopy and upper canopy tree layers). The size and age of the cottonwoods in this reach were notable.

This reach showed little impact of human activities, and can serve as a reference reach for others streams of similar size and gradient in this elevation range in the Mancos Watershed.

4. West Mancos River, Jackson Gulch Reservoir Diversion Reach

Location of beginning of reach: 12 S 0744389 East, 4149234 North
Elevation: 2324 meters (7623 feet)
References Photos: Figure 11. A, B
Aerial Location Photo: Figure 12

Overall Score: 3.6

Individual Area Scores:

- **Water Quality Mean Score: 3.5**
  - Algal Growth: 5
  - Channel Shading: 2
- **Hydrogeomorphology Mean Score: 3.0**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 5
  - Hydraulic Habitat Diversity: 3
  - Riparian Area Soil Integrity: 5
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 3.2**
  - Pool Distribution: 2
  - Underbank Cover: 2
  - Cobble Embeddedness: 4
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 2
  - Overbank Cover: 4
- **Riparian Vegetation Mean Score: 4.6**
  - Lower Riparian Zone Plant Cover: 4
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 4
  - Tree Demography and Recruitment: 5
  - Non-native Herbaceous Plant Species: 5
  - Non-native Woody Plant Species: 5
  - Mammalian Herbivory on Ground Cover: 5
  - Mammalian Herbivory on Shrubs and Small Trees: 5
- **Terrestrial Wildlife Habitat Mean Score: 3.5**
  - Shrub Patch Density: 4
  - Mid-canopy Patch Density: 4
  - Upper Canopy Patch Density: 5
  - Fluvial Habitat Diversity: 1

This reach is located just below the diversion structures for the inlet canal to Jackson Gulch Reservoir, and is downstream from Reach 3. It is within the West Mancos canyon, and the floodplain is approximately 50 meters wide at this point. Cottonwoods and various pine species are the primary tree species within the floodplain. The reach has been impacted primarily by the construction activities associated with the diversion structure and the Mesa Verde pipeline. This pipeline runs downstream along the east bank of the river channel, until it crosses the stream at end of the assessment reach. After that point it is located in the floodplain away from the channel.

Algal growth in the reach received an excellent score, but channel shading was only fair due to channel morphology (see below).

Figure 11. Reference photos for the Below Jackson Reservoir Diversion Reach, West Mancos River. The Mesa Verde diversion pipeline crosses the stream channel in the lower

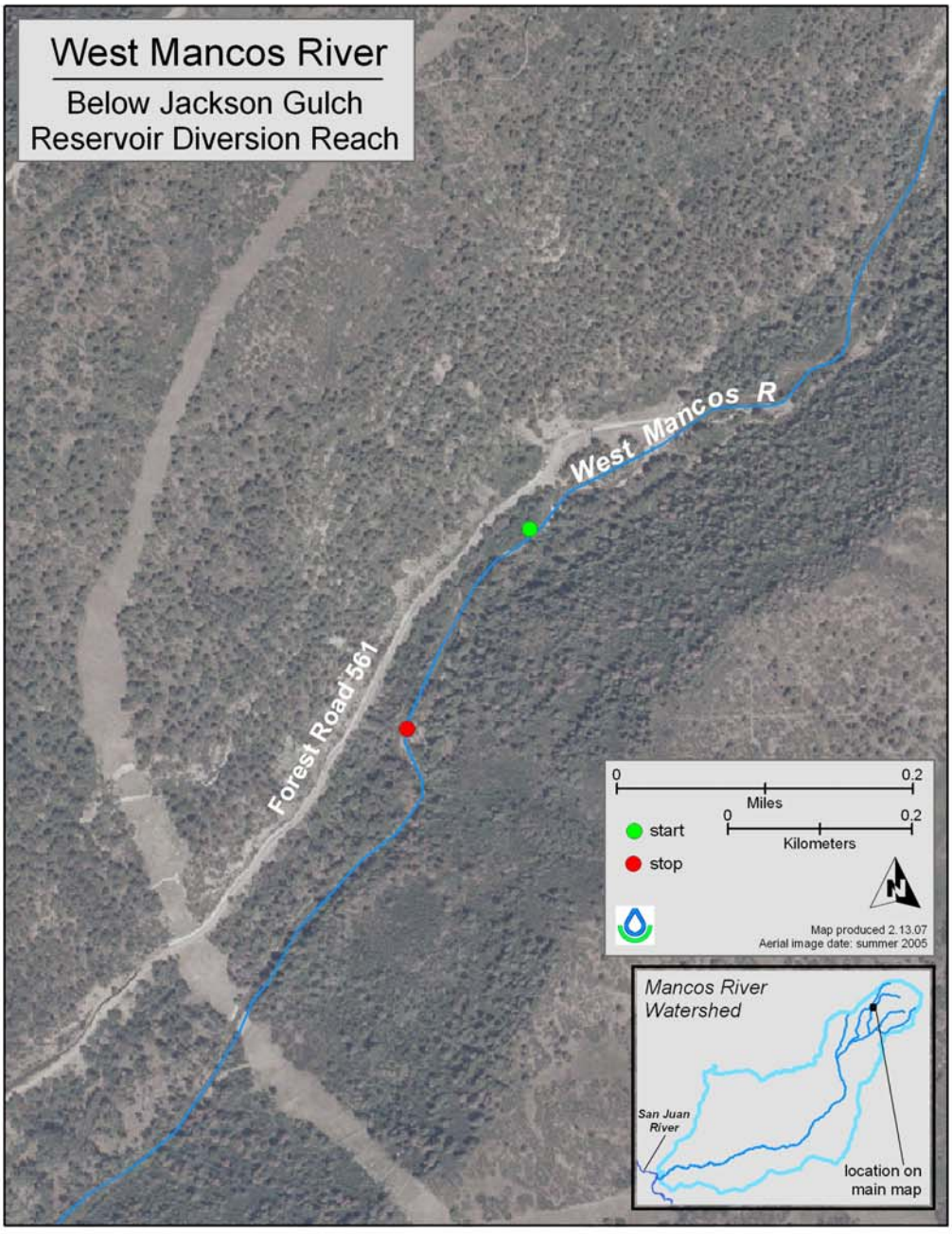

Figure 12.Aerial photo showing the location of the Below Jackson Gulch Reservoir Diversion Reach, West Mancos River (*photo compiled by Marianna Young*).

In the Hydrogeomorphology section, this reach received a poor rating for floodplain connection. This was due to the presence of a levee on the east side of the channel that resulted from the construction of the Mesa Verde Pipeline, and isolated the stream from its floodplain in this section. The stream channel itself is wide and shallow, also probably the result of pipeline construction. As a result, hydraulic habitat diversity was only good. However, where the pipeline was located away from the channel, below the assessment reach, hydraulic habitat diversity became excellent, and as would be expected for this geomorphic setting. Vertical bank stability and riparian soil integrity was excellent through the entire reach, reflecting the absence of livestock grazing, roads, or other impacts. There are no beavers in this reach, although the habitat would be suitable for them.

The suitability of the reach as Fish/Aquatic Habitat was variable. Pool distribution and underbank cover were only fair, reflecting channel morphology, levees and the results of past construction activities. There was little woody debris. However, cobble embeddedness, overbank cover, and macroinvertebrate diversity was very good or excellent, indicating that the area has the potential to be excellent fish habitat.

Riparian Vegetation was very good or excellent in this reach, including the absence of non-native grasses and forbs, or shrubs and trees. Grazing and browsing impacts are very light. The reach also scored very good or excellent as Terrestrial Wildlife Habitat, with the exception of fluvial habitat diversity. This factor received a score of poor, which was the result of the channelization of the reach created by the construction of the pipeline.

5. West Mancos River, Colyer Ranch Reach

Location of beginning of reach: 12 S 0742993 East, 4141784 North
Elevation: 2310 meters (7577 feet)
References Photos: Figure 13. A, B
Aerial Location Photo: Figure 14

Overall Score: 3.4

Individual Area Scores:

- **Water Quality Mean Score: 3.0**
  - Algal Growth: 2
  - Channel Shading: 4
- **Hydrogeomorphology Mean Score: 3.0**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 5
  - Hydraulic Habitat Diversity: 5
  - Riparian Area Soil Integrity: 3
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 4.3**
  - Pool Distribution: 4
  - Underbank Cover: 3
  - Cobble Embeddedness: 4
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 5
  - Overbank Cover: 5
- **Riparian Vegetation Mean Score: 3.8**
  - Lower Riparian Zone Plant Cover: 3
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 5

Figure 13. Reference Photos for the Colyer Ranch Reach, West Mancos River.

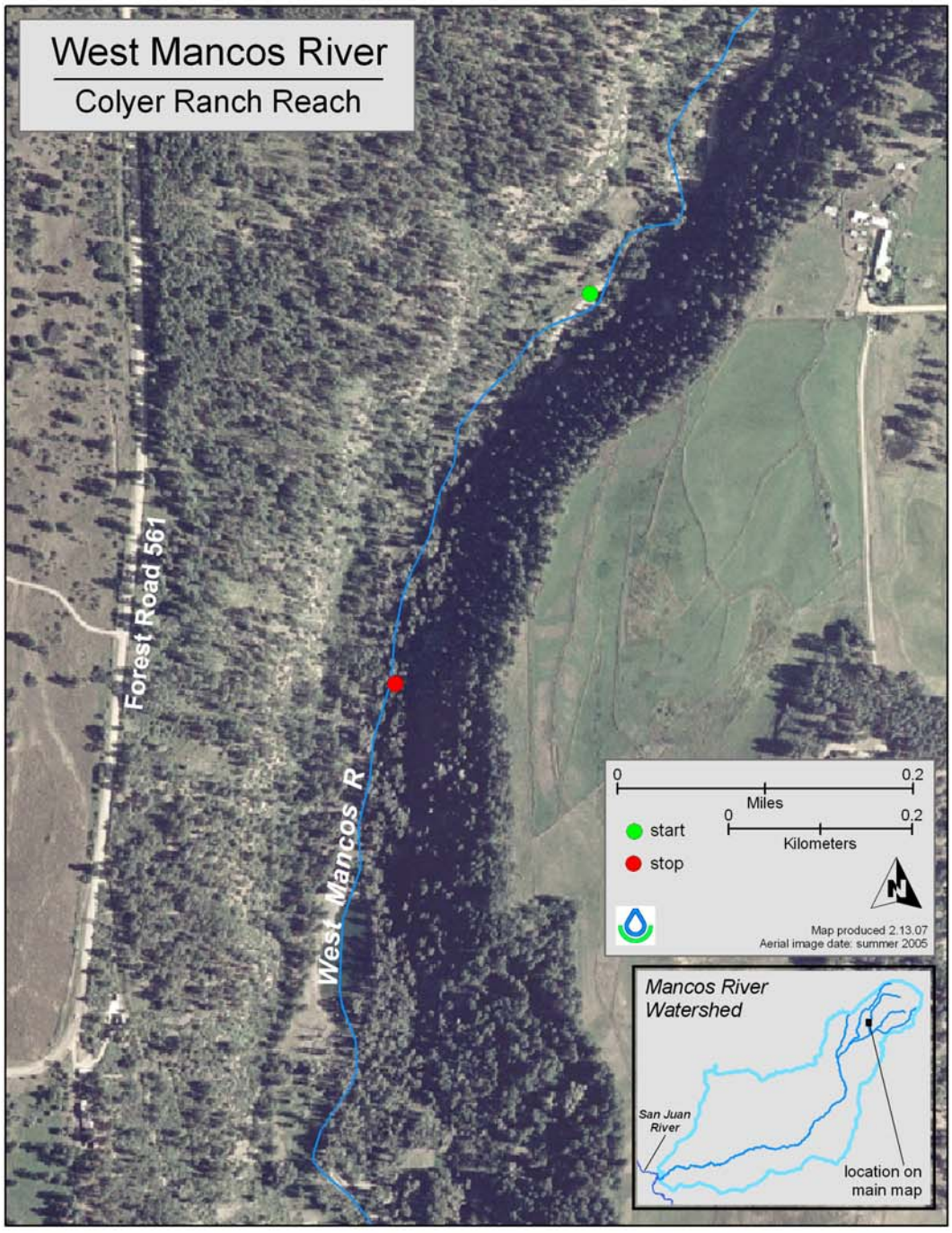

Figure 14. Aerial photo showing the location of the Colyer Ranch Reach, West Mancos River (*photo compiled by Marianna Young*).

Tree Demography and Recruitment: 4
Non-native Herbaceous Plant Species: 5
Non-native Woody Plant Species: 5
Mammalian Herbivory on Ground Cover: 3
Mammalian Herbivory on Shrubs and Small Trees: 1

Terrestrial Wildlife Habitat Mean Score: 3.3

Shrub Patch Density: 4
Mid-canopy Patch Density: 2
Upper Canopy Patch Density: 3
Fluvial Habitat Diversity: 3

This reach is located downstream of the Jackson Gulch Reservoir diversion. It is still in the West Mancos Canyon, but where the canyon and floodplain are beginning to widen just before the stream enters Mancos Valley. It has a lower gradient than the reaches further upstream. Vegetation is primarily cottonwood, pines and junipers in the floodplain, with aspen, ponderosa pine and scrub oak on the canyon sides. There is a large excavated pond in the floodplain on the west side of the drainage. The channel runs on the east side of the canyon, and the bank on the west side of the river has levees throughout most of the reach. These may have been constructed to protect the pond from major floods.

Algal growth was high in this section relative to the reaches further upstream, leading to a rating of fair. Cow manure was observed in the stream itself, suggesting there is nutrient loading in this reach from livestock use. Channel shading, in contrast, was very good.

Hydrogeomorphology scores were variable. The levees completely isolated the floodplain from all but the most extreme high water events. There are no beavers in this reach, although the habitat is suitable. In contrast, both vertical bank stability and hydraulic habitat diversity were excellent (compare the latter score with the value for Reach 4, upstream from this reach). Riparian soil stability was only good, reflecting the current livestock and native ungulate (deer and elk) use of this area.

Fish/Aquatic habitat was very good. Only underbank was rated good or lower; this was the result of the levees and stream channelization. Large woody debris was excellent in this reach.

Riparian Vegetation was generally very good. The only issues were the lack of vegetative cover in the lower riparian zone, which was the result of the levees, and the levels of grazing (only good) and browsing by livestock and deer and elk (poor). Sixty-three per cent of the shrubs and small trees had been browsed in the sample transect. This level of browsing could lead to a failure in the recruitment of new shrubs and trees in the riparian zone along this reach in the future.

Terrestrial Wildlife Habitat received an overall score of good, although there was a lack of continuous canopy in the middle and upper tree levels as was observed in the reaches further upstream. This may be the result of heavy livestock and native ungulate use of the river bottom in the past.

B. Mancos Valley Sites

6. West Mancos River, Weber Diversion Reach

Location of beginning of reach: 12 S 0743245 East, 4141784 North
Elevation: 2226 meters (7301 feet)
References Photos: Figure 15. A, B.
Aerial Location Photo: Figure 16

Figure 15. Reference Photos for the Above Weber Diversion Reach, Mancos River.

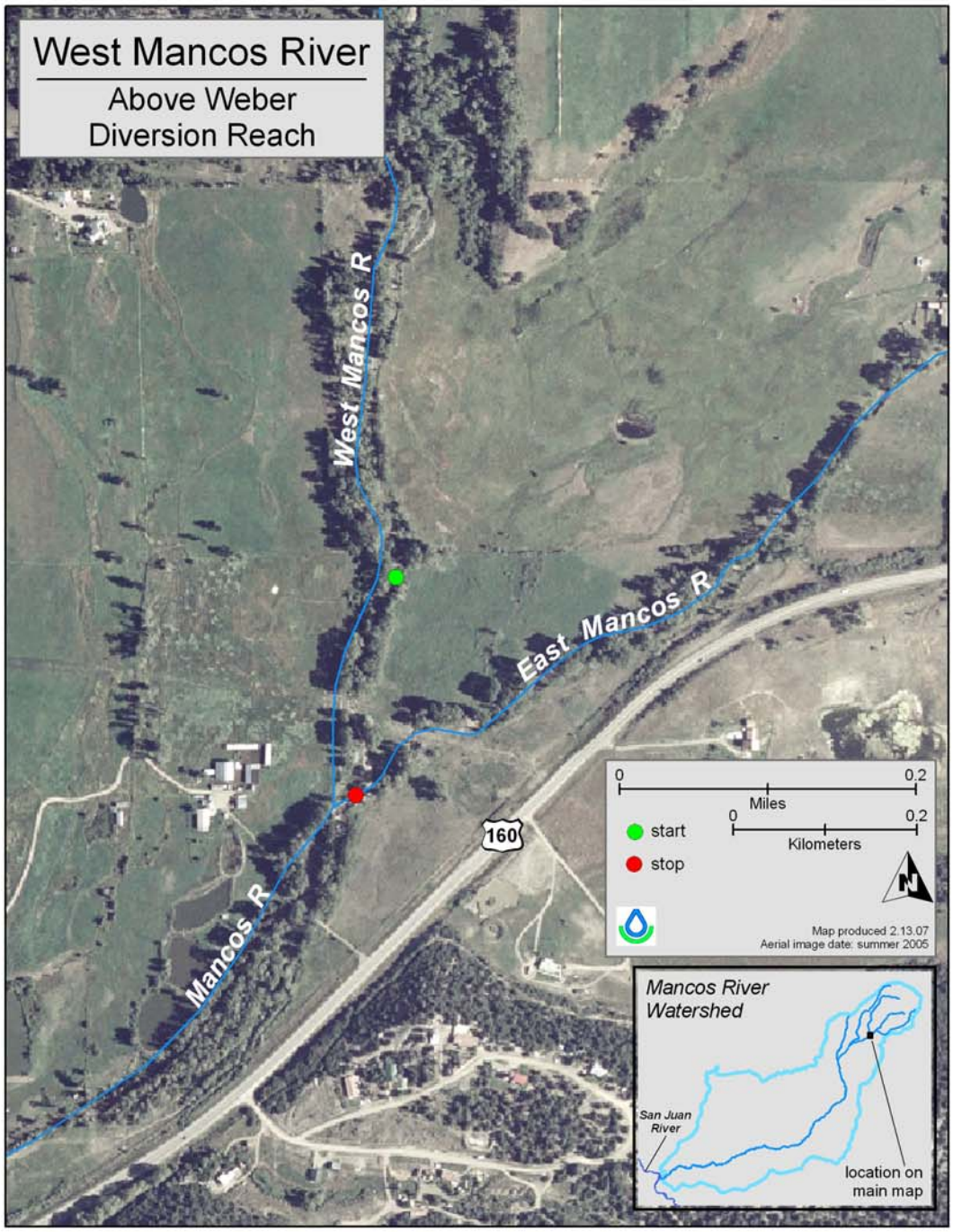

Figure 16. Aerial photo showing the location of the Above Weber Diversion Reach, West Mancos River (*photo compiled by Marianna Young*).

Overall Score: 3.2

Individual Area Scores:

- **Water Quality Mean Score: 3.0**
  - Algal Growth: 2
  - Channel Shading: 4
- **Hydrogeomorphology Mean Score: 2.2**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 5
  - Hydraulic Habitat Diversity: 3
  - Riparian Area Soil Integrity: 1
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 4.0**
  - Pool Distribution: 1
  - Underbank Cover: 3
  - Cobble Embeddedness: 5
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 5
  - Overbank Cover: 5
- **Riparian Vegetation Mean Score: 3.8**
  - Lower Riparian Zone Plant Cover: 3
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 5
  - Tree Demography and Recruitment: 5
  - Non-native Herbaceous Plant Species: 3
  - Non-native Woody Plant Species: 5
  - Mammalian Herbivory on Ground Cover: 2
  - Mammalian Herbivory on Shrubs and Small Trees: 3
- **Terrestrial Wildlife Habitat Mean Score: 3.0**
  - Shrub Patch Density: 2
  - Mid-canopy Patch Density: 3
  - Upper Canopy Patch Density: 4
  - Fluvial Habitat Diversity: 3

This reach is located just above the diversion for the Weber ditch, and just above where the East Mancos joins the West Mancos to form the Mancos River. The reach is in the eastern end of the Mancos Valley itself, and has a gradient characteristic of the rest of the Valley. The reach is surrounded by irrigated pastures. The strip of riparian trees is narrow, and extends only one to two trees away from the stream.

Algal growth was fair, presumably resulting from runoff of fertilizer and/or other nutrients from the surrounding fields and pastures. Channel shading was very good.

The channel in this reach, as in the case with the rest of the reaches in the Mancos Valley, is wide and shallow, and has a cobble lined bottom. The banks in this reach have not been leveed, but several bends have been armored to prevent channel migration. As a result, there are no meanders in this reach. Vertical bank stability was excellent, indicating little current erosion and sediment input to the stream from the banks. The channel is isolated from the floodplain, and there is no beaver activity. Riparian soil integrity was poor, due to livestock use in the surrounding pastures.

Fish/Aquatic habitat was generally excellent, with the exception that there were no pools or riffles (resulting from the wide and shallow channel, with cobble lining) and there was only limited underbank cover. Cobble embeddedness, woody debris, overbank cover, and macroinvertebrate diversity were excellent.

Riparian Vegetation was generally good to excellent. There was limited non-native grass and forb cover, and no non-native shrubs or trees. Grazing on grasses and forbs was scored as only fair (45% of plants grazed), and browsing on shrubs and trees as good. Both shrub and tree demography and recruitment were excellent, indicating the woody riparian vegetation can replace itself along this reach over time.

Terrestrial Wildlife Habitat was good or very good, with the exception of shrub patch density, which was rated as only fair due to an overall lack of shrubs along the banks.

7. Mancos River, Root and Ratliff Ditch Diversion Reach

Location of beginning of reach: 12 S 0742596 East, 4137425 North
Elevation: 2199 meters (7213 feet)
References Photos: Figure 17. A, B.
Aerial Location Photo: Figure 18.

Overall Score: 3.6

Individual Area Scores:

- **Water Quality Mean Score: 2.5**
  - Algal Growth: 1
  - Channel Shading: 4
- **Hydrogeomorphology Mean Score: 3.0**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 5
  - Hydraulic Habitat Diversity: 3
  - Riparian Area Soil Integrity: 5
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 4.0**
  - Pool Distribution: 3
  - Underbank Cover: 3
  - Cobble Embeddedness: 5
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 3
  - Overbank Cover: 5
- **Riparian Vegetation Mean Score: 4.5**
  - Lower Riparian Zone Plant Cover: 3
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 5
  - Tree Demography and Recruitment: 5
  - Non-native Herbaceous Plant Species: 5
  - Non-native Woody Plant Species: 5
  - Mammalian Herbivory on Ground Cover: 5
  - Mammalian Herbivory on Shrubs and Small Trees: 4

Figure 17. Reference Photos for the Below Ratliff Diversion Reach, Mancos River.

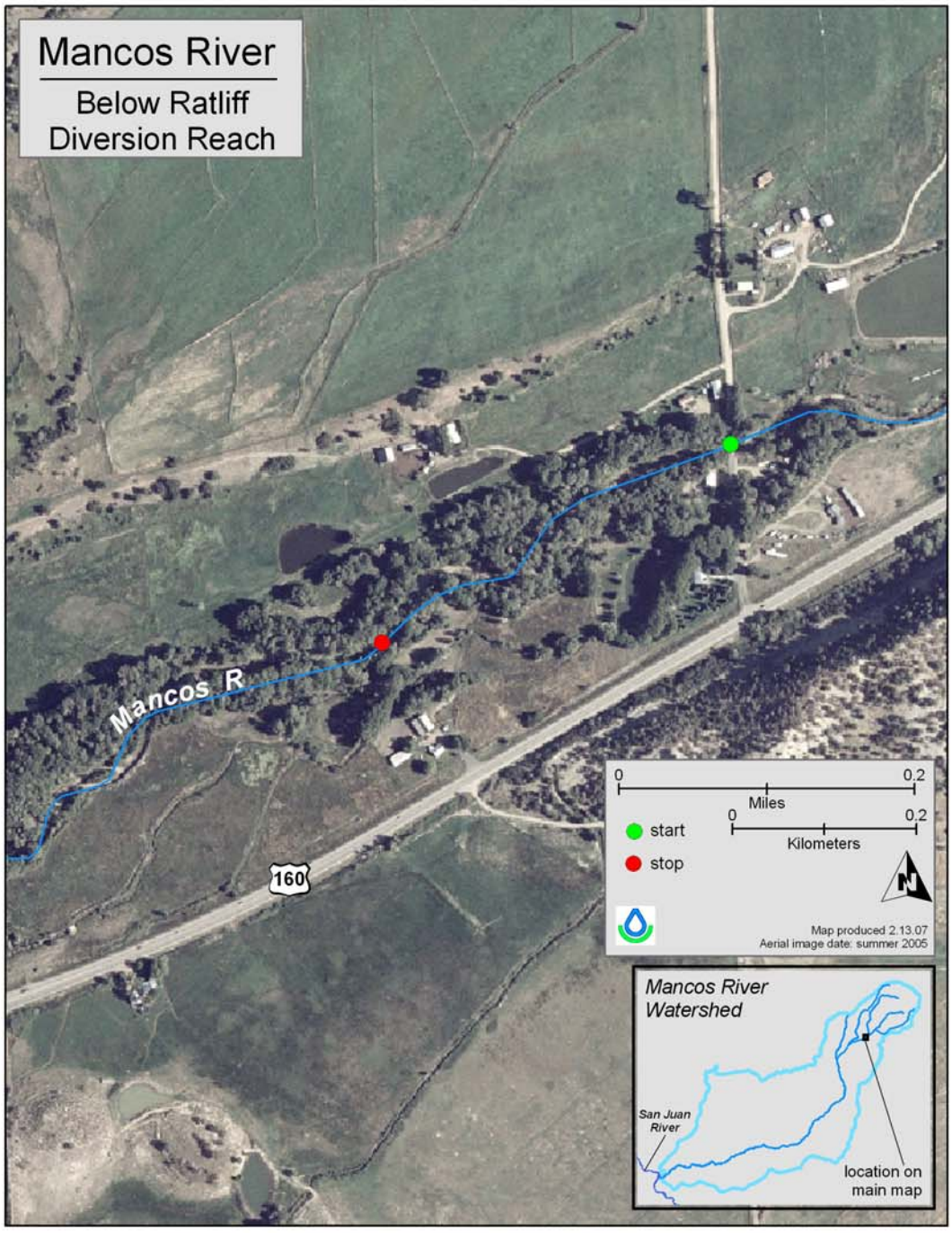

Figure 18. Aerial photo showing the location of the Below Ratliff Diversion Reach, Mancos River (*photo compiled by Marianna Young*).

Terrestrial Wildlife Habitat Mean Score: 3.8

Shrub Patch Density: 3
Mid-canopy Patch Density: 4
Upper Canopy Patch Density: 5
Fluvial Habitat Diversity: 3

This reach is located downstream from the confluence of the East and West Mancos Rivers, and below the diversion structure for the Root and Ratliff Ditch. At the time of the survey, a substantial proportion of the stream flow was being diverted into the ditch. The reach begins just downstream of the bridge that crosses the Mancos River. Two houses are located within the floodplain on either side of the upstream end of the reach. Otherwise, there has been no recent development or pasture use in the floodplain along this section of the Mancos. The floodplain is well vegetated. There are numerous geomorphologic indications of past channel migrations and bar formations within the historic floodplain, indicating that the area downstream from the bridge has been relatively undisturbed for a considerable period. According to a local landowner, a natural gravel bar was removed or excavated from the center of the channel downstream from the bridge by an unidentified government agency "a number of years ago". The landowner also stated that several "fish structures" had been installed at this site, but that they all had subsequently been washed away during high flow events. Both activities may have affected the current degree of cobble armoring along the channel bottom in this reach.

For non-chemical Water Quality, algal growth was high, leading to a poor score. However, channel shading was very good, as a result of the well-developed riparian vegetation along the sides of channel.

Hydrogeomorphology was variable, as at other sites in the Mancos Valley. The stream is channelized and currently isolated from the historic floodplain. Although the banks are not leveed, vertical bank stability was excellent, as was riparian soil integrity (<1% disturbed). Hydraulic habitat diversity was only good, reflecting the cobble armoring of the stream channel bottom. There were no beavers present, although the habitat would be suitable in this reach.

Fish/Aquatic habitat was good to excellent. There was limited pool and riffle systems, underbank cover or large woody debris, but cobble embeddedness, macroinvertebrate diversity and overbank cover scores were all excellent.

Riparian vegetation was mostly excellent with the exception of lower riparian zone vegetation cover, which reflected the steepness of the banks and stream channelization. Non-native grasses and forb cover was less than 5%, and there were no non-native shrubs or trees. There was very little grazing, and only limited browsing, presumably from native ungulates, as there was no sign of recent domestic livestock use of the area.

Terrestrial wildlife habitat was good to excellent– the major deviation from expected conditions was a relative lack of shrub patches and shrub diversity in the riparian understory, and limited fluvial habitat diversity resulting from the current channelization of the stream.

Overall, the riparian or terrestrial part of the ecosystem in this reach was in very good condition, and with a few exceptions, such as shrub cover, it could serve as a reference condition for other reaches further downstream in the Mancos Valley.

8. Mancos River, Redwood/Black Reach

Location of beginning of reach: 12 S 0740942 East, 4136453 North
Elevation: 2171 meters (7121 feet)

Figure 19. Reference Photos for the Redwood/Black Reach, Mancos River.

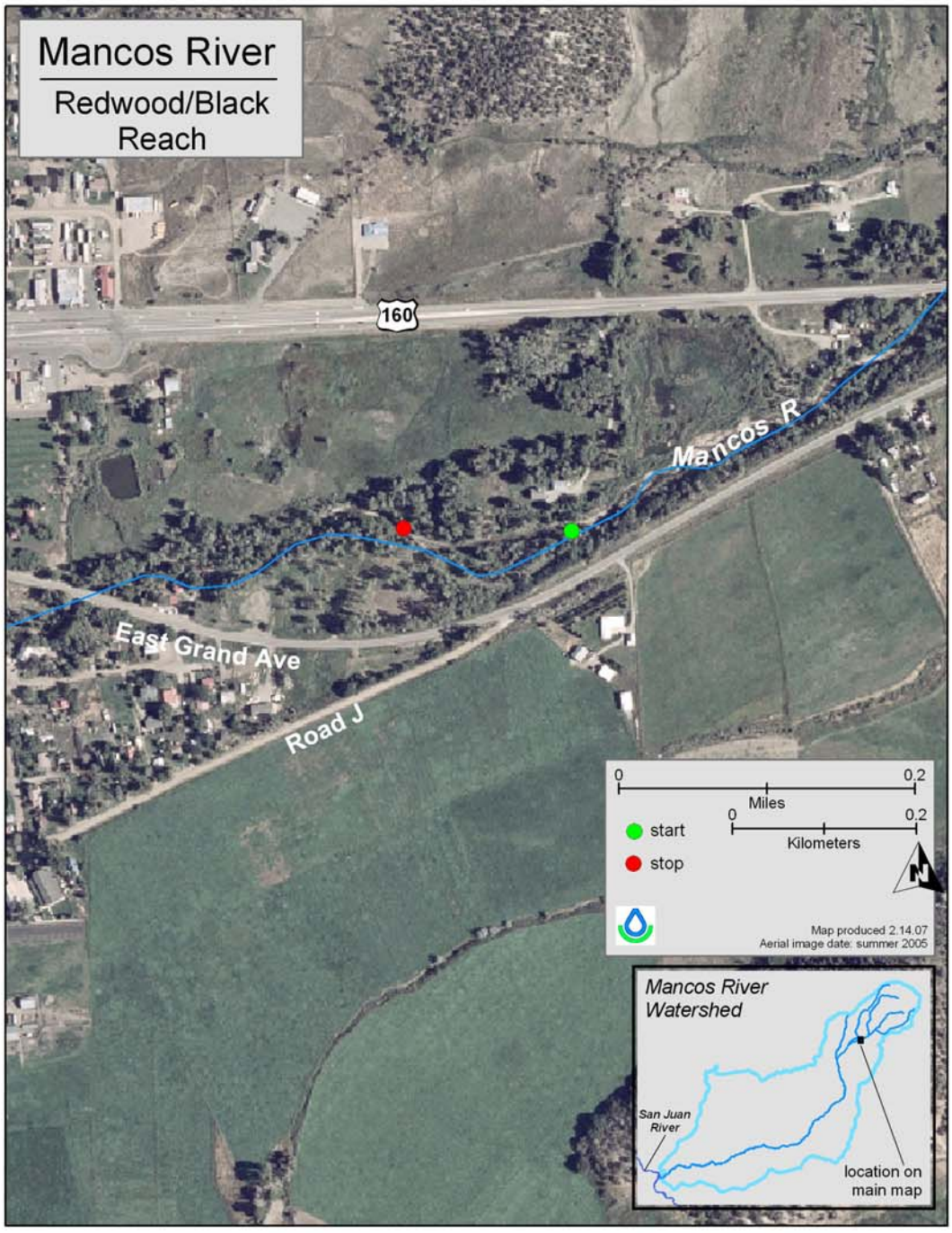

Figure 20. Aerial photo showing the location of the Redwood/Black Reach, Mancos River (*photo compiled by Marianna Young*).

References Photos: Figure 19. A, B.
Aerial Location Photo: Figure 20.

Overall Score: 3.1

Individual Area Scores:

- **Water Quality Mean Score: 2.5**
  - Algal Growth: 3
  - Channel Shading: 2
- **Hydrogeomorphology Mean Score: 2.8**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 5
  - Hydraulic Habitat Diversity: 2
  - Riparian Area Soil Integrity: 5
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 3.3**
  - Pool Distribution: 2
  - Underbank Cover: 2
  - Cobble Embeddedness: 4
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 2
  - Overbank Cover: 5
- **Riparian Vegetation Mean Score: 4.0**
  - Lower Riparian Zone Plant Cover: 3
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 4
  - Tree Demography and Recruitment: 5
  - Non-native Herbaceous Plant Species: 3
  - Non-native Woody Plant Species: 5
  - Mammalian Herbivory on Ground Cover: 5
  - Mammalian Herbivory on Shrubs and Small Trees: 3
- **Terrestrial Wildlife Habitat Mean Score: 3.0**
  - Shrub Patch Density: 5
  - Mid-canopy Patch Density: 4
  - Upper Canopy Patch Density: 2
  - Fluvial Habitat Diversity: 1

This reach is located upstream from the town of Mancos, and the floodplain has been affected by urban activities. There is a house at the upstream end of the reach. The stream has a gradient and channel configuration typical of other reaches in the Mancos Valley. This is the first reach as one moves downstream where most of the banks are lined with small levees. As a result, the stream here and further downstream is highly channelized. The floodplain is not currently used for agricultural purposes, although it may have been in the past.

Algal growth in this reach was good (15%), but stream shading was only fair, due to a lack of mature vegetation along the stream banks.

Like other reaches in the Mancos Valley, Hydrogeomorphology scores were variable and primarily reflect stream channelization and the presence of the small levees. Floodplain connection and hydraulic habitat diversity were poor and fair respectively, while vertical bank stability was excellent. Riparian soil integrity was also excellent, reflecting the lack of current agricultural or recreational use of the floodplain.

Beavers have created a dam and associated wetlands in a side channel or ditch outlet just upstream from this reach, but there was no beaver activity within the reach itself.

Fish/Aquatic habitat was also variable as a result of the stream channelization and the presence of the small levees. Pool/riffle distribution and underbank cover was only fair, and there was little large woody debris. Macroinvertebrate diversity and overbank cover were excellent. Cobble embeddedness was very good.

Riparian vegetation was generally very good to excellent. Non-native grass and forb cover received only a good score, reflecting an increasing amount of exotic grasses and forbs as one moves downstream through the Mancos Valley. However, there were very few non-native shrubs or trees. There was almost no grazing impact, but browsing levels were only good (18% of shrubs and small trees impacted). Since there were no signs of domestic livestock use of this reach, browsing must have been exclusively the result of deer activities.

Terrestrial Wildlife Habitat was also variable. There was very good or excellent shrub and mid-canopy tree patch density, but there were few large cottonwood trees in this reach, in contrast to the previous reach. Fluvial habitat diversity was poor, reflecting the high degree of stream channelization.

9. Mancos River, Excelsior Plant Reach

Location of beginning of reach: 12 S 0738984 East, 4135964 North
Elevation: 2106 meters (6927 feet)
References Photos: Figures 23. A, B.
Aerial Location Photo: Figure 24.

Overall Score: 3.3

Individual Area Scores:

- **Water Quality Mean Score: 2.0**
  - Algal Growth: 2
  - Channel Shading: 2
- **Hydrogeomorphology Mean Score: 2.8**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 4
  - Hydraulic Habitat Diversity: 4
  - Riparian Area Soil Integrity: 4
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 4.2**
  - Pool Distribution: 4
  - Underbank Cover: 3
  - Cobble Embeddedness: 3
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 5
  - Overbank Cover: 5
- **Riparian Vegetation Mean Score: 3.6**
  - Lower Riparian Zone Plant Cover: 3
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 5
  - Tree Demography and Recruitment: 5
  - Non-native Herbaceous Plant Species: 2

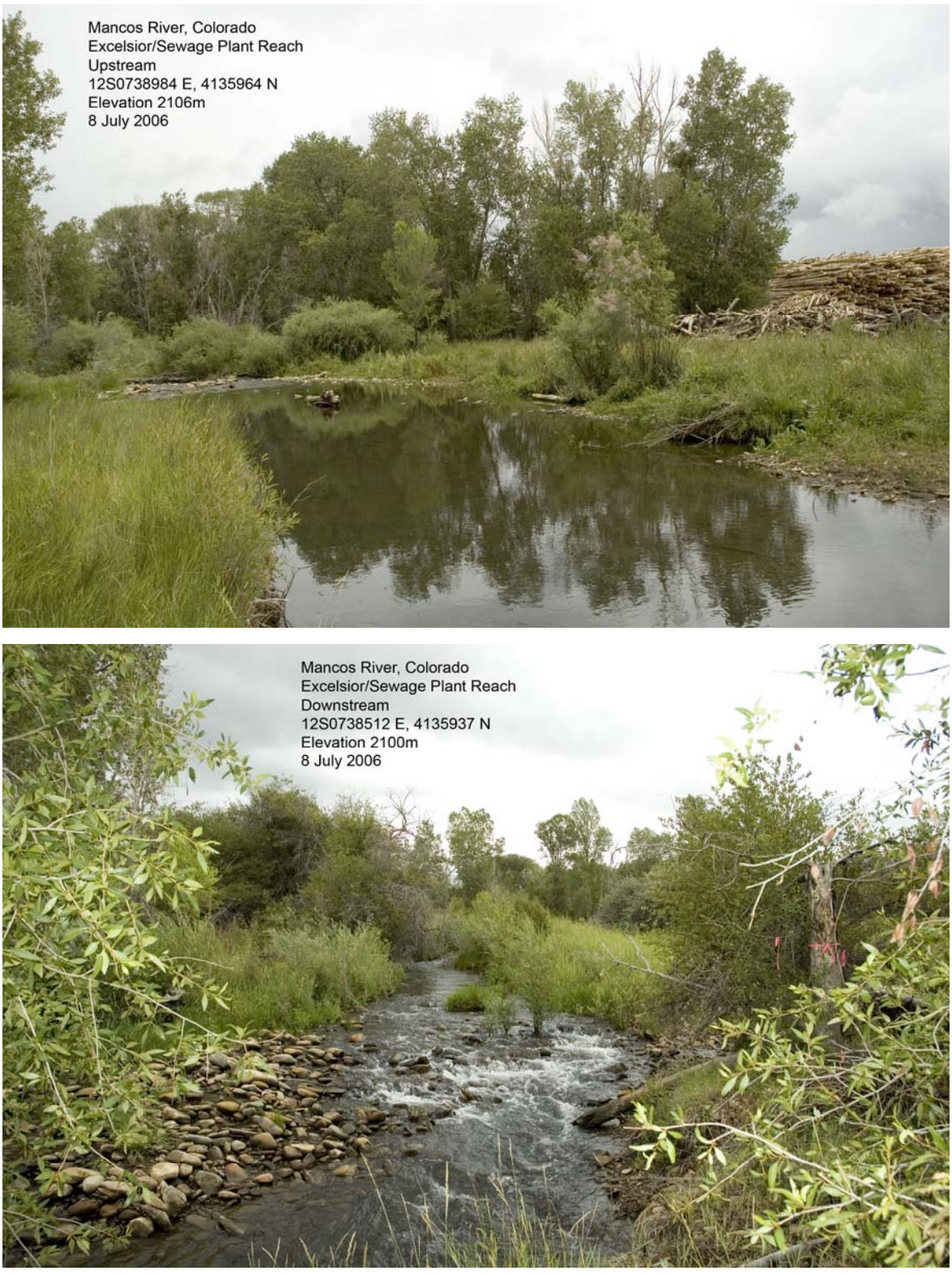

Figure 21. Reference Photos for the Excelsior/Sewage Plant Reach, Mancos River.

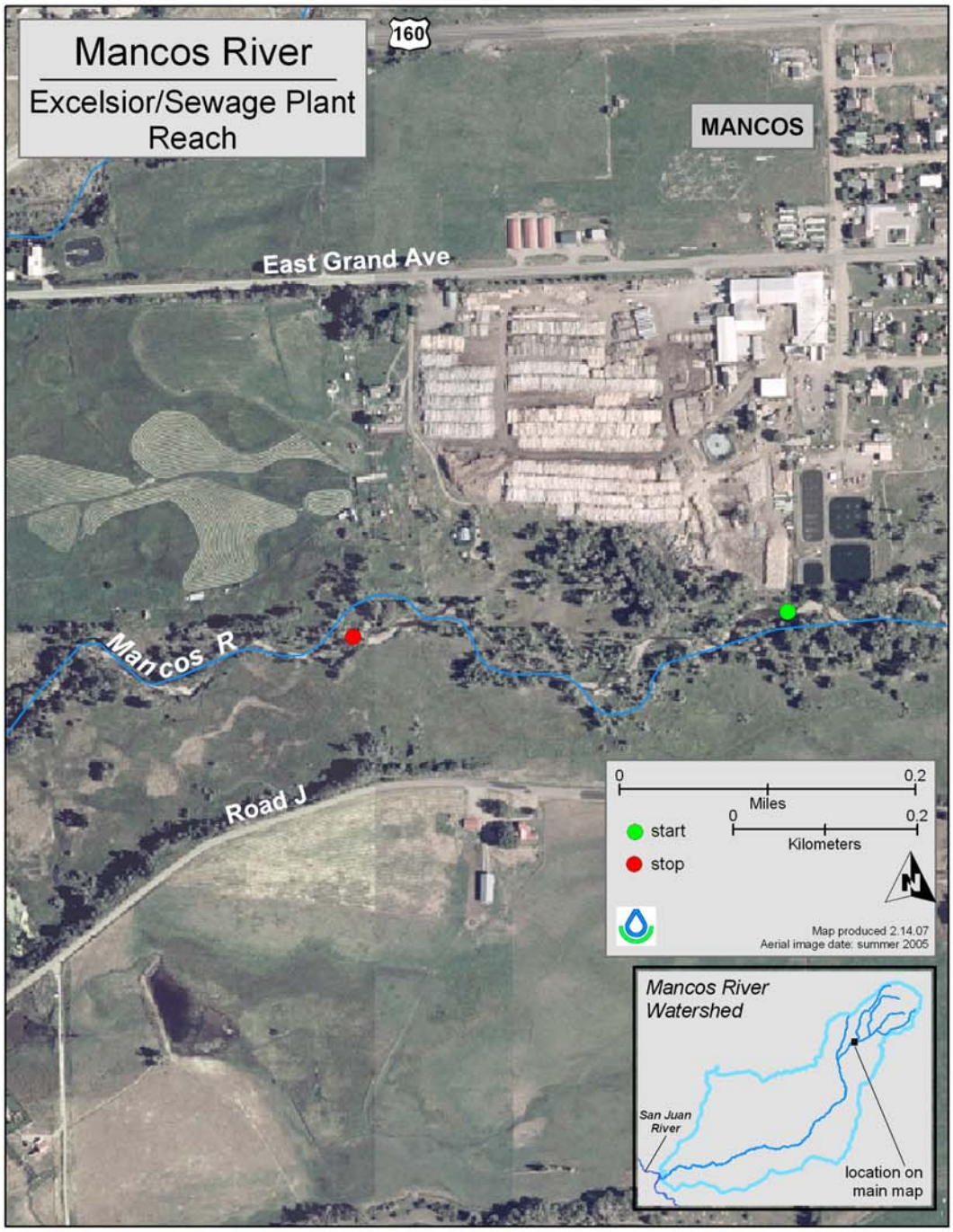

Figure 22. Aerial photo showing the location of the Excelsior/Sewage Plant Reach, Mancos River (*photo compiled by Marianna Young*).

Non-native Woody Plant Species: 5
Mammalian Herbivory on Ground Cover: 3
Mammalian Herbivory on Shrubs and Small Trees: 2

Terrestrial Wildlife Habitat Mean Score: 3.8

Shrub Patch Density: 2
Mid-canopy Patch Density: 4
Upper Canopy Patch Density: 4
Fluvial Habitat Diversity: 5

This reach is located within the Mancos townsite, and is adjacent to the Excelsior Plant and just downstream from the Mancos Sewage Treatment Plant. Both facilities are located on the north (town) side of the channel, and at least partially within the historic floodplain. The floodplain on the south side of the reach was presumably once used for pasture lands, but there appears to be only limited use of this area by livestock at the present time. The north bank has levees to protect the industrial facilities, but levees are not present on the south bank. Thus, the stream here is only partially channelized. There is considerable side flow reaching the creek as a result of irrigation on the south side of the river. The reach is low gradient like the other reaches in the Mancos Valley.

Algal growth was only fair, which presumably reflects nutrient input from the sewage plants, as well as possibly from the meadows and pastures to the south. However, as noted below, aquatic macroinvertebrate diversity was excellent, suggesting that this nutrient input is not having a significant ecological effect at the present time. Channel shading was also only fair.

Floodplain connectivity was poor, as a result of the levees on the north side of the reach. However, a new floodplain is slowly developing as a result of the absence of levees on the south side, and the channel is beginning to create several new meanders. Other Hydrogeomorphic scores were very good, with the exception of beaver activity. This reach would be suitable habitat for beavers.

Fish and aquatic habitat was variable. Pool and riffle distribution was very good, unlike the reaches further upstream on the Mancos. This may be a result of the presence of high amounts of large woody debris (score of excellent), plus the lack of levees on the south side of the reach. There was good underbank cover for fish on the south side of the reach, but not on the north side, where the levees were located. Cobble embeddedness was only good– at one sample site there was some sediment input from the excelsior plant, but the impact was limited and did not persist further downstream.

Riparian Vegetation was again variable. There was good or very good riparian zone plant cover, and both shrub and tree demography was excellent, with all age classes of both groups present along the reach. Non-native grass and forb cover was only fair (30%), but non-native shrubs and trees were almost entirely absent. There were very high levels of browsing on small shrubs and trees (>50% of the plants impacted in the upper riparian zone); this amount of browsing may limit recruitment of shrubs and trees along this reach in the future.

Terrestrial Wildlife Habitat was very good or excellent, with the exception of only fair shrub patch densities. This is probably the result of the high levels of browsing noted above. Notable was the excellent rating for fluvial habitat diversity, which reflects the absence of the levees on the south side of the reach, and the resulting active channel movements. The return of irrigation water on the south side of the channel has also created a number of wet meadows and wetlands that provide habitat diversity for terrestrial wildlife.

10. Mancos River, Road J Bridge Reach

Location of beginning of reach: 12 S 0737005 East, 4134791 North
Elevation: 2068 meters (6740 feet)
References Photos: Figure 23. A, B.
Aerial Location Photo: Figure 24.

Overall Score: 2.9

Individual Area Scores:

- **Water Quality Mean Score: 2.5**
  - Algal Growth: 3
  - Channel Shading: 2
- **Hydrogeomorphology Mean Score: 2.8**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 5
  - Hydraulic Habitat Diversity: 3
  - Riparian Area Soil Integrity: 4
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 2.8**
  - Pool Distribution: 1
  - Underbank Cover: 2
  - Cobble Embeddedness: 3
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 4
  - Overbank Cover: 2
- **Riparian Vegetation Mean Score: 3.4**
  - Lower Riparian Zone Plant Cover: 3
  - Upper Riparian Zone Plant Cover: 4
  - Shrub Demography and Recruitment: 5
  - Tree Demography and Recruitment: 5
  - Non-native Herbaceous Plant Species: 2
  - Non-native Woody Plant Species: 4
  - Mammalian Herbivory on Ground Cover: 2
  - Mammalian Herbivory on Shrubs and Small Trees: 2
- **Terrestrial Wildlife Habitat Mean Score: 2.8**
  - Shrub Patch Density: 3
  - Mid-canopy Patch Density: 3
  - Upper Canopy Patch Density: 3
  - Fluvial Habitat Diversity: 2

This reach is located just upstream from the Road J Bridge, and begins just below the confluence of Chicken Creek and the Mancos River. Chicken Creek at this point is highly modified and resembles an irrigation ditch. The channel of the Mancos River in this reach is wide and shallow, like many other reaches in the valley. Old cobble levees, one to two meters high, line the channel banks for most of the length of the reach. There are pastures in the historic floodplain on the south-eastern side of the reach, and mixed pastures and houses on the north-western side. The return of irrigation water has created side flows in the old floodplain, and the formation of wet meadows in some areas.

Algal growth was rated as good, but channel shading was only fair as a result of the lack of vegetation

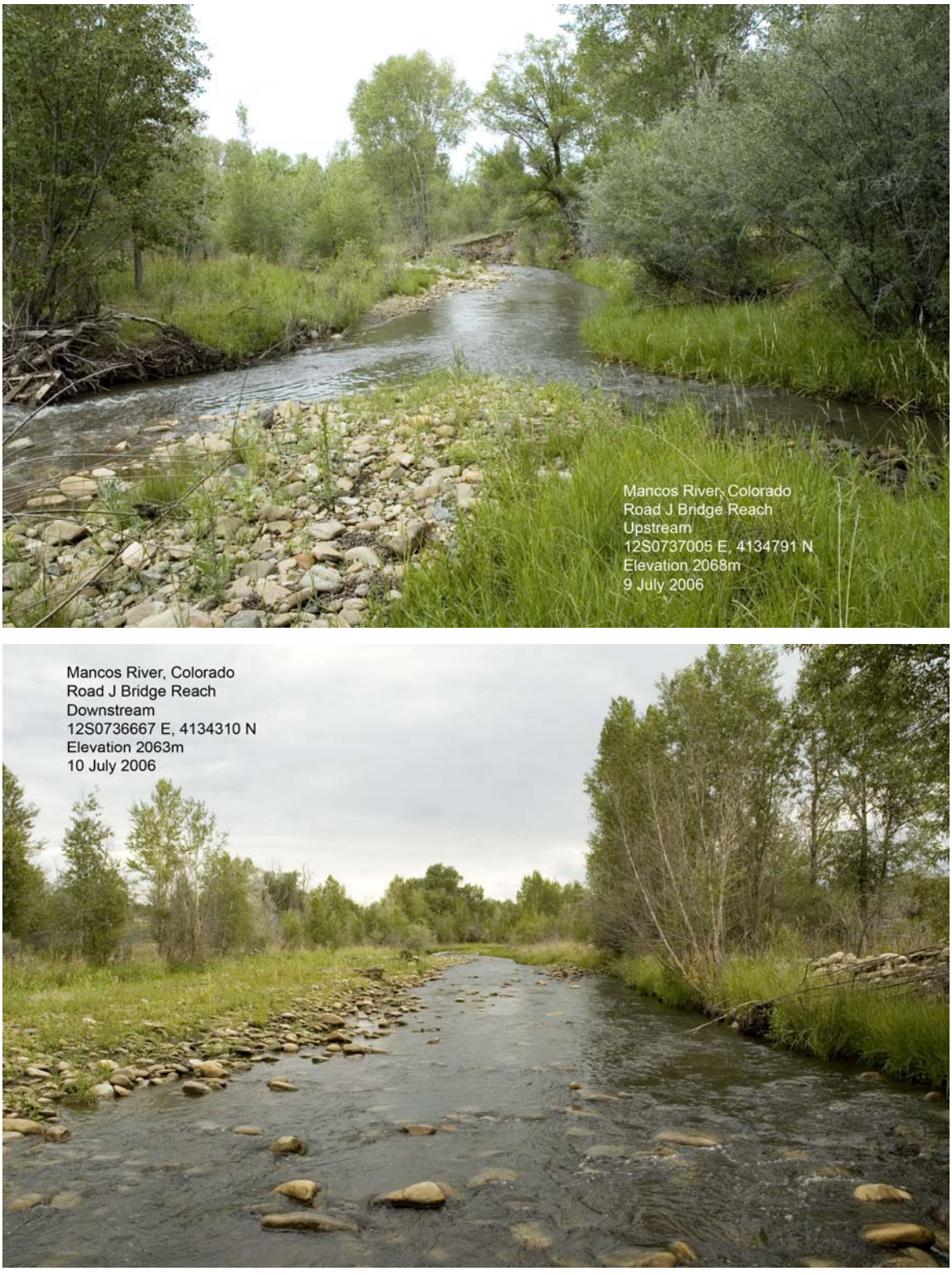

Figure 23. Reference Photos for the Road J Bridge Reach, Mancos River.

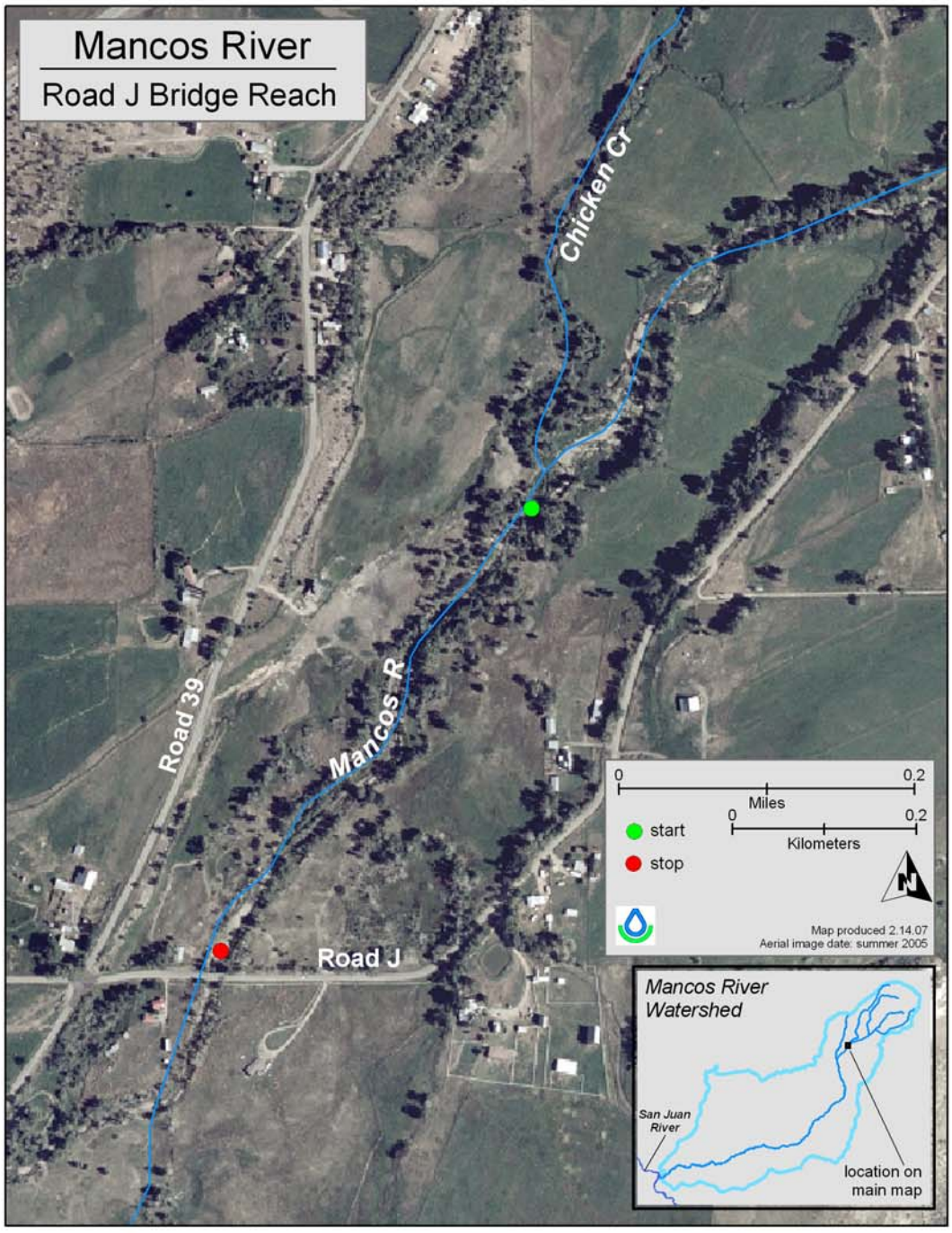

Figure 24. Aerial photo showing the location of the Road J Bridge Reach, Mancos River (*photo compiled by Marianna Young*).

along the cobble levees that line the channel. Water temperatures probably increase rapidly in this reach during sunny days.

Hydrogeomorphology was similar to other reaches in the valley. Vertical bank stability and riparian area soil integrity were excellent and very good respectively, but floodplain connection was poor due to the presence of levees, and there was no beaver activity. Beavers might not do well here due to the lack of large riparian vegetation adjacent to the stream. Hydraulic habitat diversity was rated as good.

Fish/Aquatic Habitat was similar to other reaches. There were no pools and riffles in the study transect, and underbank and overbank cover were only fair as a result of the levees. Macroinvertebrate diversity was excellent, and there was considerable large woody debris (score of very good). Cobble embeddedness was good.

Riparian Vegetation was generally good or better, with several exceptions. There was considerable non-native grass and forb cover, leading to a rating of fair. And for the first time as the surveys moved downstream, there were a number of non-native shrubs and trees (score of very good). Grazing impacts were high, particularly in the upper riparian zone (82% of plants had been grazed), as was browsing (50% of shrubs and small trees impacted by browsing in the upper riparian zone).

Terrestrial Wildlife Habitat was rated as mostly good, but was limited by the overall lack of dense riparian vegetation along this reach. Fluvial habitat diversity was only fair, as a result of the levees.

11. Mancos River, Lazy F/W Ranch Reach

Location of beginning of reach: 12 S 0736257 East, 4133469 North
Elevation: 2055 meters (6740 feet)
References Photos: Figures 25. A, B.
Aerial Location Photo: Figure 26.

Overall Score: 2.3

Individual Area Scores:

Water Quality Mean Score: 1.5
- Algal Growth: 1
- Channel Shading: 2

Hydrogeomorphology Mean Score: 1.8
- Floodplain Connection: 1
- Vertical Bank Stability: 3
- Hydraulic Habitat Diversity: 3
- Riparian Area Soil Integrity: 1
- Beaver Activity: 1

Fish/Aquatic Habitat Mean Score: 2.8
- Pool Distribution: 3
- Underbank Cover: 2
- Cobble Embeddedness: 2
- Aquatic Macroinvertebrate Diversity: 5
- Large Woody Debris: 2
- Overbank Cover: 3

Riparian Vegetation Mean Score: 2.9
- Lower Riparian Zone Plant Cover: 2
- Upper Riparian Zone Plant Cover: 3

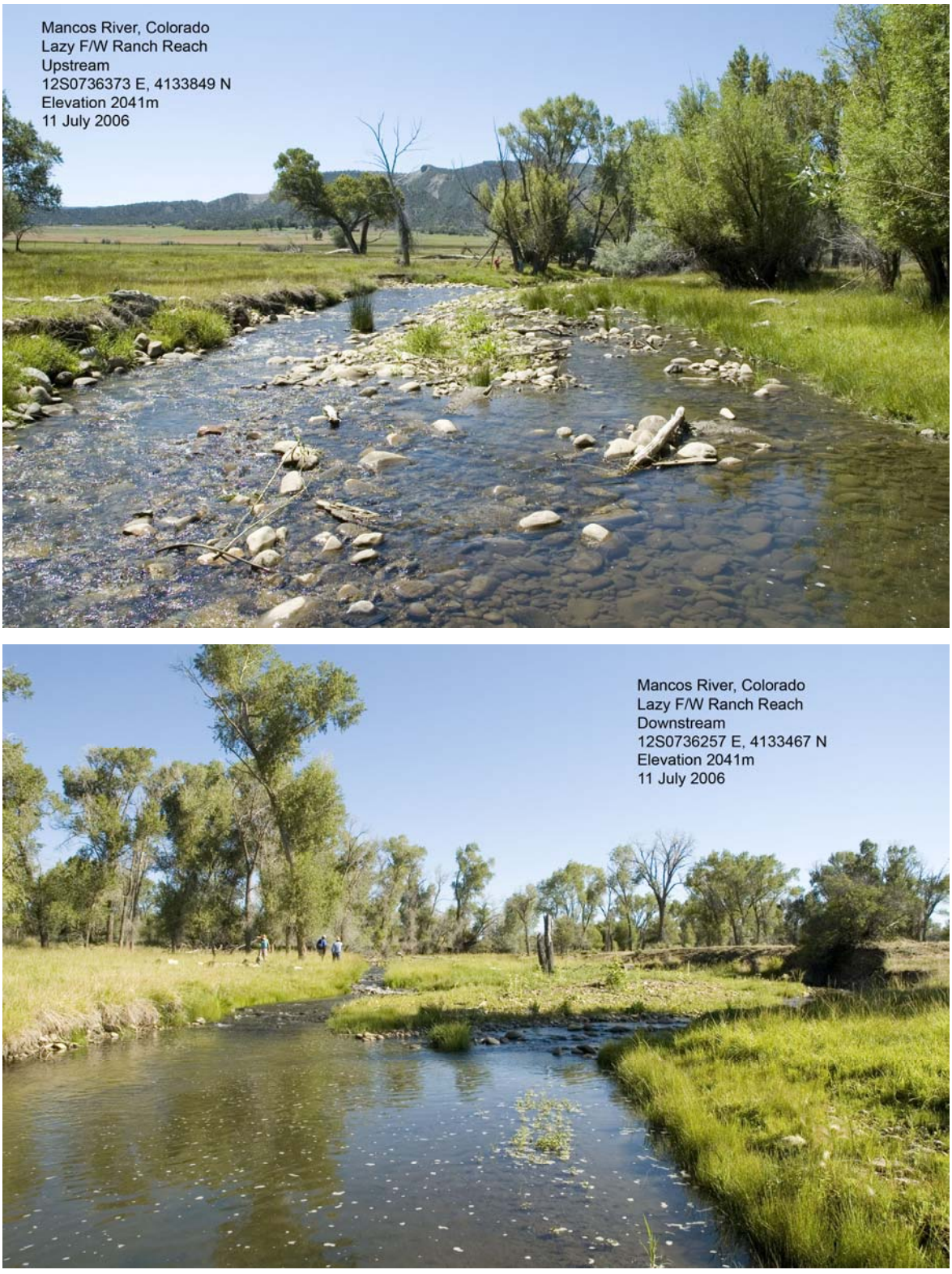

Figure 25. Reference Photos for the Lazy F/W Ranch Reach, Mancos River.

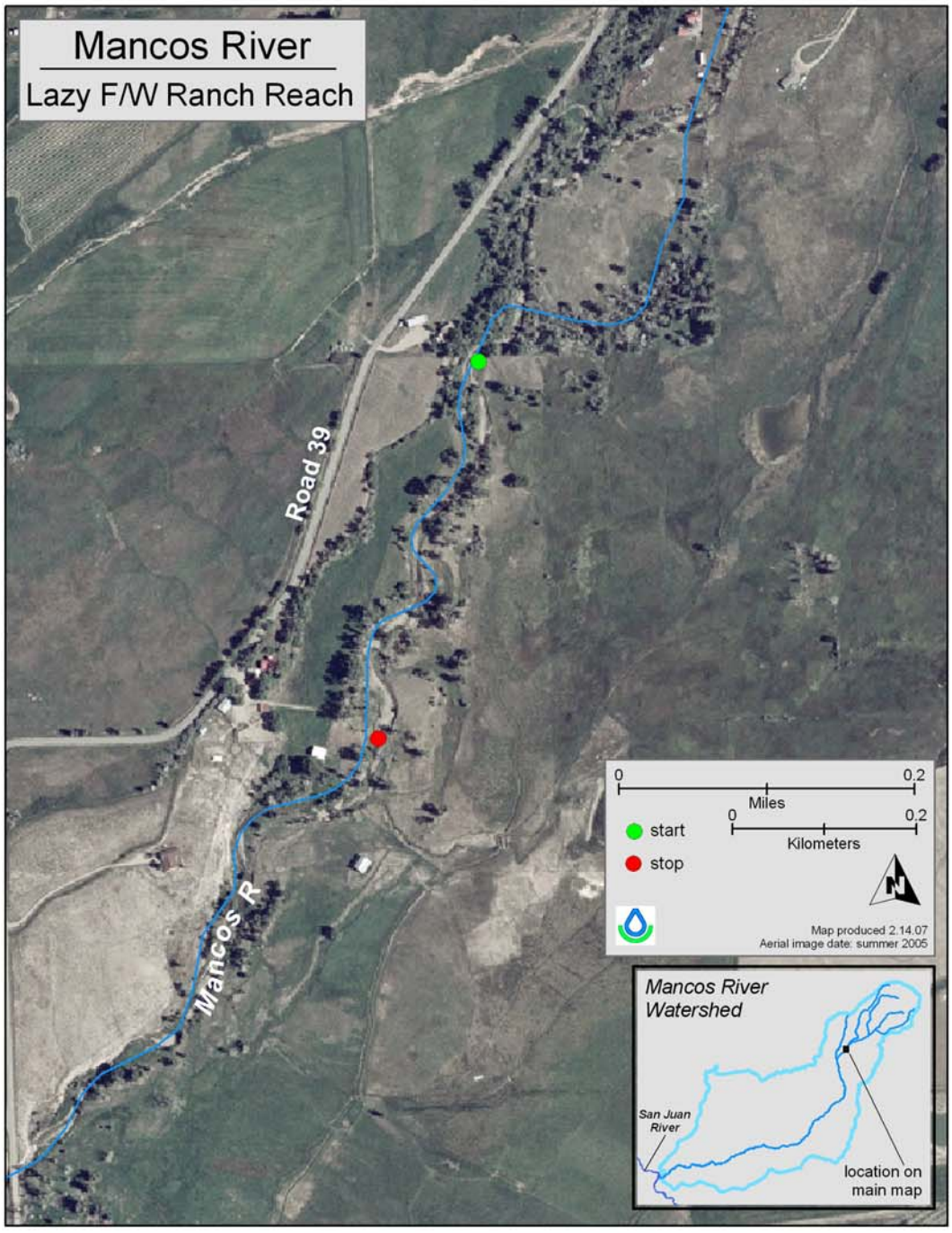

Figure 26. Aerial photo showing the location of the Lazy F/W Ranch Reach, Mancos River (*photo compiled by Marianna Young*).

Shrub Demography and Recruitment: 4
Tree Demography and Recruitment: 4
Non-native Herbaceous Plant Species: 2
Non-native Woody Plant Species: 5
Mammalian Herbivory on Ground Cover: 2
Mammalian Herbivory on Shrubs and Small Trees: 1

Terrestrial Wildlife Habitat Mean Score: 2.3

Shrub Patch Density: 2
Mid-canopy Patch Density: 2
Upper Canopy Patch Density: 2
Fluvial Habitat Diversity: 3

This reach is located at the upstream portion of the Mancos River that runs through the Lazy F/W Ranch. The ranch is an active livestock operation, and the pastures on the east side of the river are being grazed. There is less livestock activity on the west side of the floodplain in this part of the ranch. At the time of the survey, cattle had complete access to both the floodplain and the river channel; however, since the survey was completed the owner has fenced off the river and floodplain, and it will only be "flash" grazed in the future. These actions should result in a major improvement of the reach. There are no levees in this reach, although there is armoring of a short section of the west bank in the upstream part of the reach. There is substantial return irrigation flow, particularly on the east side of the floodplain, which has resulted in wet meadows within and above the historic flood plain. Unlike other reaches in the area, there is a relatively wide lower riparian zone. This is due to the fact that the river has not been channelized, and as a result there have been channel migrations after recent high flow events. Many young cottonwoods, and some willow, seedlings were observed in the lower riparian zone; this indicates that woody vegetation in the reach has the potential to recover rapidly.

Algal growth was poor, presumably as a result of nutrient input from livestock and possibly from fertilizer applied to the pastures. Solar shading was only fair, due to the lack of vegetation along the stream banks.

Hydrogeomorphology showed the impacts of heavy livestock use. Floodplain connectivity and riparian soil integrity were poor, and vertical bank stability was only good (55% of the banks were vertically unstable). There are no beavers on the reach, and it is probably not suitable habitat at the present time due to the lack of riparian vegetation. However, there is good beaver habitat just upstream from the reach.

Fish/Aquatic Habitat was rated as good or fair. Cobble embeddedness was fair (41% embedded), probably as the result of the unstable vertical banks. But macroinvertebrate diversity remained excellent, although the density of aquatic insect larvae here was lower than in the reaches further upstream.

Riparian vegetation scores were variable as elsewhere, and showed the impacts of livestock use of the riparian zone. Lower and upper riparian zone vegetation cover was low except for the ground layer. Mammalian grazing impacts were fair, while browsing impacts were rated as poor (nearly 100% of shrubs and small trees had been damaged). There were no individuals in the sapling age class of either shrubs or of trees. Non-native grass and forb cover was fair, but there were almost no non-native shrubs or trees.

Terrestrial Wildlife Habitat was generally rated as fair, as a result of the sparse woody riparian vegetation. Fluvial habitat diversity, however, was good, as a result of the fact the stream has not been channelized in this reach.

12. Mancos River, Perry Ranch Reach

Location of beginning of reach: 12 S 0734427 East, 4132055 North
Elevation: 2021 meters (6629 feet)
References Photos: Figures 27. A, B.
Aerial Location Photo: Figure 28.

Overall Score: 2.4

Individual Area Scores:

- **Water Quality Mean Score: 1.5**
  - Algal Growth: 1
  - Channel Shading: 2
- **Hydrogeomorphology Mean Score: 1.6**
  - Floodplain Connection: 1
  - Vertical Bank Stability: 3
  - Hydraulic Habitat Diversity: 2
  - Riparian Area Soil Integrity: 1
  - Beaver Activity: 1
- **Fish/Aquatic Habitat Mean Score: 2.8**
  - Pool Distribution: 2
  - Underbank Cover: 2
  - Cobble Embeddedness: 3
  - Aquatic Macroinvertebrate Diversity: 5
  - Large Woody Debris: 3
  - Overbank Cover: 2
- **Riparian Vegetation Mean Score: 3.5**
  - Lower Riparian Zone Plant Cover: 2
  - Upper Riparian Zone Plant Cover: 3
  - Shrub Demography and Recruitment: 5
  - Tree Demography and Recruitment: 4
  - Non-native Herbaceous Plant Species: 3
  - Non-native Woody Plant Species: 5
  - Mammalian Herbivory on Ground Cover: 5
  - Mammalian Herbivory on Shrubs and Small Trees: 1
- **Terrestrial Wildlife Habitat Mean Score: 2.5**
  - Shrub Patch Density: 2
  - Mid-canopy Patch Density: 3
  - Upper Canopy Patch Density: 3
  - Fluvial Habitat Diversity: 2

This reach is located on the Perry Ranch. The Mancos River at this point starts to turn north and south, before it enters Mancos Canyon. The ranch is an active livestock operation, and the floodplain on both sides of the stream had been grazed regularly in the years prior to the survey. The owners have discussed fencing off the riparian zone in the future. There are no levees in this reach. There is some return irrigation flow. On the west side, this has resulted in wet meadows at the base of the terrace forming the primary floodplain, and below the road. There are also wet areas on the east side, but these are generally above the historic floodplain.

Algal growth was poor, presumably as a result of nutrient input from livestock and possibly from

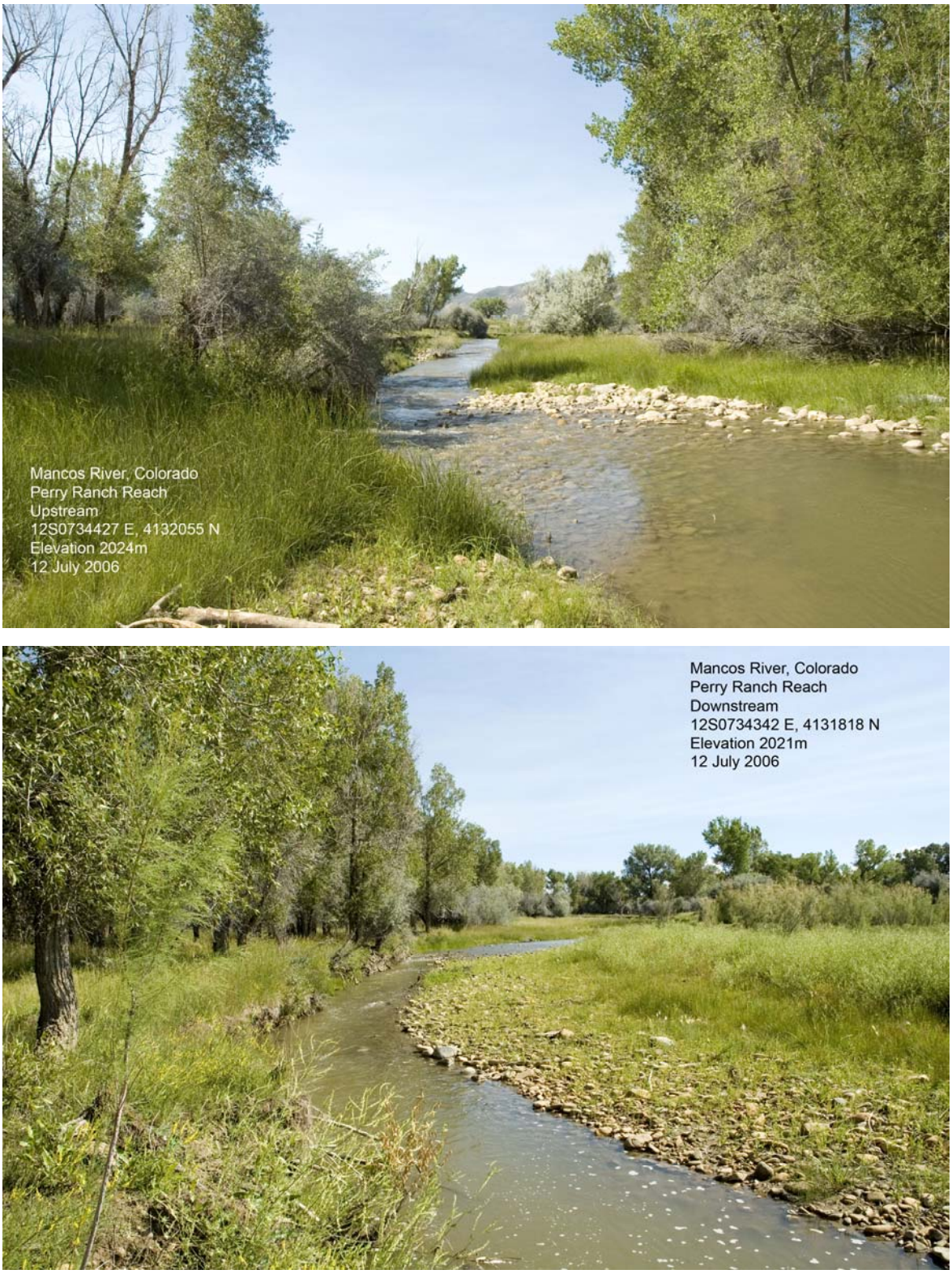

Figure 27. Reference Photos for the Perry Ranch Reach, Mancos River.

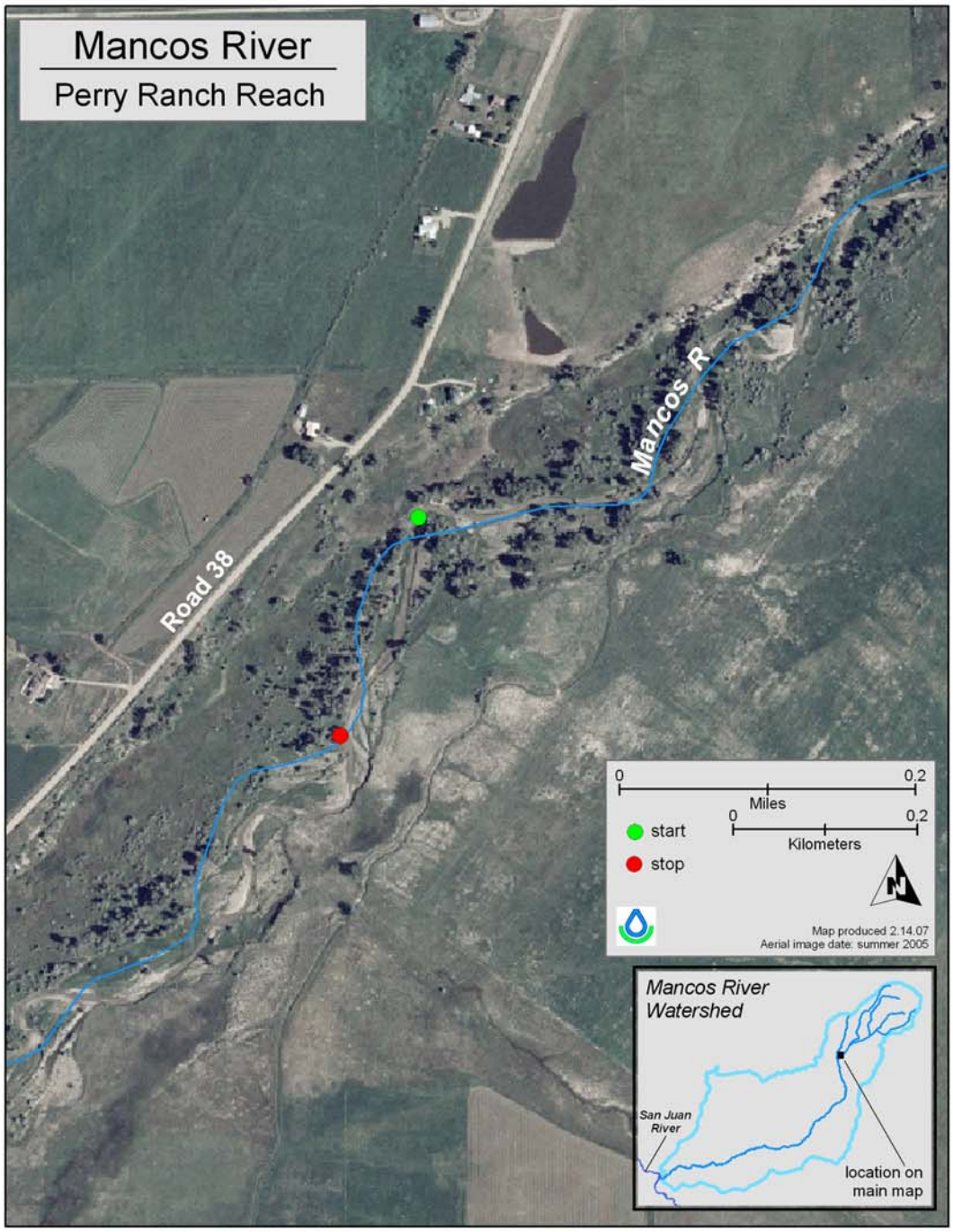

Figure 28. Aerial photo showing the location of the Perry Ranch Reach, Mancos River (*photo compiled by Marianna Young*).

fertilizer. Solar shading was fair, as a result of only limited amounts of riparian vegetation along the stream banks.

Hydrogeomorphology was rated as mostly poor. The channel was wide and shallow. Vertical bank stability was good, but hydraulic habitat diversity was fair. There are no beavers present. The reach might be suitable habitat for beavers if the woody riparian vegetation recovers in the future.

Fish and aquatic habitat features were variable. Macroinvertebrate diversity was excellent, and cobble embeddedness was good, probably as the result of good vertical bank stability. There was some large woody debris (rated as good). Pool and riffle distribution, underbank cover, and overbank vegetative cover were rated as only fair.

Riparian vegetation was also variable. Lower riparian zone vegetative cover was only fair, and much of this zone was bare. Upper riparian zone cover was good. There were numerous shrubs in the reach; these were primarily buffaloberry. Shrub demography was excellent, while tree demography was very good. There were some non-native grasses and forbs (rated as good), but very few non-native shrubs and trees (rated as excellent). The grazing impact score was excellent, and most livestock appeared to be in the pastures above the floodplain. However, browsing on shrubs and small trees was heavy, suggesting heavy use of the area by native ungulates. The reach was rated as poor on this variable. Most of the buffaloberry along the reach were large enough to survive browsing. However, this level of impact is likely to prevent the recruitment of new shrubs and cottonwoods in the future if continued.

Terrestrial wildlife habitat was fair to good, as a result of the limited woody riparian vegetation along the reach. Fluvial habitat diversity was only fair. Even though the channel does not have levees along its banks, there has been little channel migration and there were few river meanders or back channels.

13. Mancos River, Soussanna Ranch Reach

Location of beginning of reach: 12 S 0733603 East, 4130540 North
Elevation: 1999 meters
References Photos: Figure 29. A, B.
Aerial Location Photo: Figure 30.

Overall Score: 2.5

Individual Area Scores:

Water Quality Mean Score: 1.0
- Algal Growth: 1
- Channel Shading: 1

Hydrogeomorphology Mean Score: 3.0
- Floodplain Connection: 1
- Vertical Bank Stability: 4
- Hydraulic Habitat Diversity: 4
- Riparian Area Soil Integrity: 5
- Beaver Activity: 1

Fish/Aquatic Habitat Mean Score: 3.2
- Pool Distribution: 4
- Underbank Cover: 2
- Cobble Embeddedness: 1
- Aquatic Macroinvertebrate Diversity: 5

Figure 29. Reference Photos for the Soussanna Ranch Reach, Mancos River.

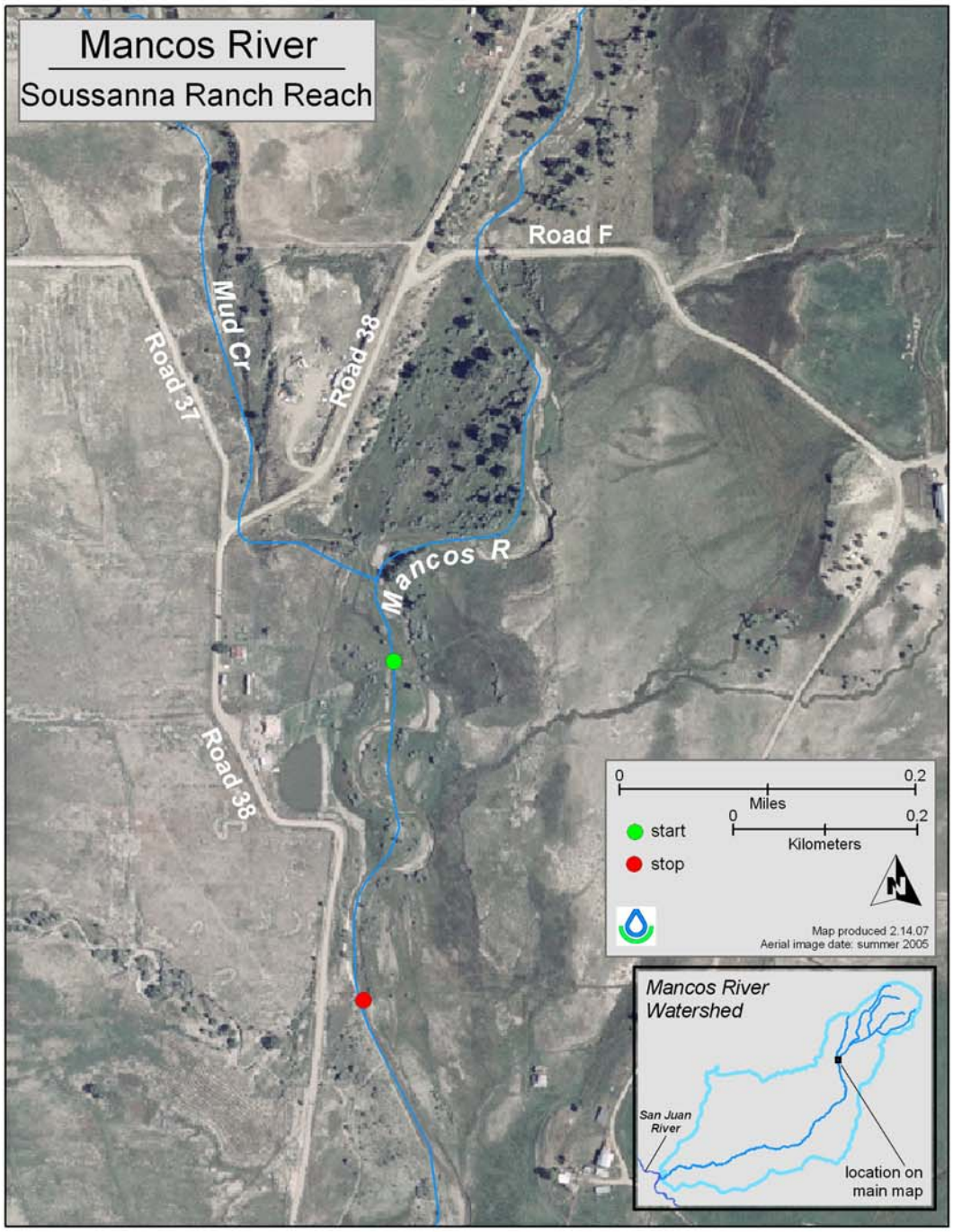

Figure 30. Aerial photo showing the location of the Soussanna Ranch Reach, Mancos River (*photo compiled by Marianna Young*).

Large Woody Debris: 1
Overbank Cover: 5

Riparian Vegetation Mean Score: 2.6

Lower Riparian Zone Plant Cover: 3
Upper Riparian Zone Plant Cover: 3
Shrub Demography and Recruitment: 3
Tree Demography and Recruitment: 3
Non-native Herbaceous Plant Species: 5
Non-native Woody Plant Species: 2
Mammalian Herbivory on Ground Cover: 2
Mammalian Herbivory on Shrubs and Small Trees: 1

Terrestrial Wildlife Habitat Mean Score: 2.5

Shrub Patch Density: 2
Mid-canopy Patch Density: 1
Upper Canopy Patch Density: 2
Fluvial Habitat Diversity: 5

This reach is located in the lower portion on Mancos Valley, and is approximately 200 meters downstream from the confluence of Mud Creek and the Mancos River. Although the streambed is wide and shallow, it differs from the other reaches in this area in a number of ways. It is not channelized, there are no levees, and the channel itself is actively migrating. There are several meanders, as well as well-developed point bars (see Figure 29A). These features are absent from most other reaches. The riparian vegetation, particularly near the stream, is primarily native rushes and sedges. There are almost no shrubs or trees along the reach. There also are irrigation return flows, particularly on the east side of the floodplain, that have resulted in wet meadows and a cattail marsh in one area. Sheep graze portions of the floodplain, and there also appears to be heavy use of this reach by mule deer. The landowner has added rock erosion control structures in several areas in an effort to limit channel migration.

Nonchemical water quality was poor, with high algal coverage (76%). This may be the result of both livestock use and fertilizer runoff from irrigated pastures. There was less than 1% channel shading.

Hydrogeomorphology scores were variable. Connection to the historic floodplain was poor, and there was no beaver activity (due to lack of woody riparian vegetation, this would not be suitable habitat for beavers). Vertical bank stability was very good, with unstable banks occurring primarily where there was channel migration and meander formation. Hydraulic habitat diversity was also very good, and riparian soil integrity was excellent (<1%) due to the presence of dense sedges and rushes.

Fish and aquatic habitat scores were also variable. Underbank cover and large woody debris were fair and poor respectively. But pool distribution was very good, and overbank cover was excellent. Macroinvertebrate diversity was also excellent, although the number of individuals was low relative to reaches further upstream.

Cobble embeddedness was poor, and averaged 51% embedded for the three sampled locations. As mentioned above, the survey reach is located approximately 200 meters downstream from the mouth of Mud Creek, and the concern was expressed by the landowner that Mud Creek could be adding significant amounts of silt to the Mancos River itself (see below for an assessment of a reach on Mud Creek). Cobble embeddedness was highest at the sample site closest to the mouth of Mud Creek (59%), and then declined as the sample locations were further downstream (52% and 42%). There also were no macroinvertebrates found at the sample site located closest to Mud Creek; they only appeared further downstream. These results suggest that sediment deposition from Mud Creek does have an impact on the Mancos River

ecosystem, but that at least at the time of the present survey, these effects are relatively localized and do not persist for long distances downstream. However, the situation might be very different after periods of high flow in Mud Creek itself.

Riparian vegetation scores were mostly good or fair. There were very few shrubs or trees on this reach. Shrub cover was 6% for the lower riparian zone and 18% for the upper riparian zone. Middle and upper canopy tree cover was completely absent in the sample transects for both zones. However, grass and forb cover was 68% and 92% respectively. Non-native grass and forb cover was excellent, as a result of the presence of sedges and rushes. However, non-native shrub and tree cover was only fair (30%) among the limited numbers of shrubs and trees present. 100% of the shrubs and small trees present had been browsed by livestock and native ungulates, which will limit the future recruitment of new woody riparian plants.

Terrestrial wildlife habitat was primarily fair or poor, due to the very limited numbers of shrubs and trees along the reach. Fluvial habitat diversity, however, was excellent as a result of the lack of channelization and the active movement of the streambed.

14. Mancos River, Mitchell Ranch Reach

Location of beginning of reach: 12 S 0734048 East, 4127867 North
Elevation: 1952 meters
References Photos: Figures 31. A, B.
Aerial Location Photo: Figure 32.

Overall Score: 2.5

Individual Area Scores:

Water Quality Mean Score: 1.5
- Algal Growth: 1
- Channel Shading: 5

Hydrogeomorphology Mean Score: 2.8
- Floodplain Connection: 1
- Vertical Bank Stability: 5
- Hydraulic Habitat Diversity: 2
- Riparian Area Soil Integrity: 5
- Beaver Activity: 1

Fish/Aquatic Habitat Mean Score: 2.0
- Pool Distribution: 3
- Underbank Cover: 2
- Cobble Embeddedness: 2
- Aquatic Macroinvertebrate Diversity: 1
- Large Woody Debris: 1
- Overbank Cover: 3

Riparian Vegetation Mean Score: 3.8
- Lower Riparian Zone Plant Cover: 3
- Upper Riparian Zone Plant Cover: 3
- Shrub Demography and Recruitment: 4
- Tree Demography and Recruitment: 4
- Non-native Herbaceous Plant Species: 1
- Non-native Woody Plant Species: 5
- Mammalian Herbivory on Ground Cover: 5

Figure 31. Reference Photos for the Mitchell Ranch Reach, Mancos River.

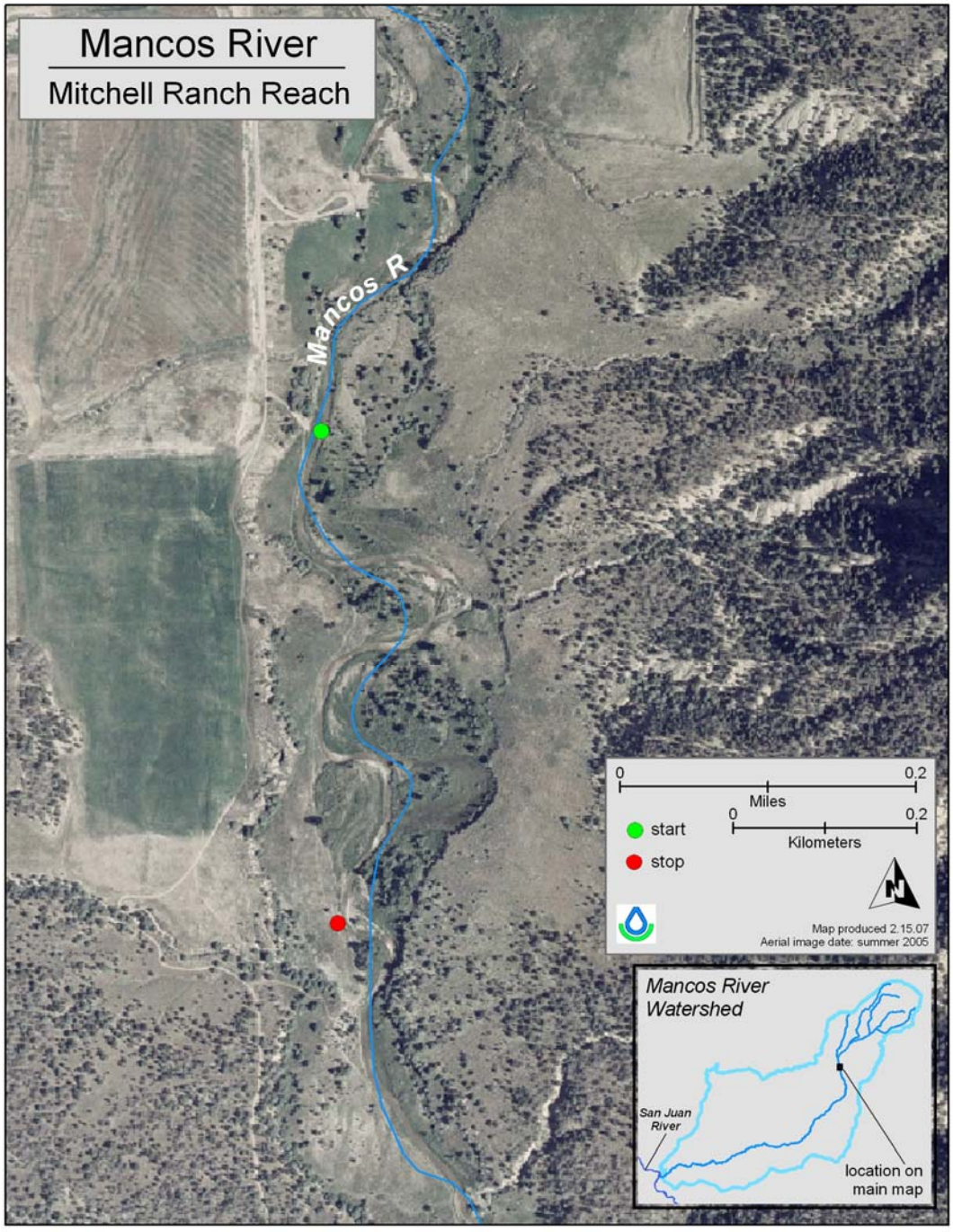

Figure 32. Aerial photo showing the location of the Mitchell Ranch Reach, Mancos River (*photo compiled by Marianna Young*).

Mammalian Herbivory on Shrubs and Small Trees: 5

Terrestrial Wildlife Habitat Mean Score: 2.5

Shrub Patch Density: 4
Mid-canopy Patch Density: 2
Upper Canopy Patch Density: 3
Fluvial Habitat Diversity: 1

This reach is located at the lower end of Mancos Valley, and is in the beginning part of Mancos Canyon. It is the last private land in the valley; below this reach the Mancos flows through Mesa Verde National Park. There are some small irrigated fields on the western side of the reach, above the flood plain, but there is no evidence of side flows back toward the river. The channel is very wide and shallow at this point. There are no levees. The stream probably goes dry at least occasionally in this reach as a result of upstream dewatering. There was considerable sedimentation, possibly due in part to the recent fires on the mesa to the west (part of Mesa Verde National Park). Although this ranch was an active livestock operation in the past, there were no livestock observed in the area during the assessment.

Nonchemical water quality was fair or poor. Algal growth was very high (79% of samples). Solar exposure was very low, with only 2% of the channel shaded at midday.

Hydrogeomorphology was variable. Vertical bank stability along the reach was excellent, indicating that the high levels of sedimentation (see below) were not originating locally. Riparian soil integrity was also excellent, possibly reflecting the current lack of use by livestock. However, floodplain connectivity and beaver activity were poor (the reach would be suitable for beavers when there are sufficient flows), and hydraulic habitat diversity was only fair. There was little active channel migration as was observed upstream on the Soussanna Ranch reach.

Fish and aquatic habitat ranged from good to poor. Pool distribution and overbank cover was good, but underbank cover was limited (fair) and there was no woody debris (poor). Cobble embeddedness was high (46% or a score of fair), and similar to the most downstream sample value in the Soussanna Ranch Reach that is upstream from this location. No aquatic macroinvertebrate insects were observed. There were a few crawfish at the sample sites, and several small unidentified fish were observed elsewhere along the reach.

The riparian vegetation appears to be recovering after a history of heavy grazing. Lower and upper riparian zone vegetation coverage averaged a rating of good, but this was due exclusively to grass/forb and shrub coverage. There was no cover from middle or upper canopy trees in the sample transects. Shrub and tree demography was very good; seedlings were present for both categories, and the only age classes missing were old clumps or snags in both cases. Non-native grass and forb cover was very high (estimated at 70% of total coverage, a rating of poor), but there were very few non-native shrubs and trees. The latter situation is very atypical of similar reaches in the American southwest, where saltcedar and Russian olives are normally very common along streams that have had a long history of grazing as well as the other characteristics of this reach. The levels of current grazing and browsing both received excellent scores, reflecting a lack of use of the riparian zone at the present time by both domestic livestock and native ungulates in this reach.

Terrestrial wildlife habitat was variable, ranging from fair (middle canopy trees) to very good (shrub patches). Fluvial habitat diversity was poor, which probably reflects a lack of channel migration along this reach in the past. However, if current conditions continue, this important fluvial process is likely to reestablish itself within the reach.

C. Mancos Canyon Sites

15. Mancos River, Mesa Verde National Park- Ute Mountain Ute Indian Reservation Border Reach

Location of beginning of reach: 12 S 0736039 East, 4122345 North
Elevation: 1880 meters
References Photos: Figures 33. A, B.
Aerial Location Photo: Figure 34.

Overall Score: 2.8

Individual Area Scores:

Water Quality Mean Score: 1.5
- Algal Growth: 1
- Channel Shading: 2

Hydrogeomorphology Mean Score: 2.4
- Floodplain Connection: 1
- Vertical Bank Stability: 5
- Hydraulic Habitat Diversity: 2
- Riparian Area Soil Integrity: 3
- Beaver Activity: 1

Fish/Aquatic Habitat Mean Score: 2.5
- Pool Distribution: 5
- Underbank Cover: 2
- Cobble Embeddedness: 1
- Aquatic Macroinvertebrate Diversity: 1
- Large Woody Debris: 1
- Overbank Cover: 5

Riparian Vegetation Mean Score: 4.1
- Lower Riparian Zone Plant Cover: 3
- Upper Riparian Zone Plant Cover: 3
- Shrub Demography and Recruitment: 5
- Tree Demography and Recruitment: 5
- Non-native Herbaceous Plant Species: 2
- Non-native Woody Plant Species: 5
- Mammalian Herbivory on Ground Cover: 5
- Mammalian Herbivory on Shrubs and Small Trees: 3

Terrestrial Wildlife Habitat Mean Score: 3.3
- Shrub Patch Density: 5
- Mid-canopy Patch Density: 3
- Upper Canopy Patch Density: 2
- Fluvial Habitat Diversity: 3

This reach is located within Mancos Canyon, on Mesa Verde National Park lands just upstream from the mouth of Weber Canyon. Weber Canyon is a major drainage that enters the river from the east, and it contains a number of ranches and irrigated pastures. At the time of the assessment, there was little water entering the Mancos River from Weber Canyon. The river here is very low gradient relative to reaches upstream (estimated at 1 meter drop over 200 meter channel length). The width of the flood plain in this section of the canyon is variable; at the assessment reach it was at least 100 meters wide. The stream itself is wide and shallow. There are no levees

Figure 33. Reference Photos for the Mesa Verde NP/Ute Mountain Ute Indian Reservation Border Reach, Mancos River.

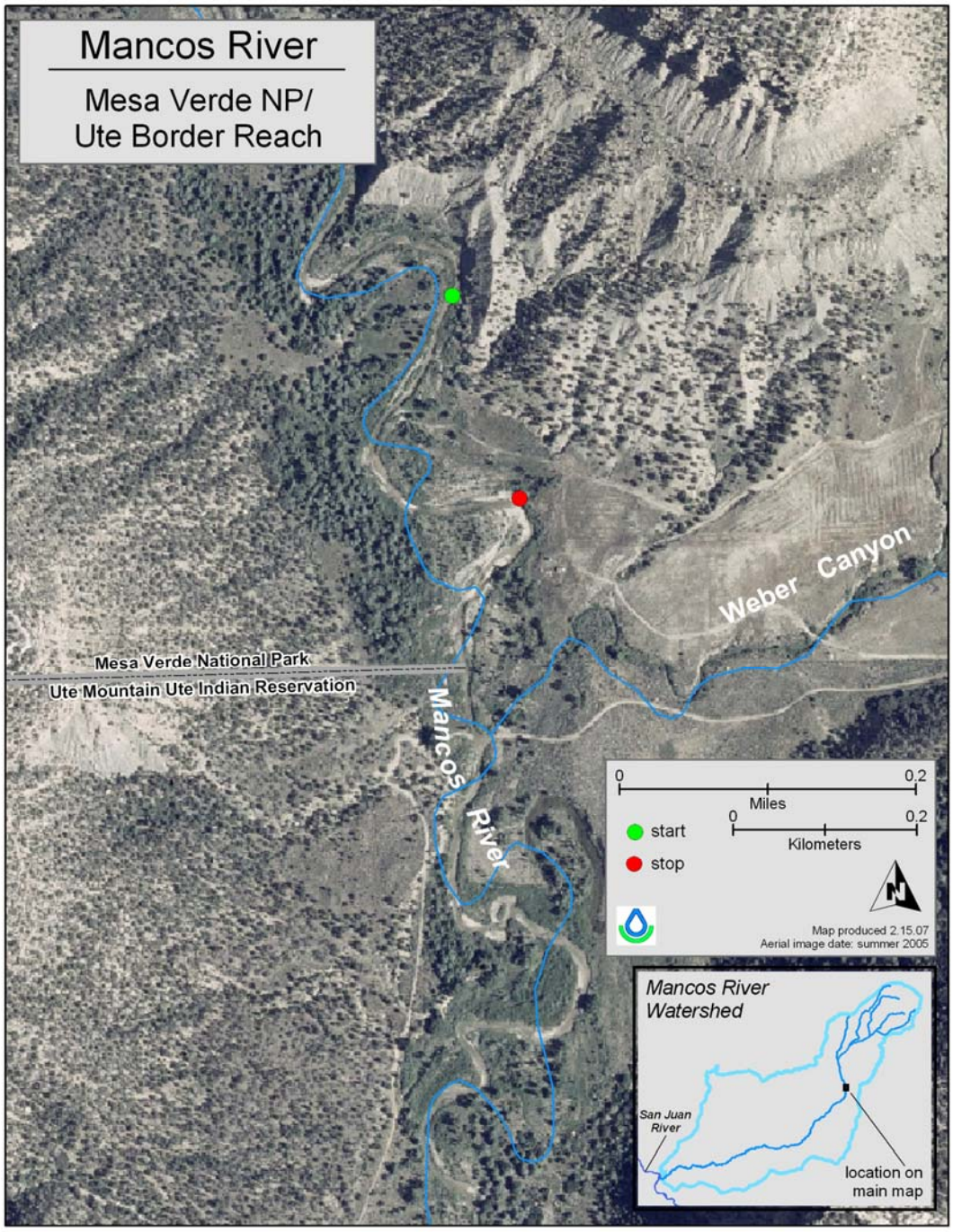

Figure 34. Aerial photo showing the location of the Mesa Verde National Park/Ute Mountain Ute Indian Reservation Border Reach, Mancos River (*photo compiled by Marianna Young*).

and the channel is actively migrating. There are the expected numbers of meanders and point bars. There is considerable sediment in the stream, and many of the cobbles are embedded in a matrix that is dark and presumably contains charcoal from the recent wildfires in Mesa Verde National Park. This matrix was very cohesive, and formed a type of "pavement" along the bottom of parts of the channel. This may have a long-term impact on the health and recovery of the stream. Personnel from the Park indicated that an active program to remove exotic shrubs and trees had recently been completed along this reach. This effort has been successful, as only one individual saltcedar was observed in the survey area. This section of the canyon historically has been used by domestic livestock, but the Park does not allow grazing at the present time. However, there were numerous signs of trespass grazing in the reach at the time of the assessment.

The assessment was conducted at the same location that is used by Mesa Verde National Park for their riparian surveys.

Nonchemical water quality was fair to poor. Algal growth was high (71% coverage). Much of the stream bottom in the sample transect was covered with fine sediment. Since this does not provide a suitable potential substrate for algal growth, the samples were taken only in locations where there was exposed cobble. Channel shading was fair, reflecting the wide nature of the stream and the lack of large trees along the channel. Solar temperature gain and evaporation are probably very high in this reach during sunny periods.

As elsewhere, hydrogeomorphology scores were variable. The stream is isolated from the historic floodplain, and there are no beavers currently in the reach (it is suitable habitat for beavers). Vertical bank stability was excellent (0% unstable), indicating that the heavy siltation in the reach was not originating from local erosion along the banks. Hydraulic habitat diversity was fair, which may reflect the "pavement" characteristics of the channel bottom in areas where it is not covered by fine sediments. Riparian area soil integrity was only good, as a result of some disturbance from the trespass grazing.

Fish aquatic habitat ranged from poor to excellent. Pool distribution and overbank cover were both excellent (the latter score was the result of dense patches of willows that lined the bank of most of this reach). Cobble embeddedness was poor (68%) and no macroinvertebrate insects were found in the reach. A number of crawfish, and a few small unidentified fish, were observed in the stream. There was no large woody debris– the reason for the absence of this material was not clear given the forested slopes of the canyon and the presence of some large cottonwoods in the flood plain. Underbank cover was rated as fair.

Lower and upper riparian zone cover was good. The values for shrub cover (mostly willows) were high in both zones (74% and 71% respectively). However, there was no cover from middle and upper canopy trees, reflecting their absence from the sample transects. Shrub and tree demography were excellent, and there is ongoing recruitment of both types. Non-native grass and forb cover was fair, but non-native shrub and tree cover was excellent as a result of the removal program. Grazing and Browsing impacts were both excellent, the later apparently reflecting a lack of recent use of this reach by native ungulates.

Terrestrial wildlife habitat ranged from fair, for upper canopy (cottonwood) tree connectivity, to excellent, for shrub patch density. Most of the willows in the reach appear to be less than 15 years old. Fluvial habitat diversity was good, due in part to overbank flooding and the formation of back channels during past periods of high flow.

D. Tributaries of the Mancos River Sites

16. Chicken Creek, Valley Inn Reach

Location of beginning of reach: 12 S 0733603 East, 4130540 North
Elevation: 1999 meters
References Photos: Figures 35. A, B.
Aerial Location Photo: Figure 36.

Overall Score: 3.0

Individual Area Scores:

Water Quality Mean Score: 1.5
- Algal Growth: 1
- Channel Shading: 2

Hydrogeomorphology Mean Score: 3.6
- Floodplain Connection: 1
- Vertical Bank Stability: 4
- Hydraulic Habitat Diversity: 4
- Riparian Area Soil Integrity: 5
- Beaver Activity: 4

Fish/Aquatic Habitat Mean Score: 4.2
- Pool Distribution: 5
- Underbank Cover: 4
- Cobble Embeddedness: 3
- Aquatic Macroinvertebrate Diversity: 5
- Large Woody Debris: 3
- Overbank Cover: 5

Riparian Vegetation Mean Score: 3.4
- Lower Riparian Zone Plant Cover: 3
- Upper Riparian Zone Plant Cover: 3
- Shrub Demography and Recruitment: 4
- Tree Demography and Recruitment: 2
- Non-native Herbaceous Plant Species: 5
- Non-native Woody Plant Species: 4
- Mammalian Herbivory on Ground Cover: 5
- Mammalian Herbivory on Shrubs and Small Trees: 1

Terrestrial Wildlife Habitat Mean Score: 2.3
- Shrub Patch Density: 1
- Mid-canopy Patch Density: 2
- Upper Canopy Patch Density: 1
- Fluvial Habitat Diversity: 5

Chicken Creek is a tributary of the Mancos River. It drains a watershed located primarily to the north and west of the town of Mancos, and west of the West Mancos River. It joins the main Mancos River southwest of the town (Figure 4). The assessment reach was located where Chicken Creek enters the Mancos Valley, at the northern edge of the town of Mancos. The floodplain and areas surrounding the reach were part of a ranch, and were probably heavily grazed in the past. At the present time, much of the

Figure 35. References Photos for Valley Inn Reach, Chicken Creek.

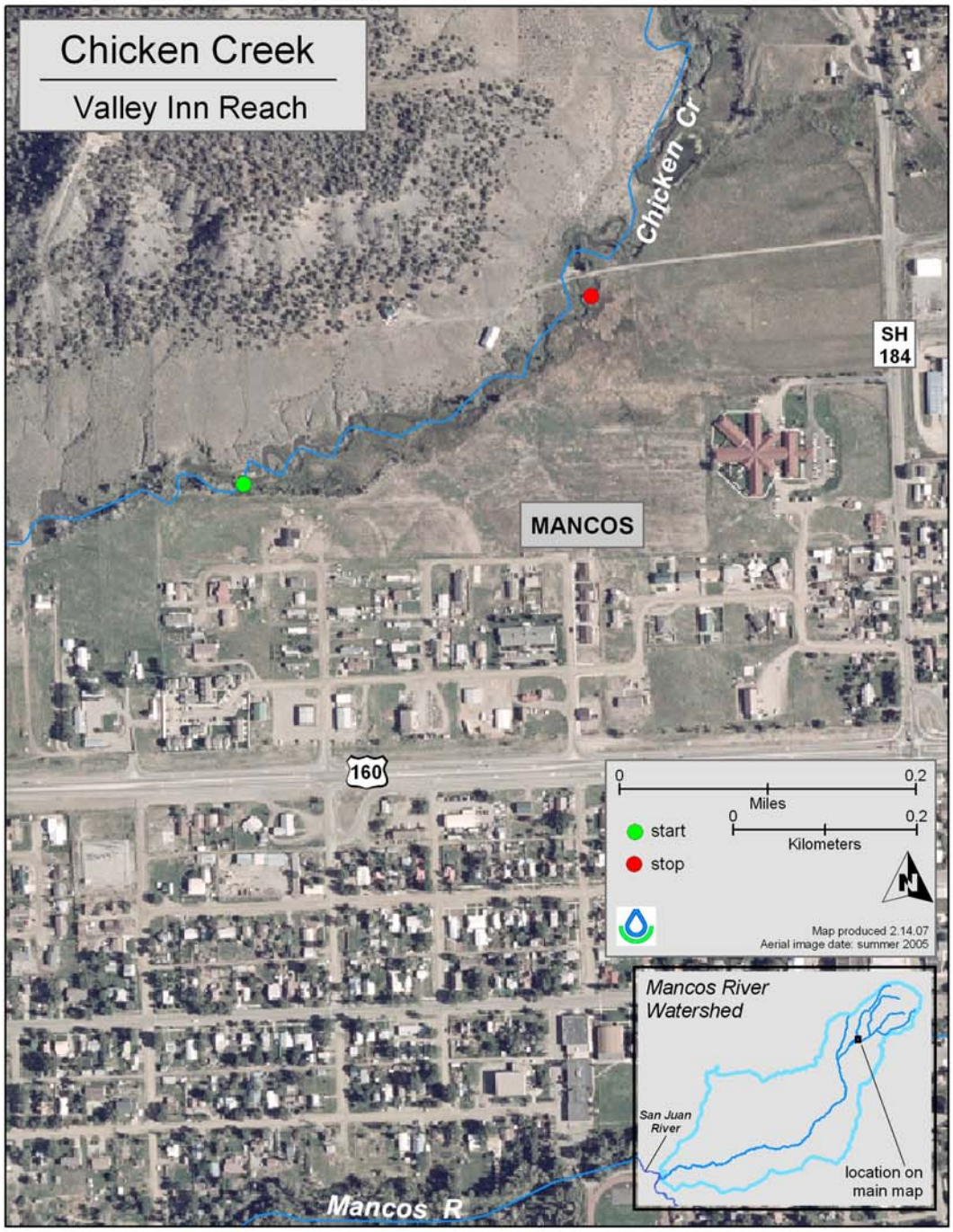

Figure 36. Aerial photo showing the location of the Valley Inn Reach, Chicken Creek (*photo compiled by Marianna Young*).

historic floodplain on the south side of the reach is being prepared for a housing development. Chicken Creek is not a very large stream, and there are a number of small water diversions upstream for irrigation. The channel in this section is primarily narrow and somewhat deep, and has a medium gradient. Although the stream has downcut in the past, it is now developing a new flood plain below the historic one. There is a large beaver dam at the lower end of the reach, which has created a pond, a longer section of slow flows, and an adjacent wet meadow with rich organic soils.

Nonchemical water quality was fair to poor. Algal growth was rated as poor, and presumably was the result of nutrient inputs from upstream agricultural fields and possibly from septic tanks from the houses adjacent to and within the floodplain above the assessment reach. Channel shading was fair, reflecting a general lack of shrubs and trees along the banks of the reach.

Hydrogeomorphology was very good or excellent, with the exception of floodplain connection, which was poor due to past entrenchment. The channel is beginning to meander again, and to establish very good hydraulic habitat diversity. As mentioned above, beaver activity dominated the lower section of the reach.

Fish and aquatic habitat was good to excellent. Pool distribution, macroinvertebrate diversity, and overbank cover were all excellent. Underbank cover was very good. Cobble embeddedness was good (30%), presumably due to some areas of bank erosion upstream from the reach. There was also some large woody debris. Although fish were not observed during the assessment, this reach could provide good habitat for native trout, particularly if non-native trout species are absent.

Grass cover in both the lower and upper riparian zones was very high (89% and 94%, respectively). Grazing impacts were also excellent. Both results reflect an absence of livestock in the reach at the current time. However, middle and upper tree canopy cover was very low (2% or less in all cases), indicating that the area was heavily grazed in the past. Shrubs are returning to the reach, and had intermediate levels of cover. Shrub demography was very good, but tree demography was only fair reflecting the overall lack of cottonwoods along the reach. Non-native grass and forb cover was excellent (less than 5%), and non-native shrubs and trees were nearly excellent (comprising 5% of the total woody plant coverage, which is at the high end of the range for very good). However, browsing impacts, presumably from deer and possibly elk, were poor: 80% of the shrubs and small trees in the lower riparian zone, and 90% of the individuals in the upper riparian zone, had been browsed. This level of impact is likely to severely affect the likelihood of new shrubs and trees being recruited into the reach in the future.

Terrestrial wildlife habitat was poor to fair, reflecting the general lack of shrubs and trees along the reach. Fluvial habitat diversity, in contrast, was excellent, reflecting the healthy condition of the stream channel and the presence of beavers at the downstream end of the reach. This beaver pond and the associated wetlands could serve as a reference condition for the potential hydrological and ecological effects of beavers within Mancos Valley and the surrounding areas.

17. Mud Creek, Mud Creek Ranch Reach

Location of beginning of reach: 12 S 0735537 East, 4137587 North
Elevation: 2058 meters
References Photos: Figure 37. A, B.
Aerial Location Photo: Figure 38.

Overall Score: 2.2

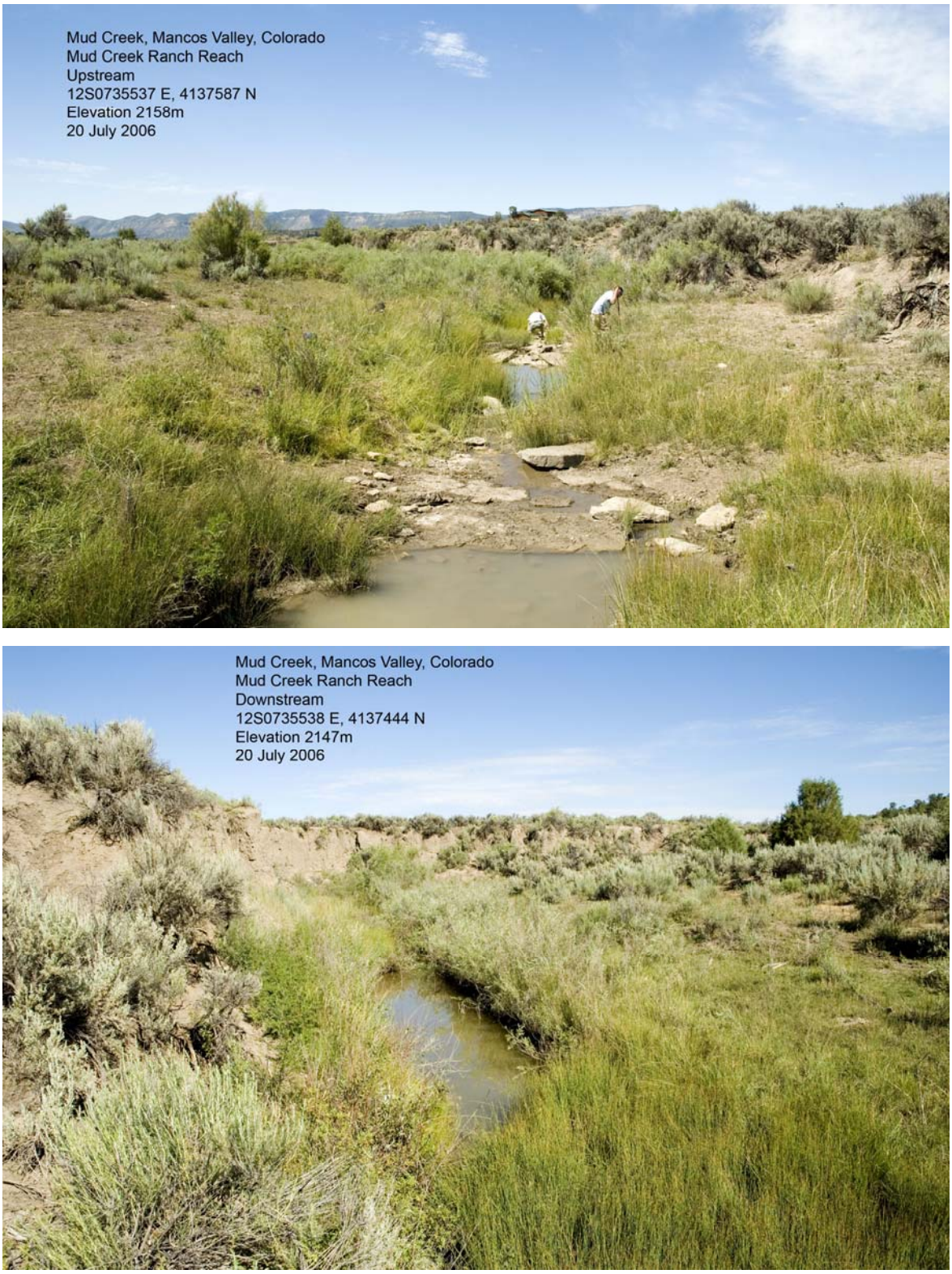

Figure 37. Reference Photos for the Mud Creek Ranch Reach, Mud Creek.

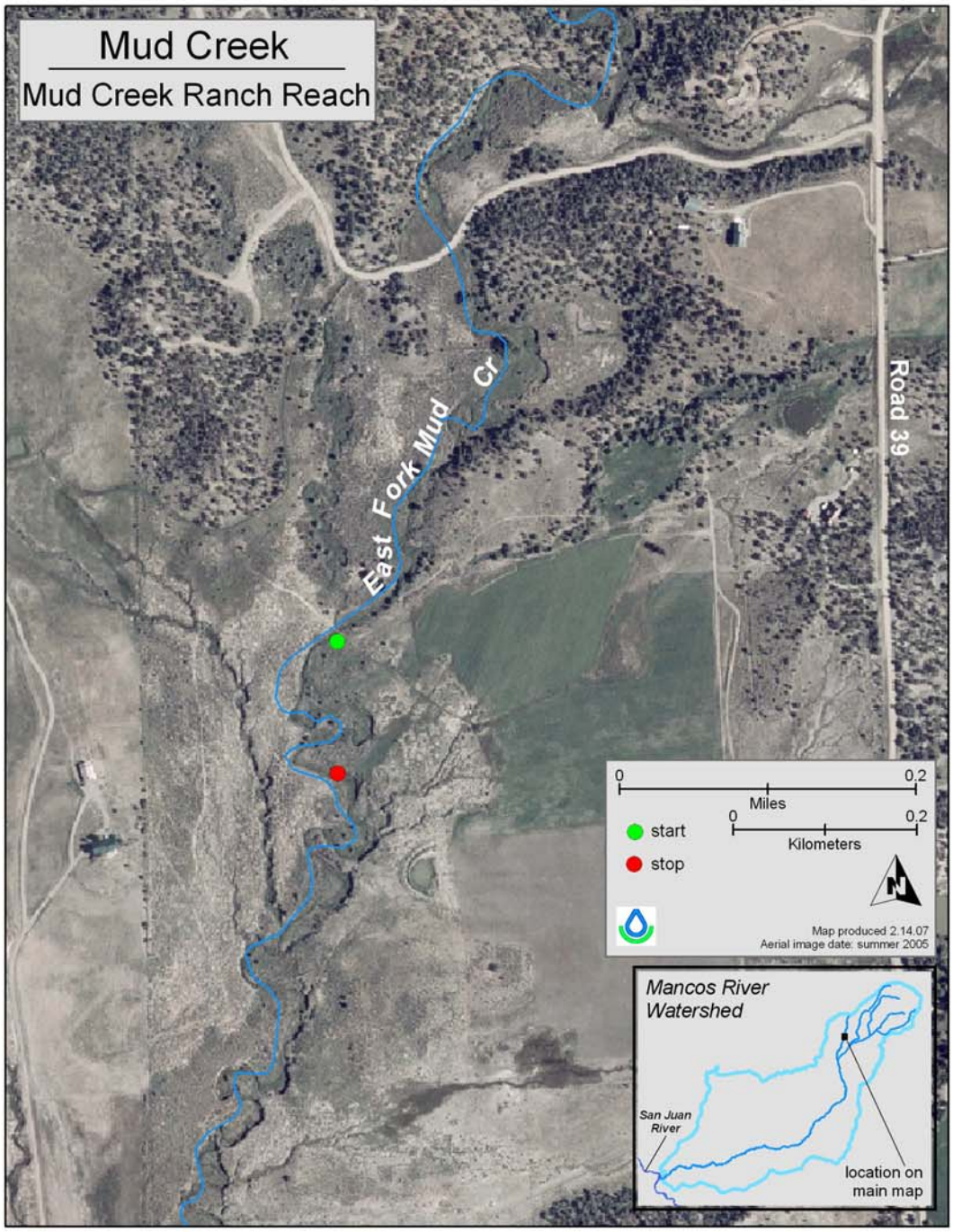

Figure 38. Aerial photo showing the location of the Mud Creek Ranch Reach, Mud Creek (*photo compiled by Marianna Young*).

Individual Area Scores:

Water Quality Mean Score: 2.0
- Algal Growth: not measurable
- Channel Shading: 2

Hydrogeomorphology Mean Score: 2.0
- Floodplain Connection: 1
- Vertical Bank Stability: 4
- Hydraulic Habitat Diversity: 2
- Riparian Area Soil Integrity: 2
- Beaver Activity: 1

Fish/Aquatic Habitat Mean Score: 2.8
- Pool Distribution: 4
- Underbank Cover: 3
- Cobble Embeddedness: 3
- Aquatic Macroinvertebrate Diversity: 1
- Large Woody Debris: 1
- Overbank Cover: 5

Riparian Vegetation Mean Score: 2.8
- Lower Riparian Zone Plant Cover: 3
- Upper Riparian Zone Plant Cover: 2
- Shrub Demography and Recruitment: 4
- Tree Demography and Recruitment: 2
- Non-native Herbaceous Plant Species: 1
- Non-native Woody Plant Species: 4
- Mammalian Herbivory on Ground Cover: 3
- Mammalian Herbivory on Shrubs and Small Trees: 3

Terrestrial Wildlife Habitat Mean Score: 1.5
- Shrub Patch Density: 2
- Mid-canopy Patch Density: 1
- Upper Canopy Patch Density: 1
- Fluvial Habitat Diversity: 2

Mud Creek drains the lower elevation portions of the Mancos watershed to the northwest of Mancos Valley. The assessment reach was located on the east fork of Mud Creek, about 5km west northwest of the town of Mancos. The area surrounding the reach is primarily piñon-juniper woodlands and sagebrush, typical of open rangelands at this elevation in southwestern Colorado. There was a small irrigated pasture on the bench above the reach on the east side of the stream. None of the other areas were irrigated, although they may have been so at some time in the past. The stream itself is incised throughout most of the reach, and the banks consist of easily erodible fine alluvial soils. In much of the reach, the channel bottom has reached the underlying Mancos shale, which has probably prevented further downcutting. There were a number of meanders along the reach, and the channel is actively migrating. The reach appears to be used by livestock at the present time. The assessment was made during a period of very low water flow along the creek.

It was not possible to examine algal growth on this reach because the riffles had dried up, and the only water present was in small pools. Channel shading was fair; in addition to vegetation some shading was provided by steeply cut banks.

Hydrogeomorphology scores were variable. Twenty-five per cent of the banks were vertically

unstable and actively eroding; this resulted in a rating of just barely very good. Floodplain connection was poor due to the deep incision of the channel. Hydraulic habitat diversity and riparian soil integrity were only fair. There was no beaver activity in the reach. Some sections of the reach might provide suitable habitat for beavers, and the presence of this species would probably have a large positive impact of the functioning of the stream.

Fish and aquatic habitat also was variable. There was excellent overbank cover and very good pool and riffle distribution. Underbank cover was good. Cobble embeddedness was good at 27%. This result was somewhat surprising, considering the amount of exposed fine soils along the bank. Two possible explanations are that stream flows are not large enough to create much erosion, or that there has recently been a large and "flushing" flow event in Mud Creek, which, given the exposed shale layer on the bottom of much of the stream channel, would have carried the sediments further downstream (see comments for the Soussanna Ranch Reach, above). There was no large woody debris (score of poor), and no aquatic macroinvertebrate insects were found. However, large numbers of crayfish were present.

Riparian vegetation was also variable. There was good grass/forb and shrub cover in both the lower and upper riparian zones, but less than 3% cover in either zone for middle canopy trees, and no cover at all for upper canopy trees (no large cottonwoods were observed, although there were a few mature individuals just upstream from the assessment reach). Most of the shrub cover was from sagebrush, with only limited willows present. Overall, cover was good for the lower riparian zone, and only fair for the upper riparian zone. Shrub demography was very good, but tree demography was only fair (only a single age class present). Non-native grasses and forbs were assessed as poor (>50% of the cover was non-native), but non-native shrub and tree cover was very good, with only a few saltcedar individuals present within the reach. Grazing impacts were good, possible because there was limited food for livestock along the reach. Browsing was also good. Native ungulate use of the reach may be limited by the lack of suitable bedding and hiding cover near the stream.

Terrestrial wildlife habitat on the reach was either fair or poor, as a result of the limited presence of dense shrubs, and the very small number of middle or upper canopy trees. The highly incised nature of the stream channel also limited the number and diversity of fluvial habitats.

TRENDS IN THE FUNCTIONAL CONDITION OF THE MANCOS RIVER THROUGH MANCOS VALLEY

The individual RSRA surveys constitute the basic unit of analysis for this study. The scores for each reach describe the current functional condition of that reach, and suggest where restoration efforts might or might not be needed and where they could be most effective. The individual surveys also serve as a specific benchmark or point of reference by which the effects or impacts of any future restoration action (or lack of action) taken at that site can be monitored. However, because the surveys were repeated at a number of different locations within the Mancos Valley as well as at several upstream tributaries, it is also possible to examine trends in the functional condition of the Mancos River before, during and after it moves downstream through the valley. This type of detailed spatial analysis has several benefits. First, the condition of a reach will depend to some extent upon what is happening upstream of that reach, and in turn the condition of the reach will also affect what happens in areas that are further downstream. As a result, the interpretation and prioritization for possible restoration action of an individual reach always should be placed when possible within the context of the condition of adjacent areas. Second, because most of the human impacts on the Mancos River occur within the Mancos Valley itself, a spatial analysis of trends in functional condition makes it possible to examine the cumulative impacts of various human activities as the river moves through the Valley. This information in turn makes it possible to determine which elements of the existing stream-riparian ecosystem are most closely related to human activities, and therefore which of those elements that may be most suitable for future restoration programs.

The following section examines the overall and individual variable RSRA scores for reaches located first on tributaries of the Mancos River before they enter Mancos Valley, then for the reaches along Mancos River within the Valley itself, and finally for a reach in Mancos Canyon after the river has

Table. 3. Number and location of surveys for geographic trend analysis of functional condition (see text).

Number	River	Survey Reach	Elevation (m)	(feet)
1	West Mancos	Above Mesa Verde Diversion	2544	8344
2	West Mancos	Below Jackson Gulch Reservoir Diversion	2431	7974
3	West Mancos	Colyer Ranch	2310	7577
4	West Mancos	Above Weber Diversion	2226	7301
5	Mancos	Below Ratliff Diversion	2199	7213
6	Mancos	Redwood/Black	2171	7121
7	Mancos	Excelsior/Sewage Plant	2112	6927
8	Mancos	Road J Bridge	2068	6783
9	Mancos	Lazy F/W Ranch	2055	6740
10	Mancos	Perry Ranch	2021	6629
11	Mancos	Soussanna Ranch	1999	6557
12	Mancos	Mitchell Ranch	1952	6403
13	Mancos	Mesa Verde NP/Ute Reservation Border	1880	6166

left the Valley. The specific reaches included in this analysis are listed in Table 3; the number for each reach in the Table is then used as the identifier for the reach the Figures. The descriptions of the results for the surveys on the other tributaries (e.g., Chicken Creek, Mud Creek, etc.) are given above.

Overall Mean Score for Functional Condition

Figure 39 plots the overall condition score for the reaches included in the trend analysis. As might be expected, the condition of the stream-riparian ecosystem declines as one moves downstream through the Valley. It begins to improve once again after the river enters Mancos Canyon, although the data from the canyon itself are limited to the single site at the confluence of the river with Weber Canyon.

All of the reaches that were surveyed have been impacted to some extent by human activities. The trend in Figure 39 suggests that not only are these impacts most intense at the lower part of the Valley, but that some of these impacts (such as water diversions) may also have a cumulative effect on the river ecosystem. Since the overall mean score is simply a composite of individual scores, any interpretation of this pattern must consider all of the variables included in the RSRA survey. These are presented below.

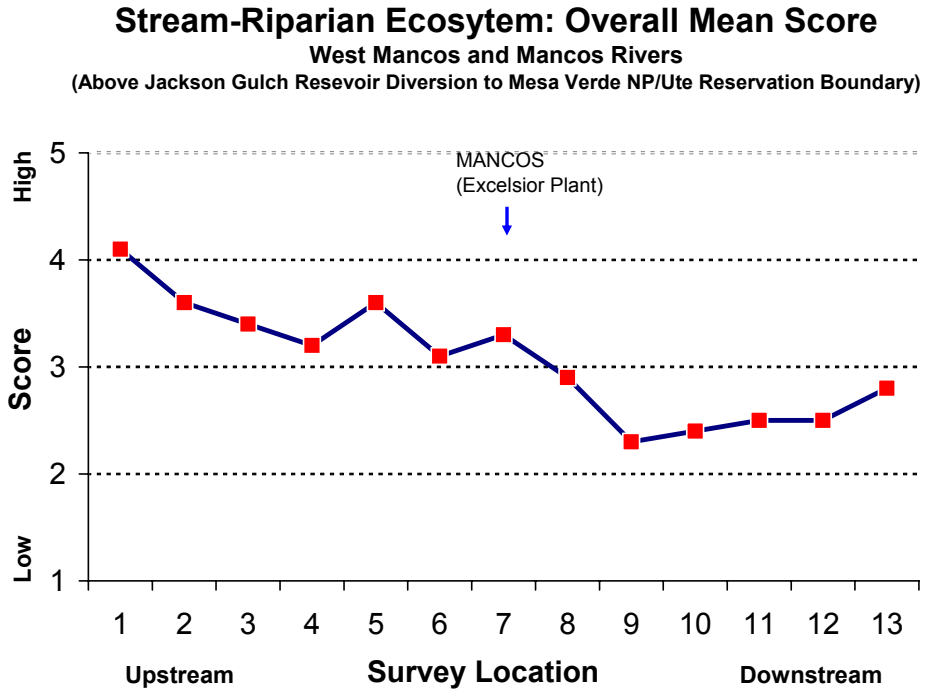

Figure 39. Overall mean score for the functional condition of the survey reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

Water Quality (non-chemical)

Figure 40 gives the mean non-chemical water quality scores for the reaches in this analysis. The scores are high before the river enters the Valley and then decline significantly by the time the river enters Mancos Canyon at the bottom end of the Valley.

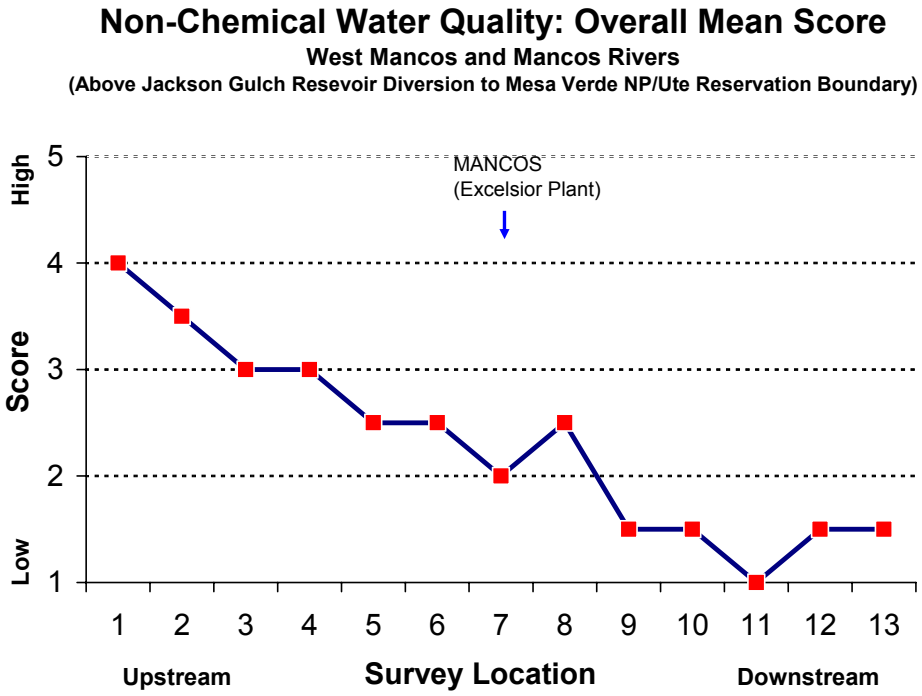

Figure 40. Mean scores for non-chemical Water Quality for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

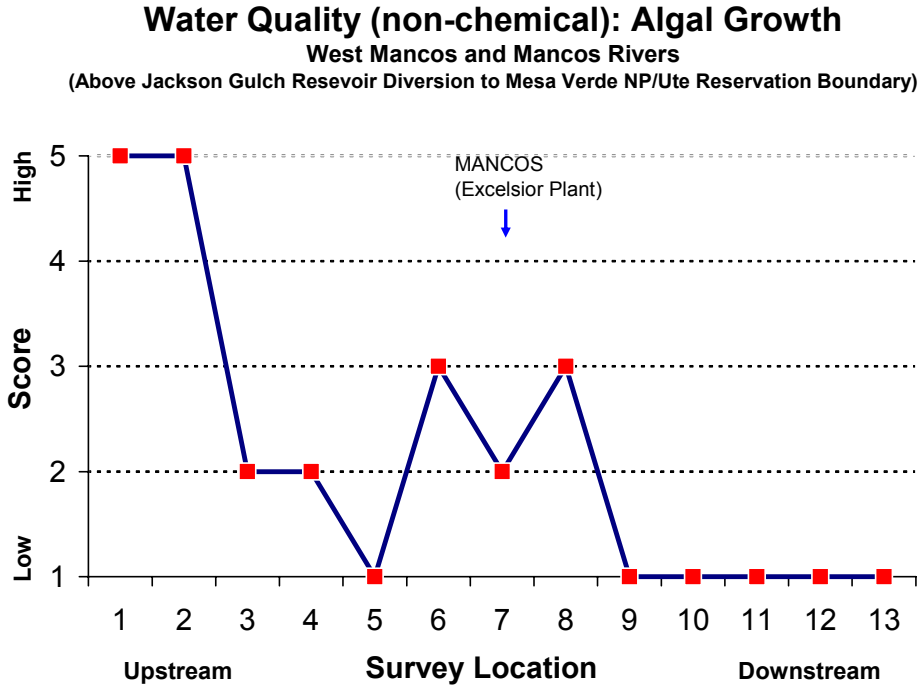

Figure 41. Scores for Algal Growth in reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

The RSRA protocol examines two aspects of water quality. The first, the amount of filamentous algal growth within the channel, reflects the amount of nutrients in the stream, such as nitrogen and phosphorus, as well as other types of pollution like animal wastes. Some amount of algae is natural in streams and rivers, and in fact is an important part of primary production within the aquatic system. However, excessive amounts of algae are usually harmful, since it will eventually cause oxygen depletion in the water column when the dead algal cells are decomposed by bacteria. This in turn will impact both aquatic insects and fish (adults and eggs). The scores for Algal Growth are shown in Figure 41. The two reaches upstream of the Valley, which are located in areas with limited human and agricultural impacts, score excellent. However, the amount of algal growth increases greatly as the river moves through the valley, to the point where algal growth may be of concern during certain periods of the year (for example, during low flows and when stream temperatures are high). The fact that there is less algal growth in the reaches that are in or directly adjacent to the town of Mancos suggests that the nutrients leading to the excessive growth are related to runoff from pastures and fields, rather than coming from urban input (including any impacts of the sewage plant). As noted below (Figure 53), the observed high levels of algae cover did not led to an absence of macroinvertebrate diversity in the middle and upper part of Mancos Valley, suggesting that it was not a major problem in those areas at least during the survey period. There were, however, very few aquatic macroinvertebrates found in the reaches in the lower part of the Valley. This suggests that the accumulating nutrient loads, when combined with limited water flows present in the lower valley, may be an issue in those areas.

The second component of non-chemical water quality examined was the percentage of the water surface in the river channel that is shaded by overhanging vegetation. Solar exposure in unshaded channels may cause increased water temperatures, particularly during the summer. Higher temperatures will in turn decrease the amount of oxygen that can be dissolved in the water. Many of the fish native to streams and rivers at the elevation of Mancos Valley require cool temperatures to survive and reproduce, and they will disappear from the system when water temperatures in the river become too high. High levels of solar exposure can also significantly increase the amount of water loss that occurs through evaporation, particularly in arid and semi-arid regions like the American Southwest.

As shown in Figure 42, the amount of channel shading was variable. It was poorer than expected in the upstream reaches on the West Mancos. This was due to the fact that the channel in these reaches was wide and shallow, as a result of past ditch and diversion structure construction activities. The scores were higher for the reaches in the upper part of the valley, where there was well developed stream-side vegetation. But in the lower part of the Valley, shading was low, due to both channel morphology (wide and shallow) and the lack of overhanging vegetation. The high scores in the upper valley suggest that the river could be well shaded through all of its length in the Valley and Mancos Canyon with appropriate management and restoration of the taller vegetation.

Hydrogeomorphology

The hydrogeomorphology section of the RSRA protocol examines the current physical structure of the channel and associated flood plain. It evaluates the extent to which fluvial processes in the stream-riparian system are in dynamic equilibrium, and they allow the ecosystem to function in a productive way as well as absorb and recover from the stresses of exceptional events (such as major flooding). Figure 43 gives the mean hydrogeomorphology scores for the Mancos Valley and adjacent reaches.

The first indicator in this group, Floodplain Connection and Inundation, is a measure of the likelihood that the stream will be able to escape its banks and flow into the flood plain during typical high flow events (every 2-5 years). Periodic flooding is important for many reasons to the health of the

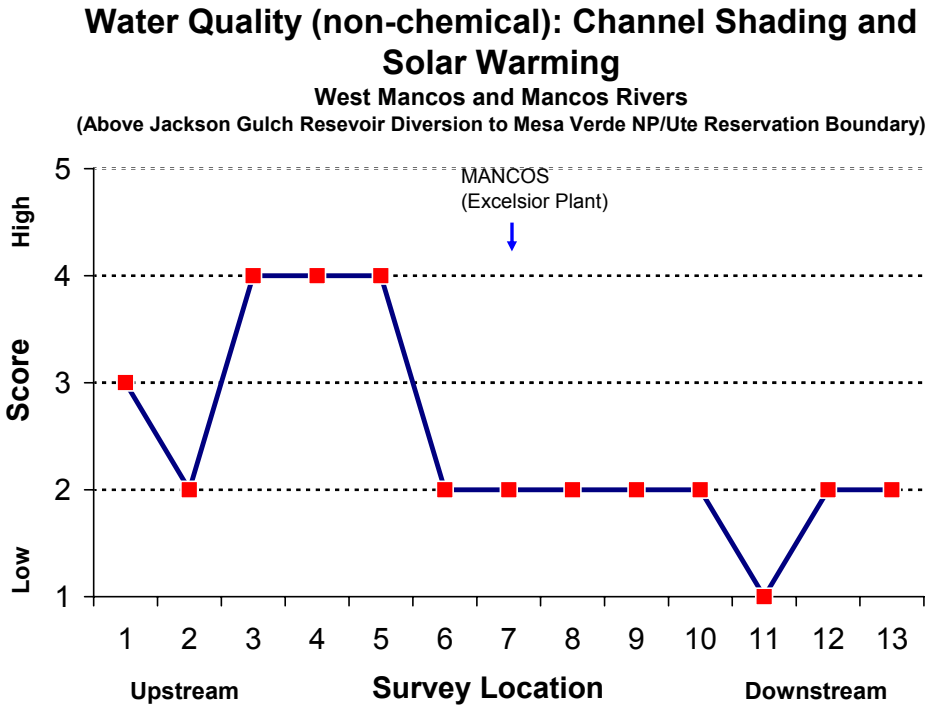

Figure 42. Scores for Channel Shading in reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

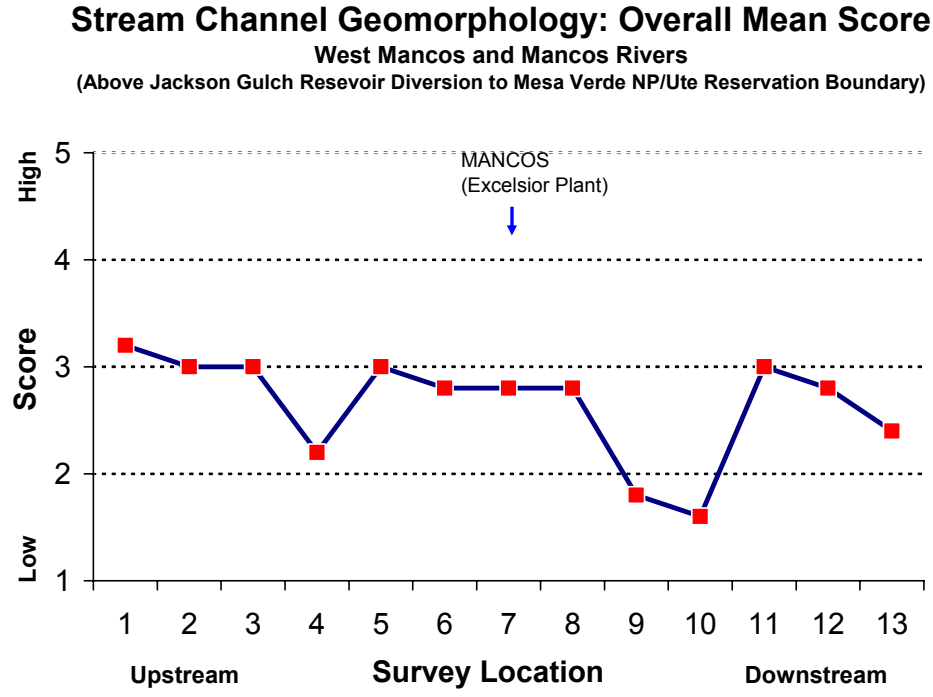

Figure 43. Mean scores for the Hydrogeomorphology, or stream channel structure, section for reaches in the Mancos Valley and adjacent areas (see text).

riparian zone. Flooding helps to maintain a high water table and moist soils, it adds nutrients to riparian soils, and it can encourage the germination and productivity of riparian plants. Conversely, when a stream or river is either downcut in a deeply incised channel, or it is isolated from the adjacent flood plain by artificial structures like levees, periodic flooding becomes impossible. Lack of flooding tends to dry out the riparian zone, to prevent the germination of new native plants, and encourage the invasion of upland and non-native plants like many exotic weeds and saltcedar. As shown in Figure 44, the survey reaches received uniformly low scores for flood plain connectivity. This was the result of both intentional levee construction, and in a few cases, an unintentional consequence of other construction activities (e.g., the Mesa Verde Pipeline in the Below Jackson Gulch Diversion reach). A consequence of

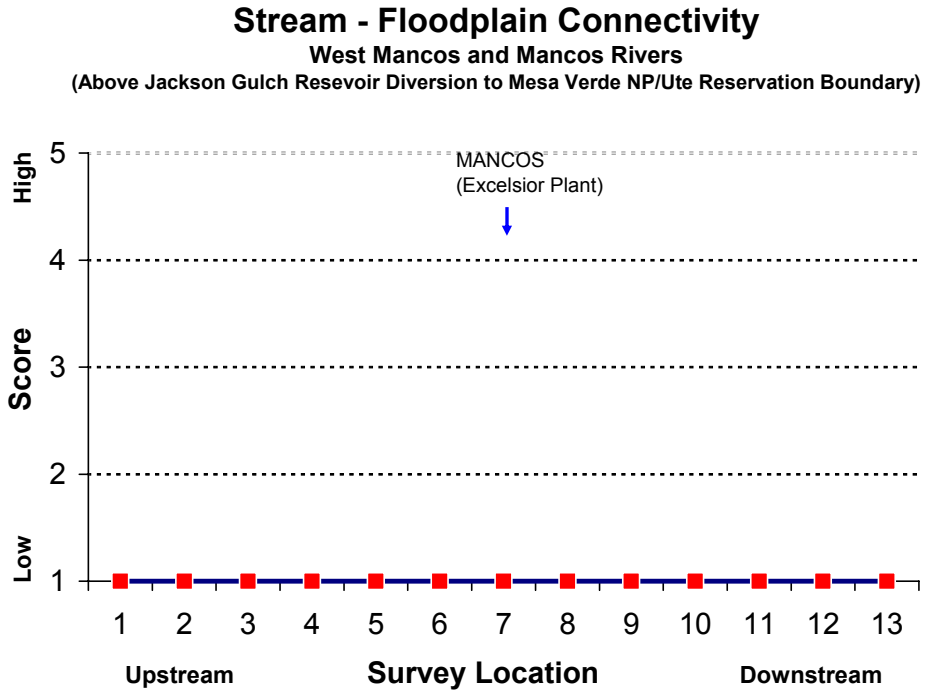

Figure 44. Scores for Stream-Floodplain Connectivity in reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

this situation is that the historic flood plain of the Mancos River in most of the Mancos Valley and the adjacent areas is no longer flooded by the river except during extreme run-off events. The implications of this situation are discussed in detail below.

Figure 45 gives the scores for Vertical Bank Stability for the survey reaches. This is a measure of the extent to which the sides of the channel are unstable and the soil is actively sloughing off into the streambed. This type of instability is usually a consequence of loss of vegetative cover, since the roots of grasses and many other plants help hold the bank soil together. Loss of vegetation usually results in accelerated rates of erosion, widening of the banks, and increased sediment loads in the stream. It will often also lead to the development of a wide and shallow channel cross-section.

Scores for Vertical Bank Stability were generally very good. This resulted from a combination of the presence of levees on the banks in many upstream areas, along with well developed vegetation elsewhere. The areas where the scores were lower tended to be located in the reaches where there was

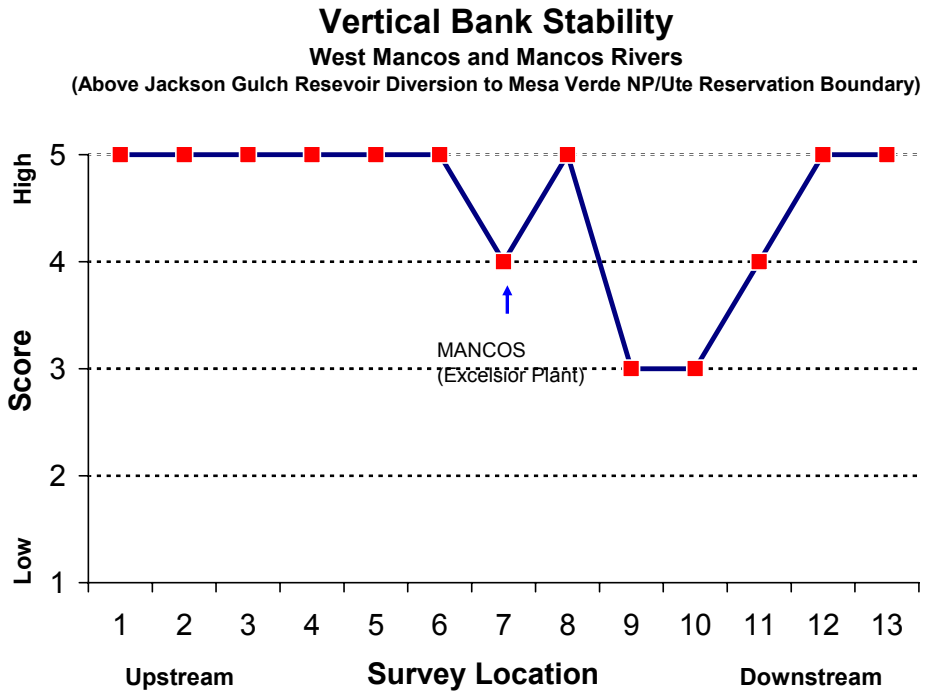

Figure 45. Scores for Vertical Bank Stability for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

substantial livestock use; however the situation in these reaches did not appear to be problematic because the channel was undergoing normal migration where the banks were unstable. Overall, the high scores for vertical bank stability are one reason why there is little active erosion or heavy sediment loads in this part of the Mancos River.

The scores for Hydraulic Habitat Diversity for the survey reaches are given in Figure 46. Different types of hydraulic features result from the interaction of the moving water column and the underlying physical substrate(s), and they provide habitats for different species of aquatic life as well as for different life-history stages of the same species. Highly modified or disturbed stream systems are often structurally simple: the channels are often straight and narrow, with a uniform depth and bottom). As a result, these streams and rivers often lack the diversity of hydraulic habitats necessary to support a diverse complement of aquatic species. The scores for the Mancos River in the survey area were variable, but they generally declined as one moves further downstream. In many cases, the combination of leveed banks, a cobbled bottom, and the absence of woody debris (which can create local erosion and increased structural diversity) where responsible for the lower scores. However, the fact that several of the downstream reaches did have very good scores for this variable indicates that there is the potential to increase hydraulic habitat diversity throughout the Valley in the future.

Figure 47 gives the scores for Riparian Area Soil Integrity and Disturbance for the survey reaches. This measure reflects the degree to which the riparian soils in the flood plain have been disturbed either by natural processes (e.g., flooding) or by human related activities (e.g., foot and vehicle traffic, trampling by domestic livestock, etc.). While some level of soil disturbance is natural in riparian ecosystems, excessive amounts can lead to increased erosion and loss of organic materials in the soils, as

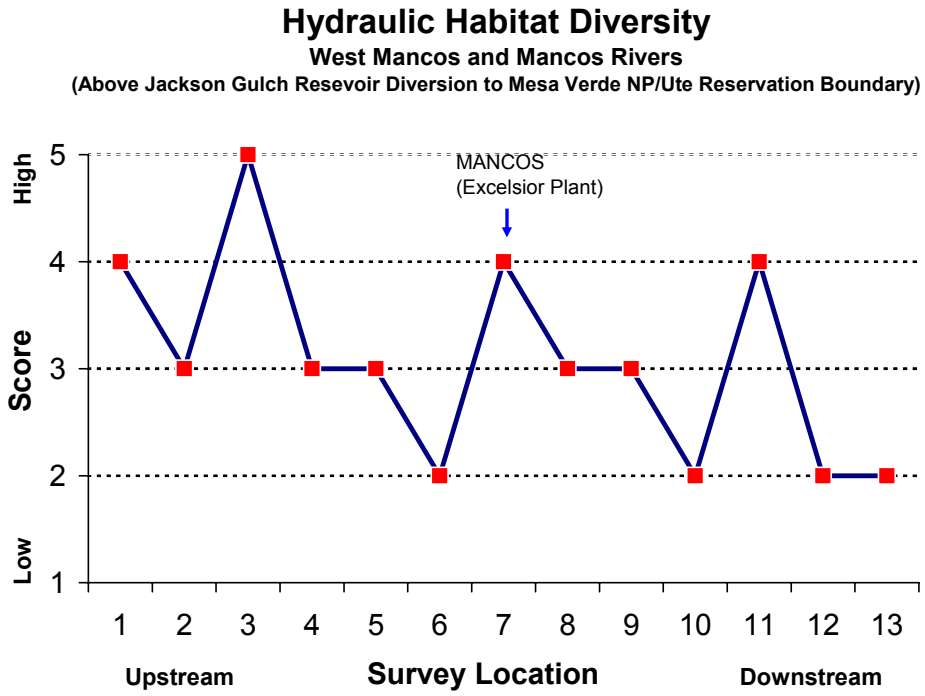

Figure 46. Scores for Hydraulic Habitat Diversity for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

well as to the invasion of the flood plain by upland and non-native or exotic species. The degree of soil disturbance was highly variable in the survey area, and showed no clear pattern as one moves downstream. There was little disturbance in reaches above the valley and in the areas near the town of Mancos. The lowest scores occurred in agricultural reaches where there was active use of the floodplain by domestic animals; however there were adjacent areas that were also used for livestock operations that received very high scores. This suggests that the degree of riparian area soil disturbance within a reach tends to reflect the specific management practices that are in place on that particular reach.

The final variable in the hydrogeomorphology sections is for beaver activity (Figure 48). Beavers are keystone species in most stream-riparian ecosystems, and they once occurred in almost all of the small and medium-sized streams and rivers in the western United States. Beavers alter many hydrogeomorphological and ecological processes: their dams and the ponds behind them reduce flooding and the annual variation in water flows, they collect silt and they reduce erosion. Beaver ponds provide important habitat for fish, amphibians, and many other types of aquatic wildlife, and the marshes and wet areas on the edges of the ponds provide germination sites and adult habitat for many different species of riparian plants. We observed no beaver activity in any of the reaches for the trend analysis, although there were beavers present in Chicken Creek and adjacent to several of the other survey locations. Almost all of the reaches could support beavers, except perhaps those where woody riparian vegetation is limited at the current time. Their presence would have a major positive impact on the overall health of the stream-riparian ecosystem within in the survey area.

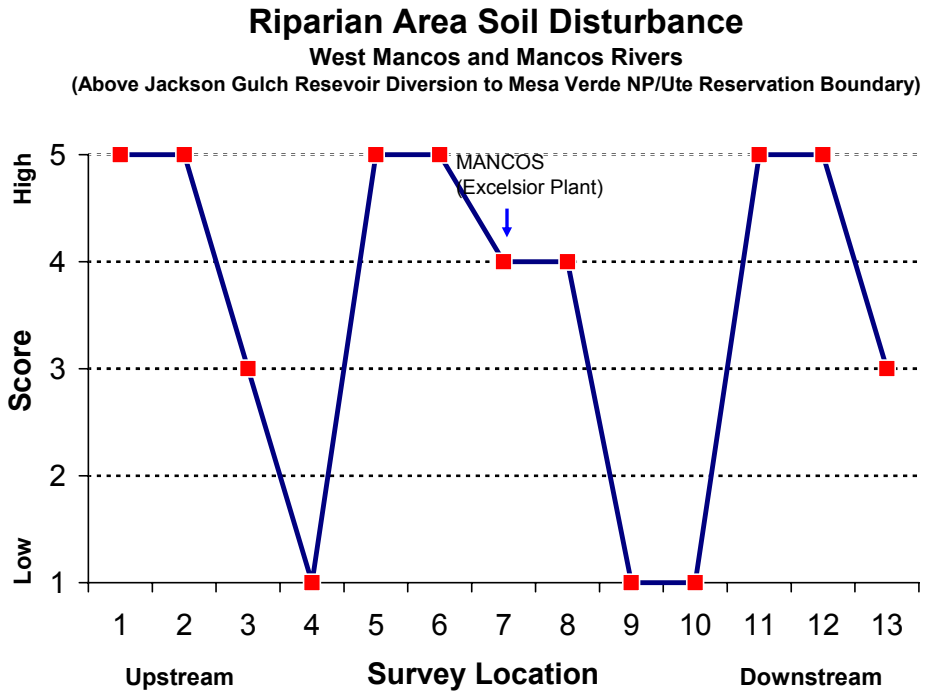

Figure 47. Scores for Riparian Area Soil Integrity and Disturbance for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

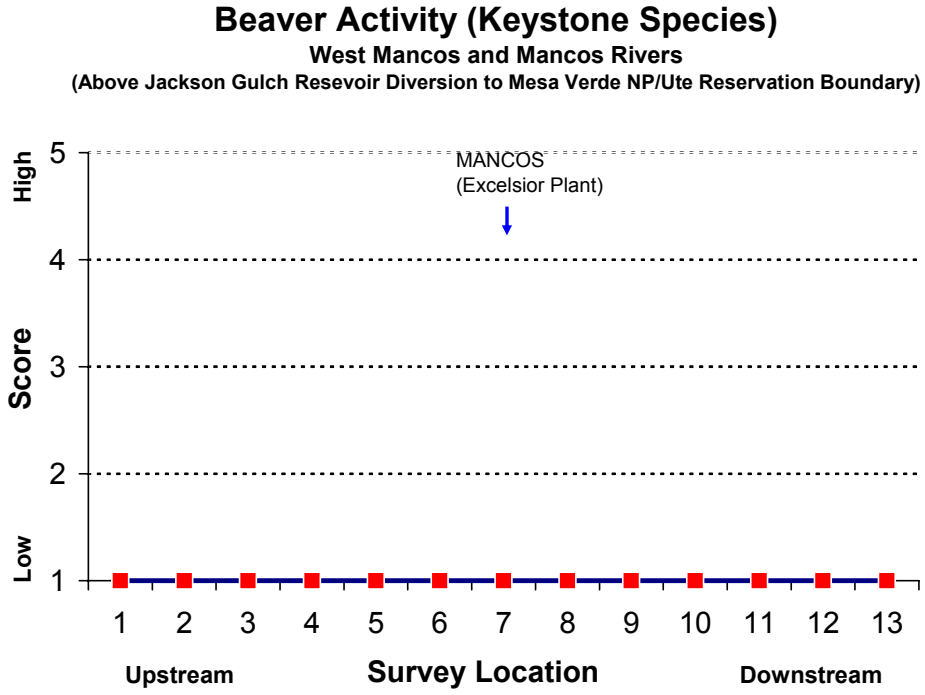

Figure 48. Scores for Beaver Activity for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

Fish and Aquatic Habitat

This section of the RSRA survey examines the suitability of the stream-riparian ecosystem as habitat for native fish and other aquatic species.

One of the most critical prerequisite for streams and rivers to provide habitat for the aquatic species that were historically present is whether or not those streams and rivers that originally flowed throughout the year (were perennial) continue to have water present within the channel at all times. All of the surveys for this study were conducted during the summer, and all of the reaches had at least some flowing water at the time that they were examined. The day to day variation in the amount of water in a system like the Mancos River (the hydrograph, see Figure 3 above) will depend on numerous factors, including both natural variables such as the amount of winter snow pack, the extent of spring and summer rains, and summer temperatures (which affect both evaporation and transpiration by plants), as well as human modified conditions such as the amount of water withdrawals for agriculture and the levels of water storage and releases in the various reservoirs. It is possible that some of the reaches included in this analysis might go dry during periods of limited precipitation and high demand. Because the RSRA protocol considers only the *current* condition of the stream-riparian ecosystem, we did not attempt to evaluate the potential impacts on fish and aquatic habitat of periods when stream flow within the reach might drop to zero.

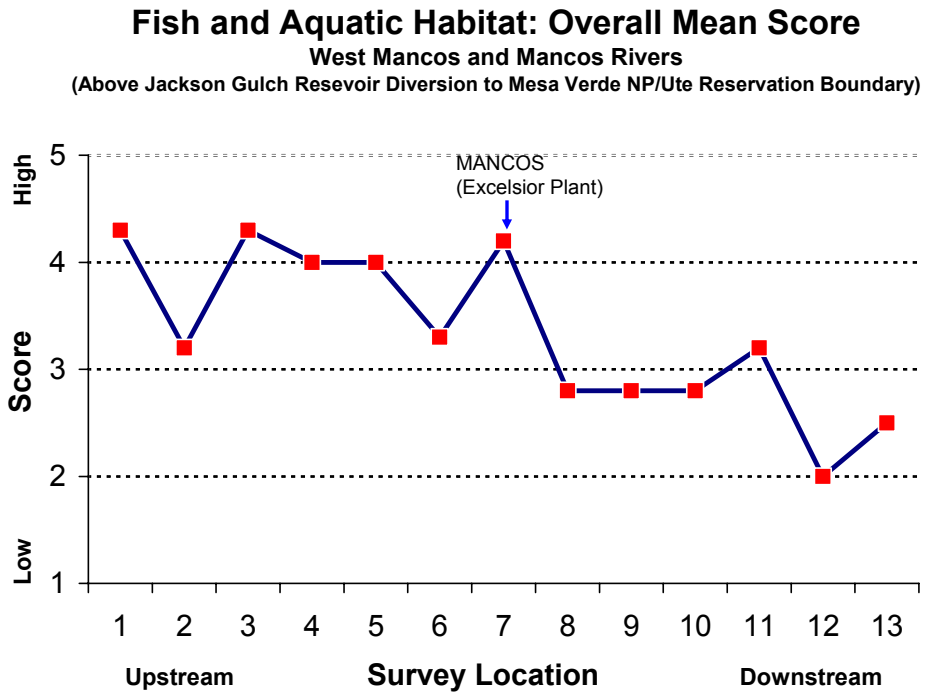

Figure 49. Mean scores for Fish and Aquatic Habitat for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

As shown in Figure 49, the mean scores for fish and aquatic habitat were generally good in the reaches above the town of Mancos. Although there were a few problems in this area (see individual scores below), with minor restoration this part of the river would be likely to provide good habitat for native cold water fish species, including native trout. The condition of reaches in the lower part of the

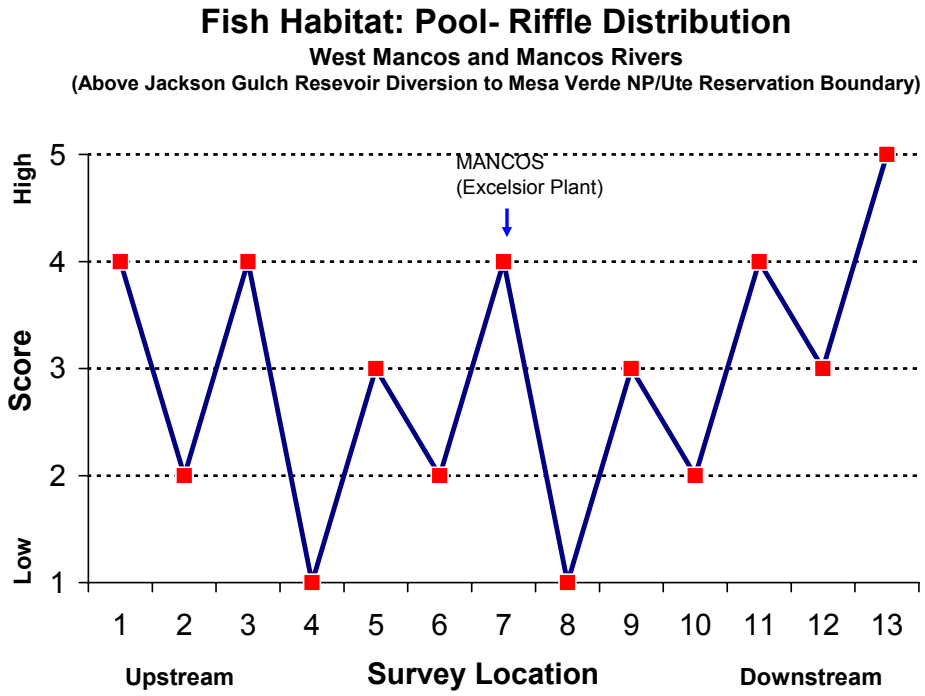

Figure 50. Scores for Pool and Riffle distribution for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

valley below Mancos was not as good. Establishing native fish populations in this area would be more problematic, although still potentially possible. There was slight improvement of the fish and aquatic habitat in the last reach, the Mesa Verde/Ute Reservation reach in Mancos Canyon, although there were specific problems in that reach that made it currently unsuitable for many native species (see discussion above). It is possible that the reaches in Mancos Canyon were originally occupied by more warm water tolerant species than the upper reaches.

Figure 50 presents the scores for the distribution of pools and riffles within the survey reach. In undisturbed streams and rivers, areas of deep and slow moving water (pools) will often alternate with sections of the channel that are shallow and where the water is fast moving (riffles). Fish use the pools to rest, feed and hide from predators. Many species use the gravel-bottomed riffles to lay their eggs because the water contains high amounts of dissolved oxygen needed by the developing embryos as it is aerated as it moves over the shallow bottom. The riffles also are where many aquatic insect larvae attach to rocks in order to develop. The number, size and distribution of pools and riffles are therefore a good indicator of habitat quality for fish and other aquatic species.

The scores for Pool and Riffle distributions were highly variable, and did not show any consistent pattern as one moved from upstream to downstream through the Mancos Valley. Most of the survey reaches exhibited a highly cobbled bottom, and were covered by medium and large sized rocks that have been transported down from the surrounding mountains and then deposited during past large flood events. Whether or not pools and riffles will develop with this type of channel will depend in part upon local variation in channel morphology. Pools and riffles were rare or absent in reaches where the banks had been leveed, where the channel was uniformly straight, and where there was an absence of woody debris.

The fact that reaches that scored low on this variable were often located adjacent to reaches where there were numerous pools and riffles suggests that this aspect of fish habitat quality could be improved with appropriate restoration action.

Figure 51 presents the scores for underbank cover along the survey reach. Fish and many other aquatic species such as crawfish and frogs often use undercut banks as a place to escape from predators. Undercuts develop when the roots of healthy riparian vegetation growing along the bank of the channel stabilizes the soil above the water line, while part of the bank that is below the roots and underwater erodes away. Conversely, undercut banks are absent in areas where is little vegetation and the entire bank is rapidly eroding, or where the banks have been armored by artificial levees.

There was only limited underbank cover for fish and other aquatic species throughout the Valley, as well as in the upstream reaches (Figure 51). This was primarily a result of levee construction (including in parts of the upstream reaches), although in a few areas downstream it was also the result of a wide and shallow channel morphology combined with only limited riparian vegetation along the banks.

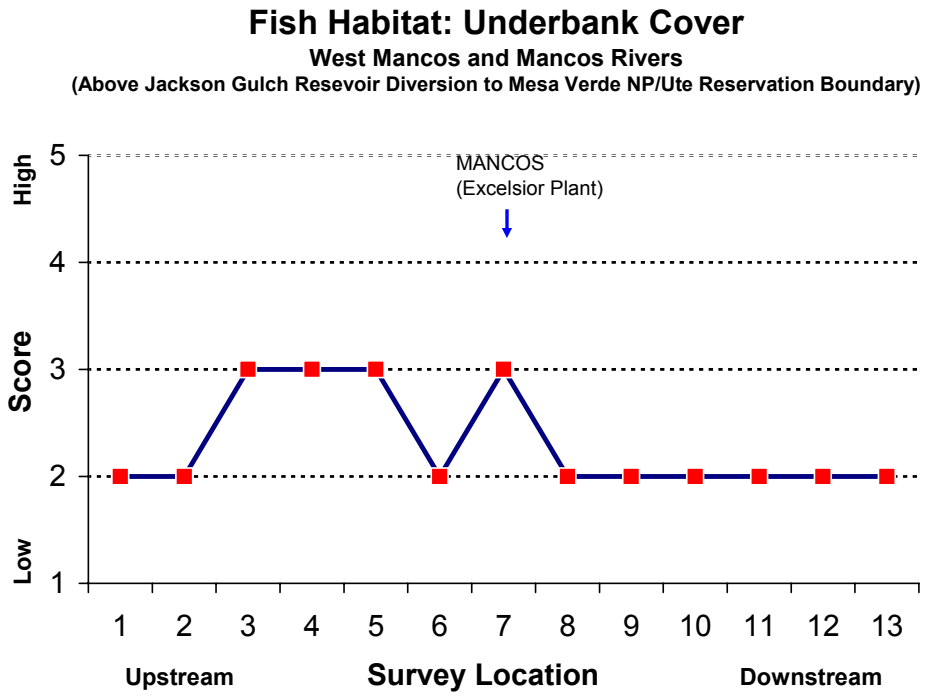

Figure 51. Scores for Underbank Cover for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

Another important component of habitat quality for fish and other aquatic species is the existence of exposed cobble on the channel bottom. Fish lay their eggs between the cobbles, and aquatic insect larva often attach themselves to the bottom of exposed rocks. However, when sediment deposition and altered hydrographs (typically when there are no longer high flows that would scour the channel bottom clear of fine sediments) causes the spaces between cobbles to fill up with silt, sand and organic material, it reduces habitat suitability for fish and their for many of the insects that they eat.

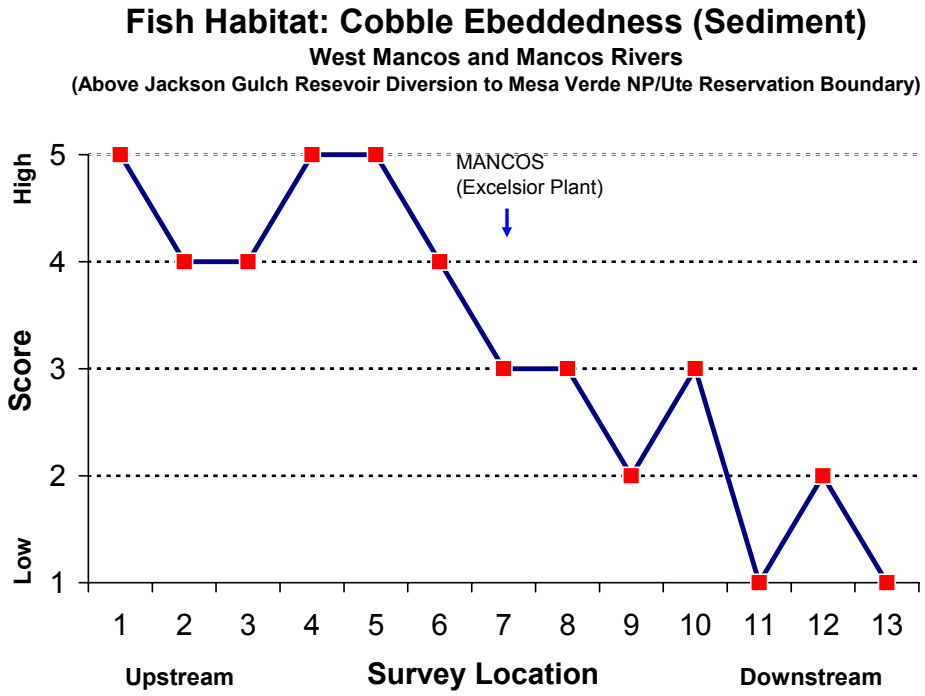

Figure 52. Scores for Cobble Embeddedness for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

Figure 52 gives the scores for this variable. The level of cobble embeddedness was very good or excellent in the reaches above Mancos Valley, as well as at most of the above the town of Mancos itself. However, below the town, the degree to which silt and other sediments covered the cobbles increased, to the point where in the lower reaches the level of embeddedness was likely to limit both fish and aquatic insect production. This situation was probably the result of both reduced water flow (progressively more water is removed from the river for irrigation as one moves downstream, with the major removals occurring just above the town of Mancos), as well as increased sediment deposition into the channel due to lower levels of vegetation on the hillside surrounding the river in the lower parts of the valley. The cobbles in the lowest reach, at the Mesa Verde National Park- Ute Indian Reservation border, were almost fully covered by sediments and ash from runoff from the areas impacted by the recent fires on the west side of Mancos Canyon.

Figure 53 gives the scores for the diversity of aquatic macroinvertebrates themselves in the study reach. These species, which in this section of the Mancos River include primarily the aquatic larvae of insects such as caddis flies, mayflies, and stone flies, and similar species, not only provide food for fish, but their presence is a good indicator of stream health and water quality, including such factors as temperature stress, nutrient and pollutant loads, dissolved oxygen levels, and sediment loads (see above). Almost all of the reaches received excellent scores for this variable, indicating water quality is generally very good throughout the Valley, and that the town of Mancos is not having a major impact on water quality. The exception was the two most downstream reaches, where there were no aquatic insects whatever, and only a few crawfish were found. The absence of the insect macroinvertebrates appeared to be due to a combination in the lower reaches of low water flows (resulting in temperatures stress), possibly high nutrient loads (see Figures 41 and 42, above) and high levels of cobble embeddedness (Figure 52).

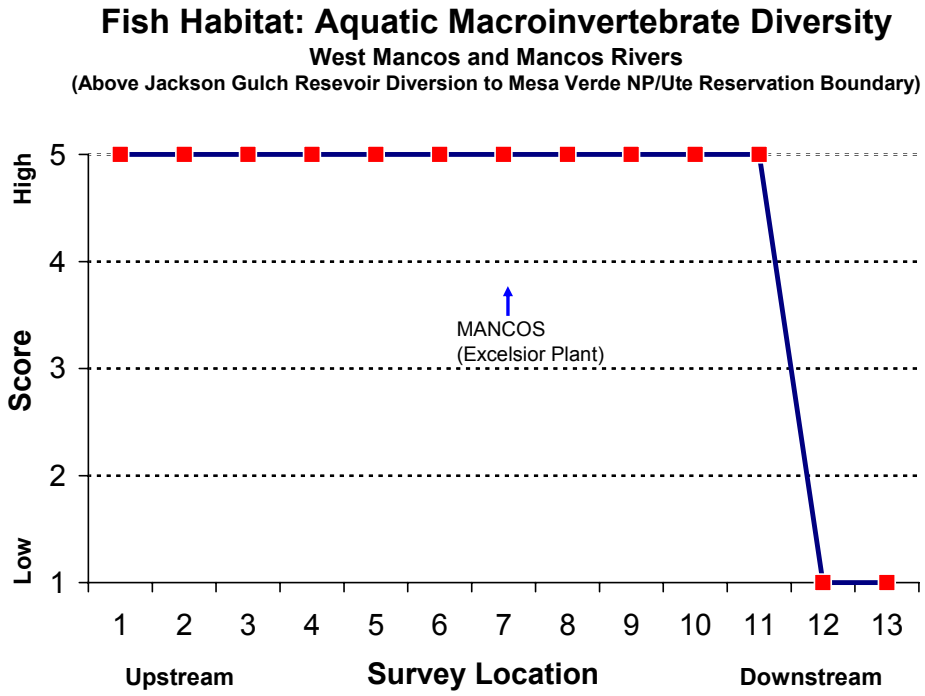

Figure 53. Scores for Aquatic Macroinvertebrate Diversity for reaches in the Mancos Valley and adjacent upstream and downstream areas. The two lower reaches held only crawfish (see text).

It should be noted that one of the other survey locations, not included in Figure 53, and on the East Mancos River near its confluence with the Middle Mancos, also had no aquatic invertebrates present during the surveys. This appears to be the result of some specific chemical pollution in the East Mancos upstream from the survey site, rather than the factors mentioned above for the downstream survey sites (see the individual description of the East Mancos reach, above).

Figure 54 gives the scores for the amount of large woody debris that was found in the survey reach. LWD was defined as pieces of wood that were at least 15 cm (6") in diameter and at least 1 m (3 ft) in length. Large woody debris that is resting in the stream channel or along the banks and at least partial submerged provides important fish and amphibian habitat, for nursery cover, feeding areas, and protection from predators. LWD also play an important role in shaping channel morphology and capturing silt, particularly in small and medium sized streams and rivers like the Mancos. Streams with adequate amounts of large woody debris tend to have greater habitat diversity, a natural number of meanders, and has greater resistance to negative impacts of high water flow. As seen in Figure 16, most of the reaches in the upper parts of the survey area had adequate or better amounts of LWD, although there were exceptions in the agricultural areas just above the town of Mancos. There was significantly less woody debris in the reaches in the lower parts of the valley; this probably was the result of both fewer trees along the banks that could fall into the river, as well of reduced water flows that would carry LWD that entered the channel in the upper parts of the area further downstream. As expected, much of the LWD in the reaches above the valley was pine and aspen trees, while downstream it consisted primarily of cottonwood. The latter decomposes quickly, and this factor may also contribute to the lack

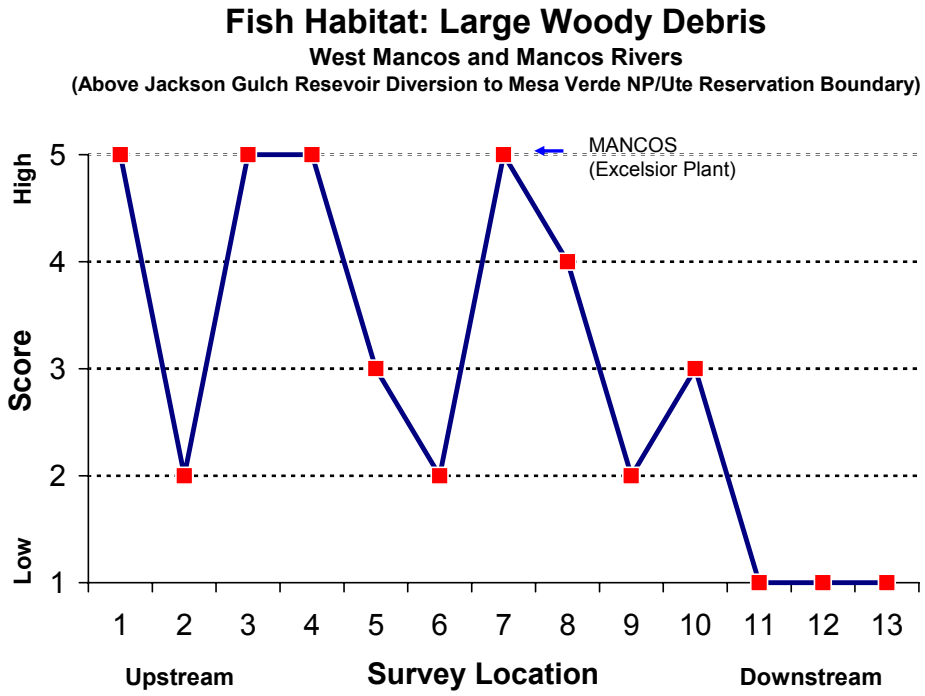

Figure 54. Scores for Large Woody Debris for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

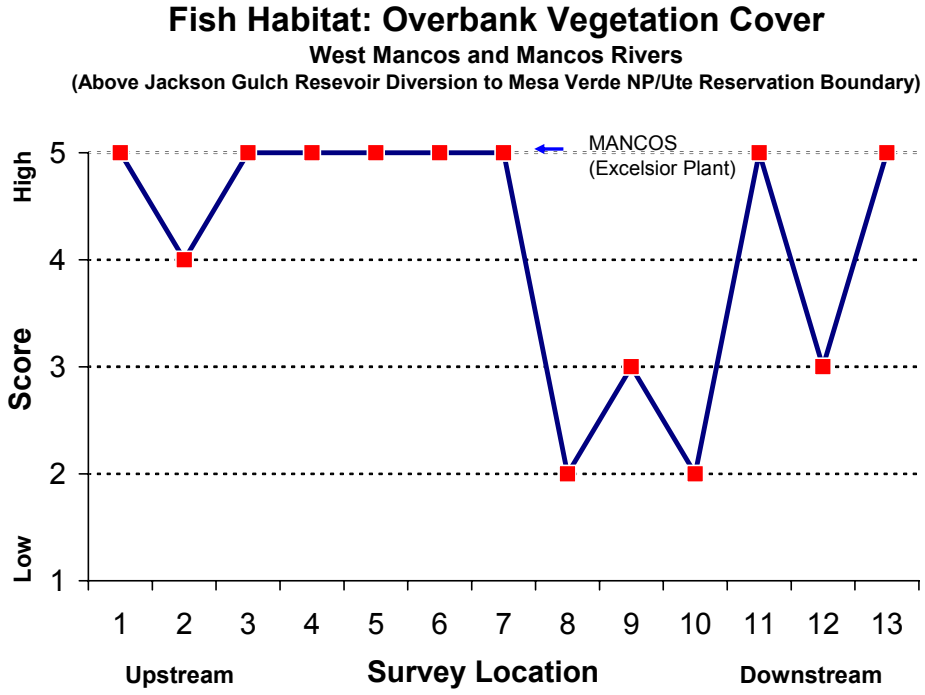

Figure 55. Scores for Overbank Cover and Terrestrial Invertebrate Habitat for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

of LWD in the lower reaches. The addition of LWD to the middle and lower reaches could result in a significant improvement in fish habitat and overall channel morphology.

The final variable in the Fish and Aquatic Habitat sections examines the amount of terrestrial vegetation on the stream bank that actually overhangs the water, also is important for fish production and survival. Both the plant material itself and the insects that live on the vegetation can drop directly into the channel, providing a critically important source of food, energy and nutrient input into the stream for fish and other aquatic species. Overhanging vegetation also provides shading, and bank protection and sediment trapping during high flow events. As shown in Figure 55 above, the scores for overbank cover were generally excellent in the tributaries and upper parts of the valley. Below the town of Mancos, the scores fell to low levels in some reaches, where there was little vegetation at all along the stream banks. However, two of the three furthest downstream reaches again achieved excellent scores, indicating that this component of fish habitat quality could recover in the lower scoring areas with appropriate management.

Riparian Vegetation

This section of the RSRA survey examines the presence and composition of the vegetation within the historic flood plain that is adjacent to the stream channel. Although there are numerous ways to define "riparian" plant species, in general riparian species are those that require higher levels of moisture in the soil than would be available in the surrounding upland areas, and which receive that moisture primarily from water moving through the stream and adjacent areas, either as surface flows during high water events (overbank flooding) or as underground flows beneath the flood plain. In many cases, riparian species need moist conditions for seed germination, and the roots of the adult plants may reach directly into the water table. Outside of the riparian zone, the roots of plants may not always be able to reach directly into the water table, and they do not require underground or surface water to grow or for their seeds to germinate. The latter area is called, in contrast to the riparian zone, the upland zone.

For the RSRA evaluation, the riparian zone is further divided into two parts. The Lower Riparian Zone (LRZ) is the area that is immediately adjacent to the stream channel, and which, during most years, is covered by flowing water during the period(s) of annual peak water runoff (i.e., for the Mancos River, during spring runoff from snowmelt, and occasionally during large summer rain events). Soils in this zone are almost always saturated, and as a result, it is occupied by wetland and water-loving plants such as sedges, rushes, as well as some types of grasses, herbs, shrubs and occasionally trees. Above the LRZ, and usually separated from it by a small bank, is the Upper Riparian Zone, which, in undisturbed systems, then extends outward in a series of terraces to the edge of the flood plain. As one moves further away from the channel, the frequency of flooding becomes progressively less, since the amount of water flow required to reach the higher elevations becomes progressively greater. While riparian water-loving plants occur in the URZ, it is characterized by an increasing frequency of species as one moves further away from the stream channel that have deep root systems, and that do not always have to have water near the surface to germinate or flourish.

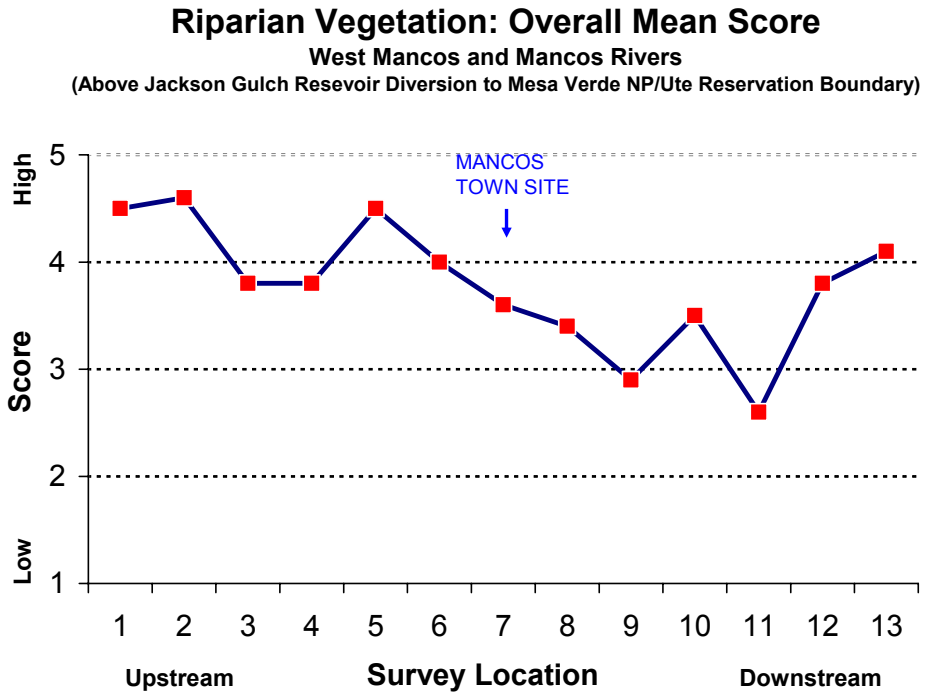

Figure 56. Mean scores for the Riparian Vegetation survey variables for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

Figure 56 gives the mean scores for Riparian Vegetation in the survey area. The condition of the vegetation was generally very good in the survey reaches above the town of Mancos (including several agricultural areas), declined somewhat in the lower parts of Mancos Valley, and then began to improve again as the River left the valley and entered Mancos Canyon. The reasons for this trend are discussed in the following sections.

Figures 57-58 give the overall vegetation cover scores for the Upper and Lower Riparian Zones separately. Cover is defined here as the probability that a ray of light from the sun at noon would hit some plant material (leaf, branch, etc.) as it moved from the sky to the ground. It is therefore a measure of the amount of vegetation present at a particular spot (see the RSRA User's Guide, Stacey et al. 2006, for a detailed explanation of this variable, and how the data for it were collected).

Cover values were determined for four different structural layers, and then combined to determine the final cover scores. Figures 59-66 below give the individual values for each of the structural layers, as the percentage of sample points where vegetation cover was present somewhere within the layer relative to the total number of points sampled: a) ground cover layer, consisting of sedges, reeds, grasses and forbs, b) shrub cover layer, defined as woody plants less than 4 meters (approximately 15 feet) tall, and including both species like willows and buffaloberry, as well as the smaller individuals of tree species, c) middle canopy shrub and tree layer (woody species, for individuals that range in height from 4 meters (approximately 15 feet) to 10 meters (approximately 35 feet) tall), and d) upper canopy tree layer, where individual trees are at least 10 meters (approximately 35 feet) tall. The data for the cover at reach 10 were collected during a stakeholders' workshop, and the information for the different structural layers was not reported individually.

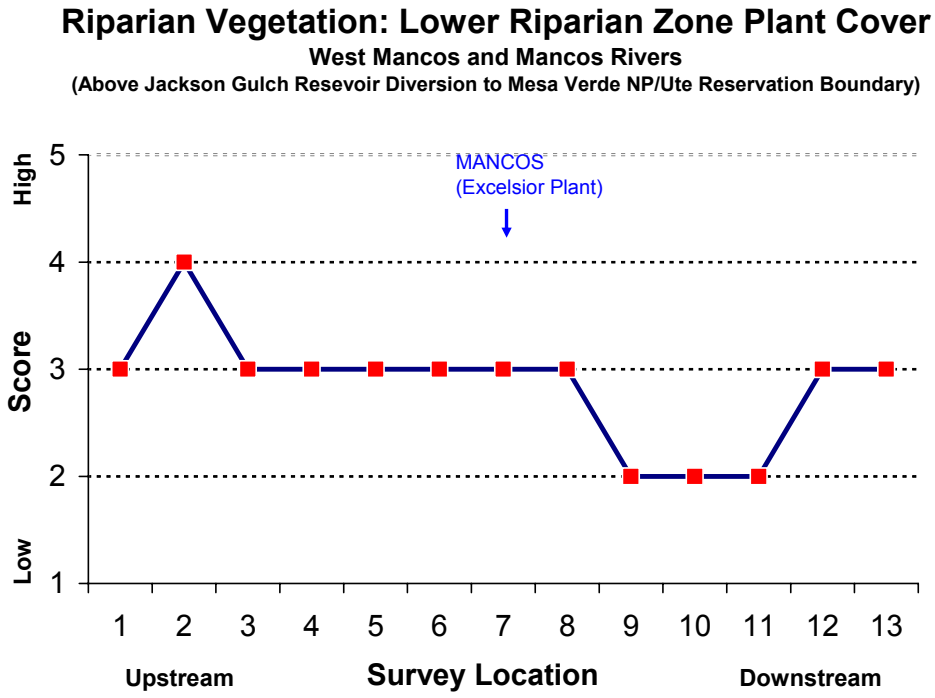

Figure 57. Scores for overall Plant Cover in the Lower Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

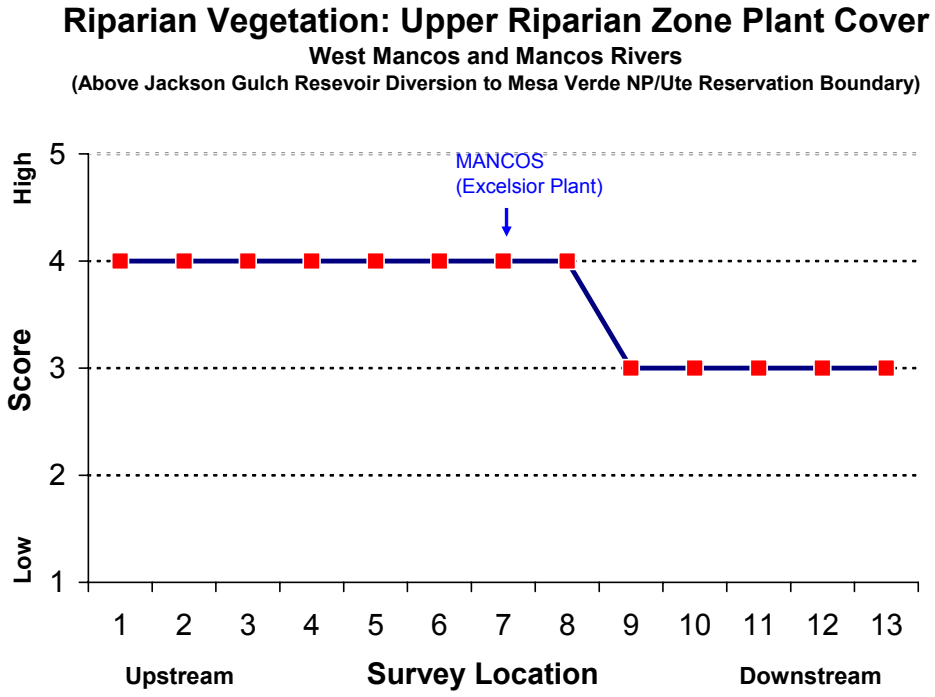

Figure 58. Scores for overall Plant Cover in the Upper Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

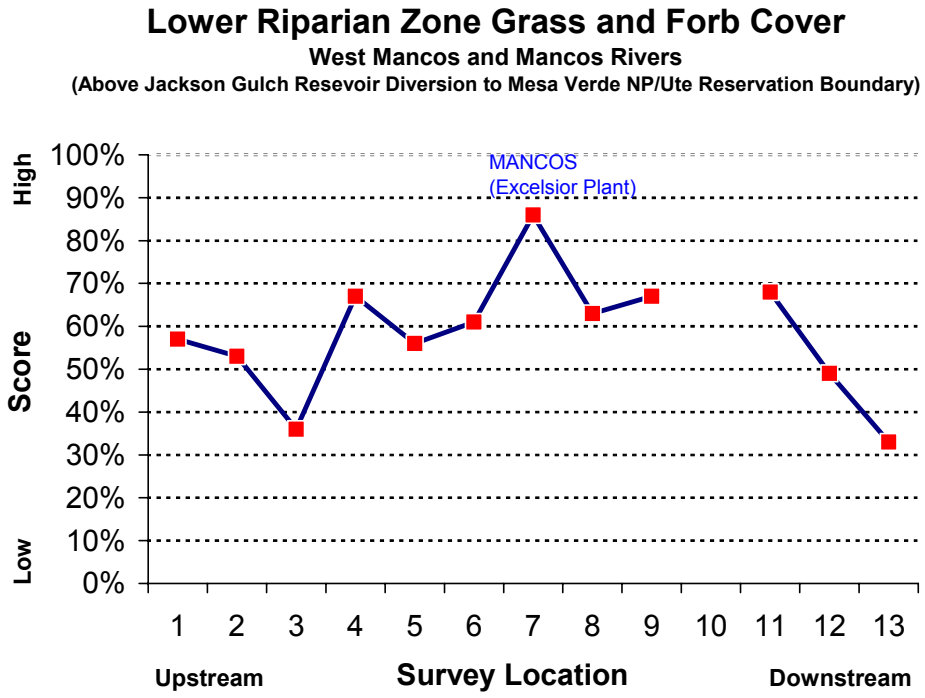

Figure 59. Values for the percentage of area with grass and forb plant cover in the Lower Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

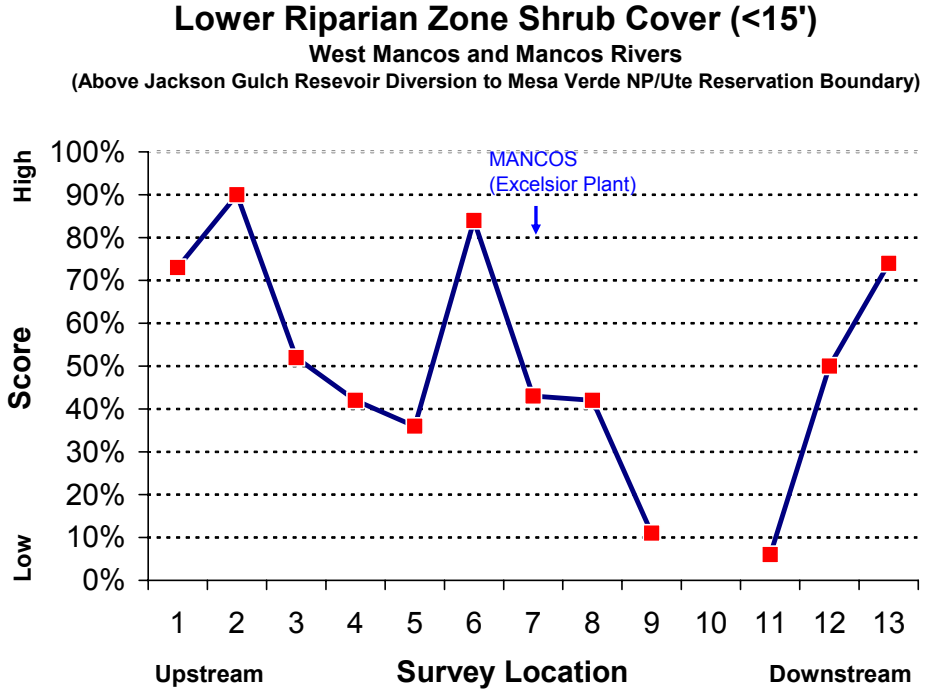

Figure 60. Values for the percentage of area with shrub cover in the Lower Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

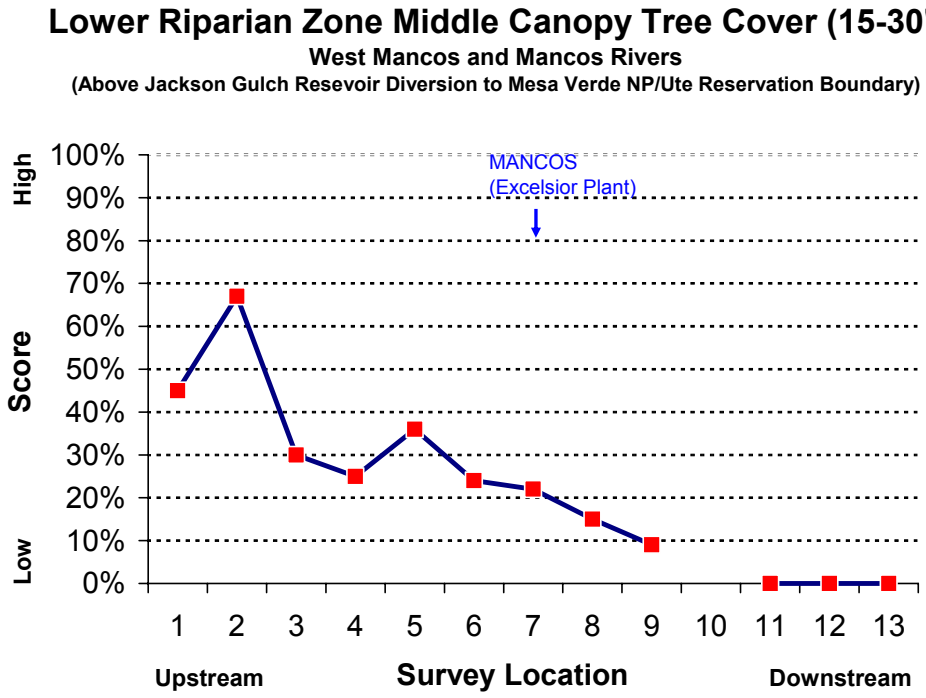

Figure 61. Values for the percentage of area with middle canopy tree cover in the Lower Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

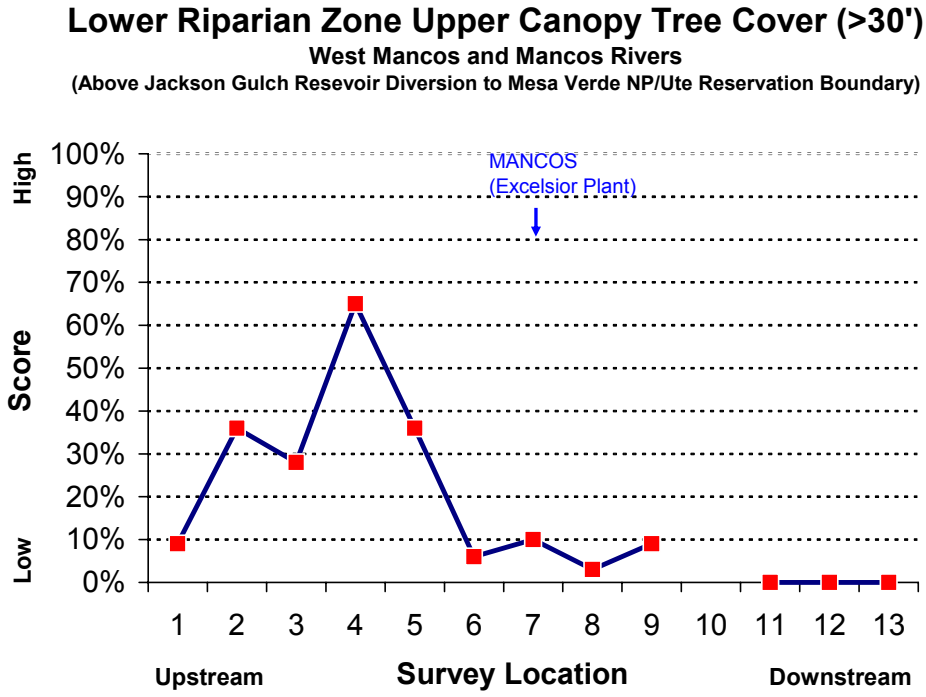

Figure 62. Values for the percentage of area with upper canopy tree cover in the Lower Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

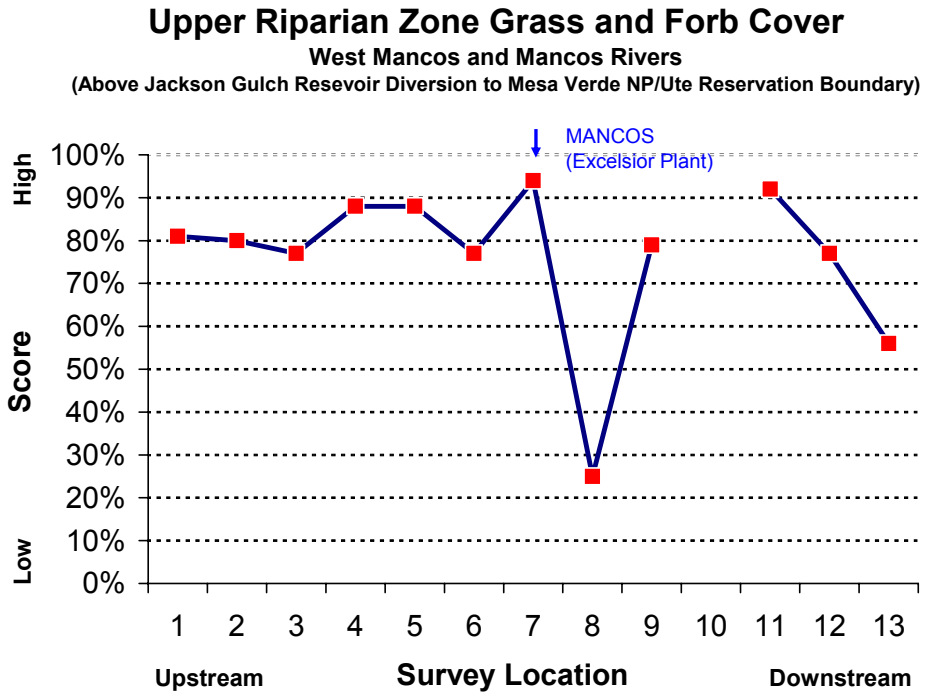

Figure 63. Values for the percentage of area with grass and forb tree cover in the Upper Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

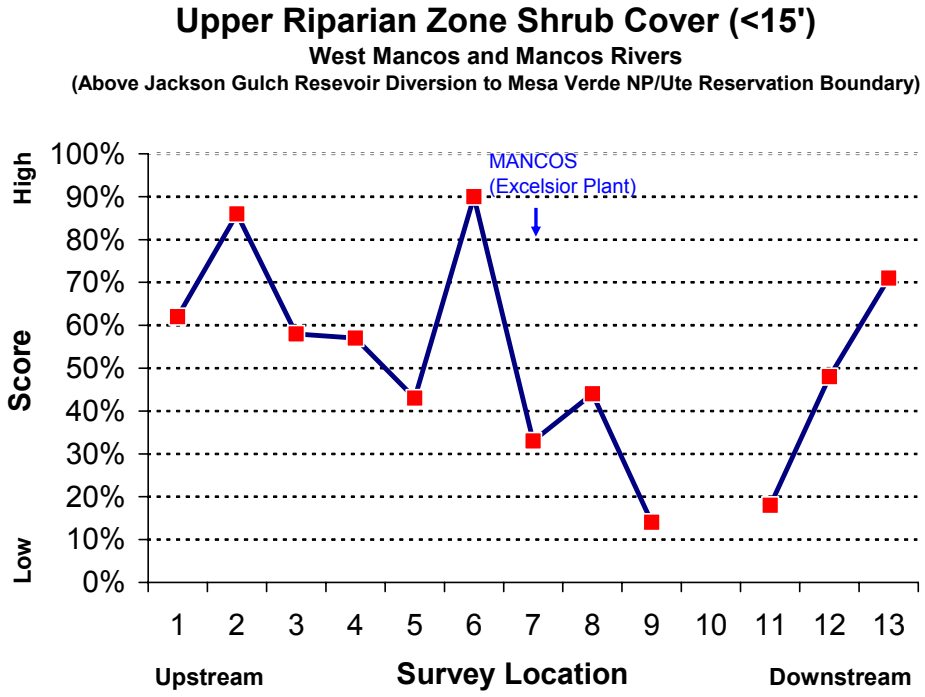

Figure 64. Values for the percentage of area with shrub cover in the Upper Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

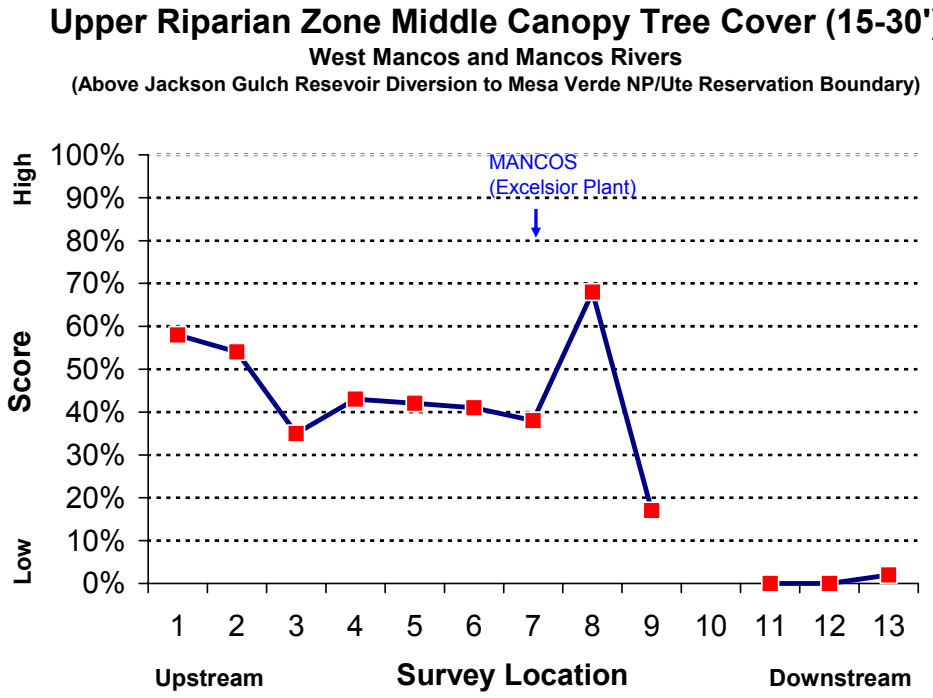

Figure 65. Values for the percentage of area with middle canopy cover in the Upper Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

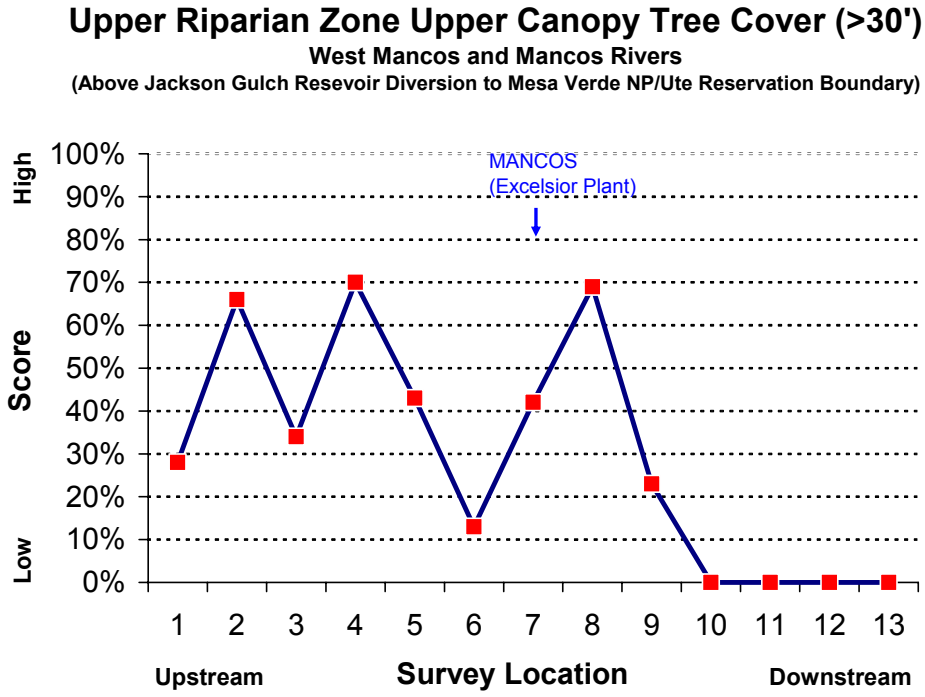

Figure 66. Values for the percentage of area with middle canopy cover in the Upper Riparian Zone for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

The mean cover scores for the lower riparian zone (the zone directly adjacent to the active stream channel) were generally only good, even in the most upstream reaches (Figure 57). Grass cover in this zone was usually less than 70%, except at the reach that was located within the town of Mancos (Figure 59). This was due primarily to the presence of levees in many of the reaches, which were made of cobble and did not provide good growing sites for grasses and forbs. There was also some effect from livestock use in several of the reaches in the lower part of Mancos Valley. Shrub cover in the LRZ was variable (Figure 60), with high values in the upstream tributaries, within the town of Mancos itself, and also after the river entered Mancos Canyon. The low cover values in the reaches just upstream and downstream from the town of Mancos appear to primarily reflect high levels of browsing by native ungulates (primarily mule deer) in these reaches (see Figure 72, below). Middle and upper tree canopy cover in the LRZ were also generally low (Figures 61 and 62), particularly in the lower reaches. The absence of tree cover in much of this area is probably a result of levee construction, combined with past high levels of browsing by both domestic livestock and native ungulates.

Overall scores for vegetation cover in the upper riparian zone (sampled at the edge of the flood plain closest to the stream) were generally better than for the lower riparian zone, reflecting in part the absence of levees in this zone. With the exception of several reaches, the amount of grass and forb cover in this zone was high, and usually 80% or more coverage (Figure 63). Shrub cover (Figure 64) was variable, as in the lower riparian zone, with the highest values in the upstream and downstream reaches, plus within the town of Mancos. Middle and upper tree canopy cover (Figures 65 and 66) was also variable but highest (although still lower than would be expected compared to reference conditions) in the upstream reaches. There were very few middle and upper canopy trees in the lower part of the valley, which again probably reflects heavy past use of the flood plain by native ungulates and domestic livestock. The absence of these trees provides a partial explanation for the low scores for channel shading and solar warming that these reaches received as seen earlier in Figure 42).

As shown in Figure 44, above, the flood plain in the survey area is almost completely disconnected from the active stream channel: all reaches received the lowest possible score of 1. As a result, the flood plain of the Mancos River in this area probably rarely receives any overbank flooding, except during periods of extremely high flows. There was little evidence that this type of flooding had occurred recently in any of the reaches examined. In most stream and river systems in the American Southwest, where the channel is as isolated as it is from its flood plain as it is in the Mancos Valley, the flood plain typically would have dried up, and there would normally be very little riparian vegetation present in the URZ. In spite of the lack of channel connectivity and overbank flooding, the riparian vegetation in most of the study reaches within the Mancos Valley itself is currently very healthy. Grass cover is extensive (Figure 63), and there are numerous wet meadows and even some cat-tail marshes throughout the entire riparian zone. The shrubs and trees that are present are healthy, and there are numerous seedlings of both willows and cottonwoods in the flood plain (see Figures 66 and 67 below). Both of these plants require moist soil conditions to germinate and grow. Because the amount and the condition of the riparian vegetation currently found in the flood plain is not consistent with the channel geomorphology of the Mancos River in this area, and the apparent lack of frequent overbank flooding due to channel incision and the presence of levees in many reaches, there must be some other input of surface and underground water flow into the flood plain. This flow must be from sources adjacent to, but outside the floodplain.

From the field observations made during the surveys, including the presence of wet meadows at the upper edge of the flood plain that is furthest away from the stream channel, as well as a number of small streams and wet areas that are adjacent to and below the irrigated fields above the flood plain, it appears that the source of the water that is maintaining the current healthy condition of the riparian vegetation along this section of the Mancos River is leakage and possibly run-off from the numerous irrigation ditches that run parallel to the river throughout most of the valley. The importance and implication of this factor in preserving a healthy and productive flood plain is discussed below.

The other variables in Riparian Vegetation section of the RSRA survey examine additional factors that affect the current and future health of the riparian vegetation in both the lower and upper riparian zones. Figure 67 gives the scores for the demographic structure and the recruitment of the dominant native shrub species along each reach, and Figure 68 gives results for the same variables for the dominant native tree species. For the reaches in the Mancos Valley and adjacent areas, the dominant native shrubs were willow and in a few lower reaches, buffaloberry, while the dominant riparian trees in all areas was either narrowleaf or Fremont cottonwood. In order for there to be healthy populations of both woody plant groups in the future, individuals of all age classes should be present in the riparian zone, including seedlings, immatures or saplings, mature individuals, and dead clumps (shrubs) or standing dead snags (trees). When one or more age classes of the dominant species is missing from an area, it indicates that something in the past or something is now disrupting the natural processes of reproduction and individual plant replacement. In time, if that is happening, there may be a complete loss of the species in the area as the older individuals die off and are not replaced by any younger plants.

As shown in Figures 67-68, the scores for native shrub and tree demography and recruitment were generally very good or excellent, and for almost all reaches, either all or all but one of the four ages classes were present. This indicates that there has been ongoing recruitment of shrubs and trees in these reaches for a number of years, and that if current recruitment continues individuals that die off as they age are likely to be replaced by new shrubs and trees. In a few reaches, particularly in some of the more heavily grazed sections, one or more age classes are missing at the current time, and particular attention should be given to the successful recruitment of seedling shrub and trees in these areas for the future (see notes to individual surveys).

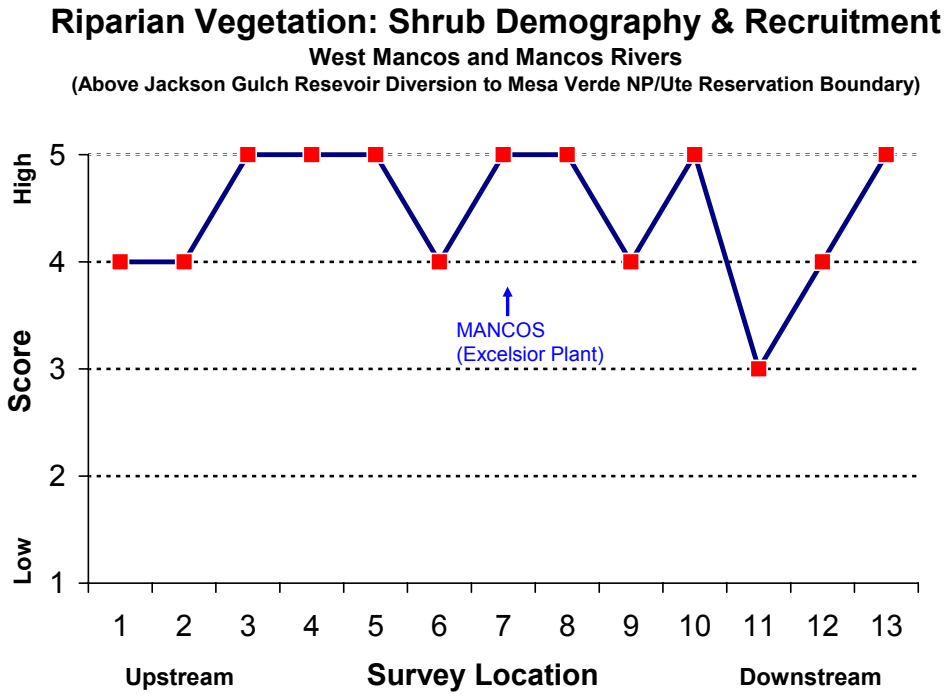

Figure 67. Scores for Native Shrub Demography and Recruitment for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

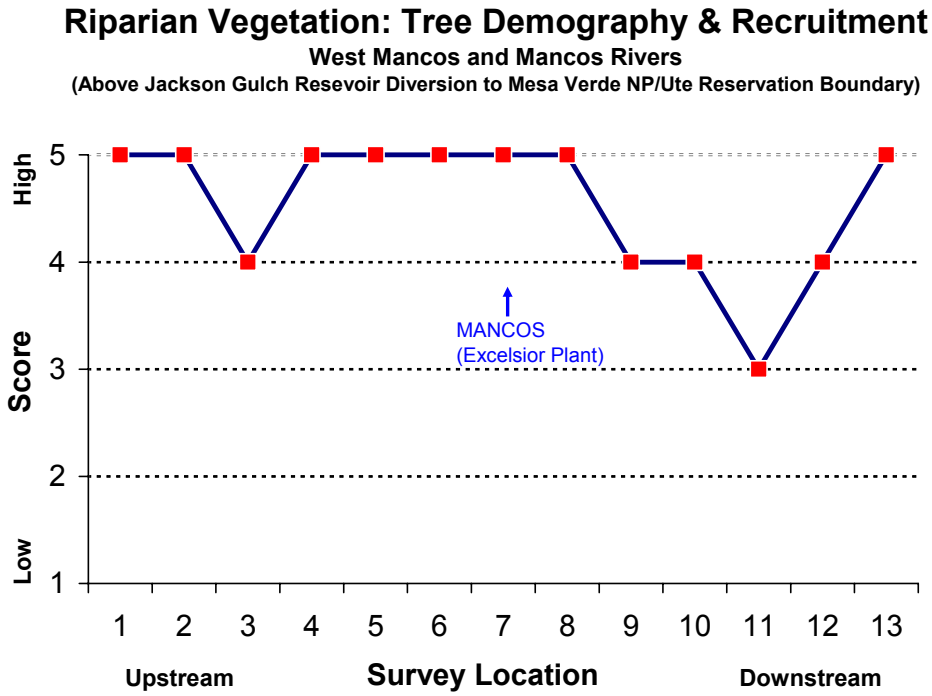

Figure 68. Scores for Native Tree Demography and Recruitment for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

A common occurrence in many riparian areas in the American Southwest and many other regions is the invasion of non-native plants, including grasses and forbs, as well as woody shrubs and trees. Non-native plants species influence ecosystem structure, and productivity, and can alter many ecosystem processes such as soil chemistry and the intensity and frequency of wildfires. Strong dominance by non-native plants may displace native species, eliminate key attributes of habitat quality for native wildlife (including invertebrates like butterflies) and may limit both native ungulate and domestic livestock use.

Figure 69 presents the scores for the estimated relative amount of cover within the survey reach that was provided by non-native grasses and forbs, compared to that provided by native species. While non-native grasses and forbs were almost entirely absent in the reaches above Mancos Valley, there were increasing levels of these species as one moved further downstream. Interestingly, non-native grasses and forbs were again almost entirely absent from one of the lower reaches (reach number 11). This was an area where there were no levees lining the channel, and where the stream was naturally meandering. As a result, the riparian soils in this section of the river were very moist and rich in organic matter. This finding suggests, as has been noted elsewhere, that non-native species are most likely to invade a riparian area when the natural hydrological processes and soils have been disturbed.

Figure 70 provides the same scores for cover from non-native shrubs and trees. In contrast to most other rivers of a similar size and elevation in the American southwest, there were no or almost no non-native woody plants in the riparian area of the upper reaches, and relative few in the lower parts of the valley as well. There were small numbers of Russian olive and saltcedar in some of the lower reaches, and these populations appear to moving slowly upstream. Saltcedar had been actively removed from the reach in Mancos Canyon by Mesa Verde National Park, and additional removal programs currently underway or planned within the Valley may halt or slow this invasion. However, the small numbers of non-native

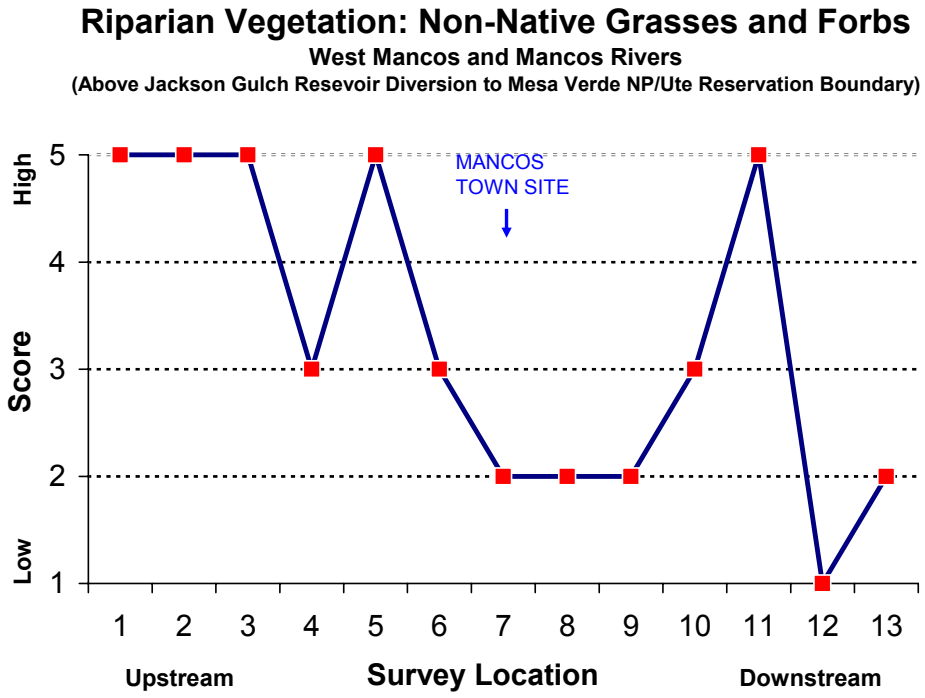

Figure 69. Scores for relative amount of cover created by Non-Native Grass and Forb species, for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

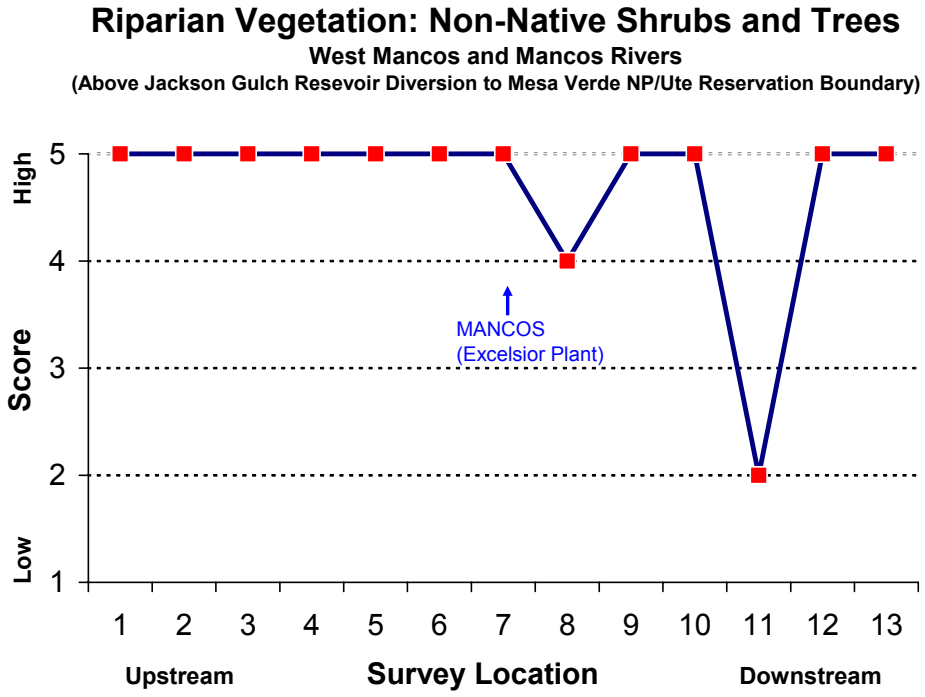

Figure 70. Scores for relative amount of cover created by Non-Native Shrub and Tree species, for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

woody species present throughout Mancos Valley at the current time is exceptional, and is probably due at least in part to the moist soils and well-developed native riparian vegetation in much of the flood plain that results from the leakage of water from the irrigation ditches within the valley.

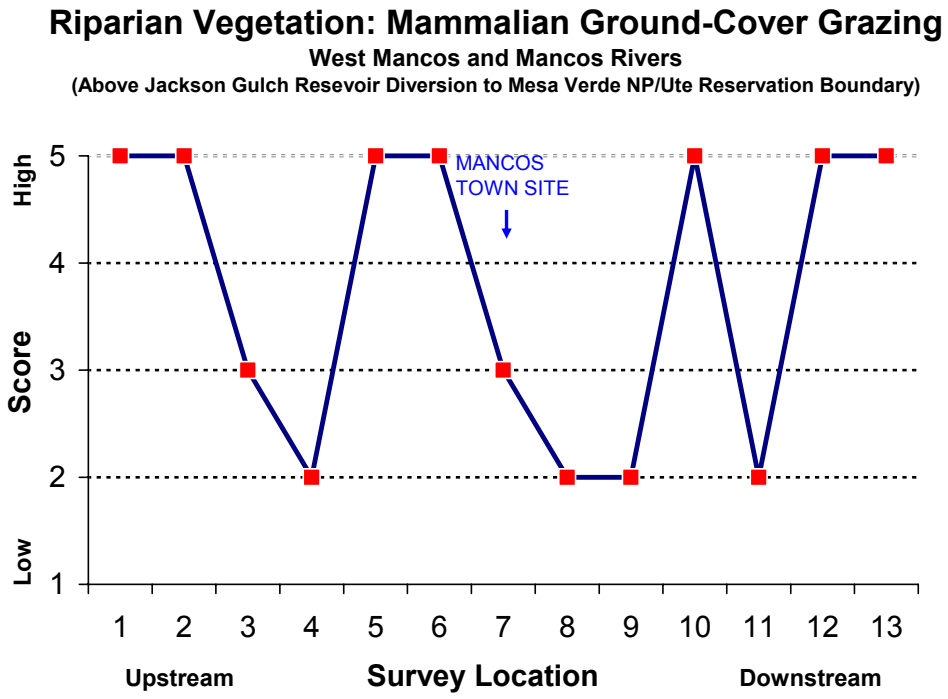

Figure 71. Scores for extent of Mammalian Herbivory, or grazing impacts on ground cover (grasses and forbs) in the lower and upper riparian zones for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

The final two variables in this section examine the impacts of large mammal use of vegetation in the upper and lower riparian zones. Figure 71 presents the scores for the level of grazing on grasses and forbs in both zones, as determined by the percentage of samples in the survey transect where the plants had been clipped off, compared to those samples where there was no evidence of clipping (see the RSRA User's Guide for a discussion of the survey protocol). Most of the grazing in the riparian zone within the Mancos Valley is done by domestic livestock, although deer and elk may also graze occasionally in some reaches, particularly in areas outside the valley. Intense levels of grazing can affect the condition of ground cover, encourage the invasion of exotic species, lead to increased soil compaction and erosion, and change overall ecosystem function. As seen in Figure 71, grazing impacts were highly variable among the survey reaches, with high rates of grazing seen primarily in areas where the reach was part of an active domestic livestock pasture. The level of grazing in these pastures was having a negative impact upon the health of the riparian ecosystem in those reaches, and the planned exclusion of livestock from the riparian corridor in several of these reaches will clearly be beneficial.

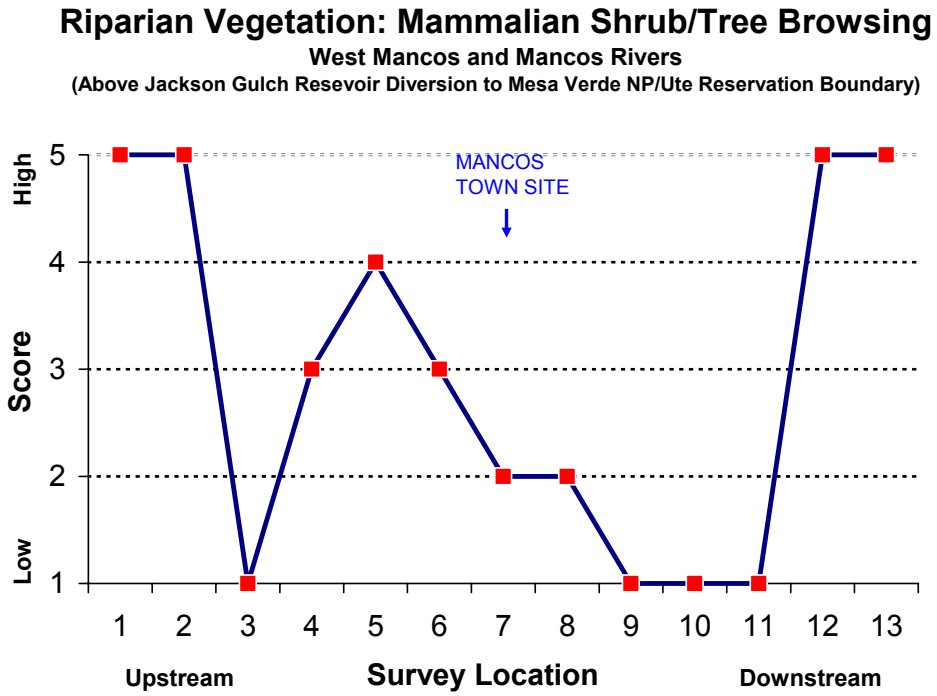

Figure 72. Scores for extent of Mammalian Browsing impacts on woody vegetation (shrubs and small trees) in the lower and upper riparian zones for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

The second major impact of large mammals on riparian vegetation is when the animal eats, or browses, the end or the growing tip of the branches of woody plants, including both shrubs and small trees. Browsing can affect the health of these plants by stopping the future growth of the branch that has been eaten, and continued high levels of utilization will eventually result in the death of the plant. Over time, this can cause the loss of all shrubs and trees in a local area, a situation that is commonly seen in many of the riparian areas in the American southwest and elsewhere. Figure 72 presents the scores for mammalian browsing, as determined by the percentage of shrubs and small trees that showed evidence of clipping at the tips of the branches somewhere on the plant, relative to those that did not show such evidence (see the RSRA User's Guide for a discussion of the survey protocol). Browsing impacts were again highly variable among reaches, with very little browsing see in the two upper and two lowest reaches, and high rates of browsing observed in the reaches around and downstream from the town of Mancos. Although we did not directly attempt to determine the specific mammal species that were responsible for the heavy browsing levels in these reaches, a number of the most impacted reaches were located in areas where there was no evidence of current domestic livestock use. In addition, we frequently encountered mule deer while conducting the surveys, particularly in areas that were close to the town of Mancos. This pattern suggests that deer are the major browser at the present time, although domestic livestock may also eat some woody vegetation, particularly when other foods are scarce. The level of browsing that was observed in the most impacted reaches is sufficient to influence the future recruitment of woody vegetation in those areas, and if continued may lead to the loss of most or all of the shrubs and trees in those areas.

Terrestrial Wildlife Habitat

The suitability of a stream-riparian ecosystem as habitat for terrestrial wildlife is a function of many different factors, since different animals may use different parts of the ecosystem for different needs and during different times of the year. The functional condition of the reach with respect to its native plant community, which may provide food, shelter, breeding and resting sites for terrestrial wildlife, is covered in the riparian vegetation section of the protocol, while the functional condition of the aquatic system, which may provide food, water and other needs for wildlife, is covered in the fish/aquatic section. This part of the protocol examines several additional features of the stream-riparian ecosystem that can indicate whether or not the reach is likely to provide good habitat for a diversity of native terrestrial wildlife, including various invertebrates, amphibians and reptiles, and native birds and mammals.

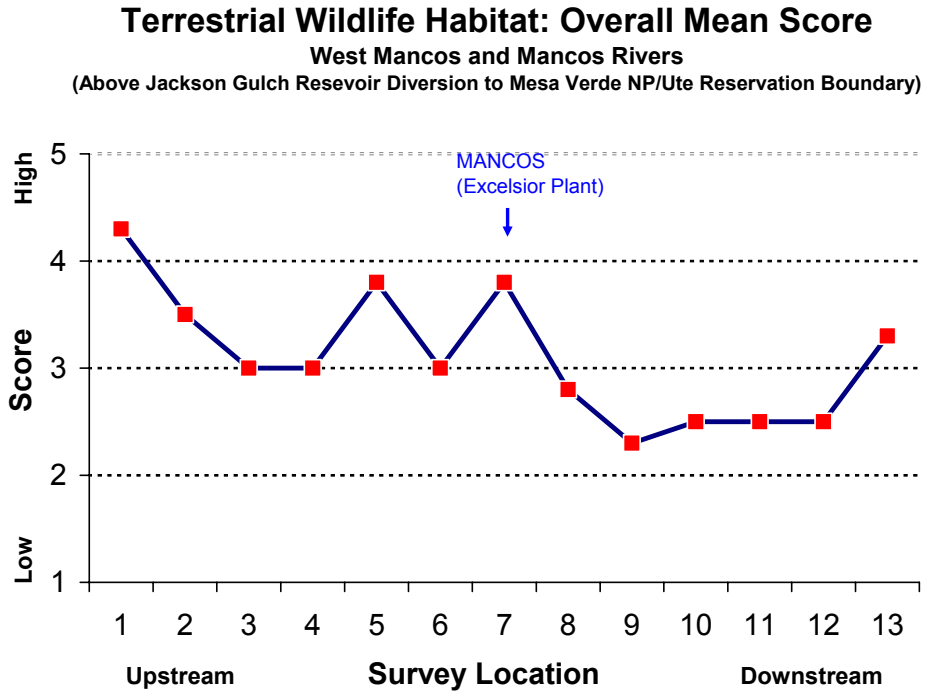

Figure 73. Mean scores for the Terrestrial Wildlife Habitat survey variables for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

Figure 73 gives the mean scores for the Terrestrial Wildlife Habitat variables. Overall, the reaches above the town of Mancos scored as having good or better habitat for terrestrial wildlife, while habitat quality declined in the lower parts of Mancos Valley, although the habitat began to improve again as the river moved into Mancos Canyon.

The first three individual Terrestrial Wildlife Habitat variables examined involve the density and connectivity of the different structural layers of woody riparian vegetation within the survey reach. Riparian shrubs and trees often grow in dense patches, and these patches provide food, thermal cover, predator protection and breeding habitat for many different wildlife species. Such patches are often absent in riparian areas that have been disturbed by various human activities or that have been heavily utilized by native ungulates and/or domestic livestock. As a result, many native wildlife species may no

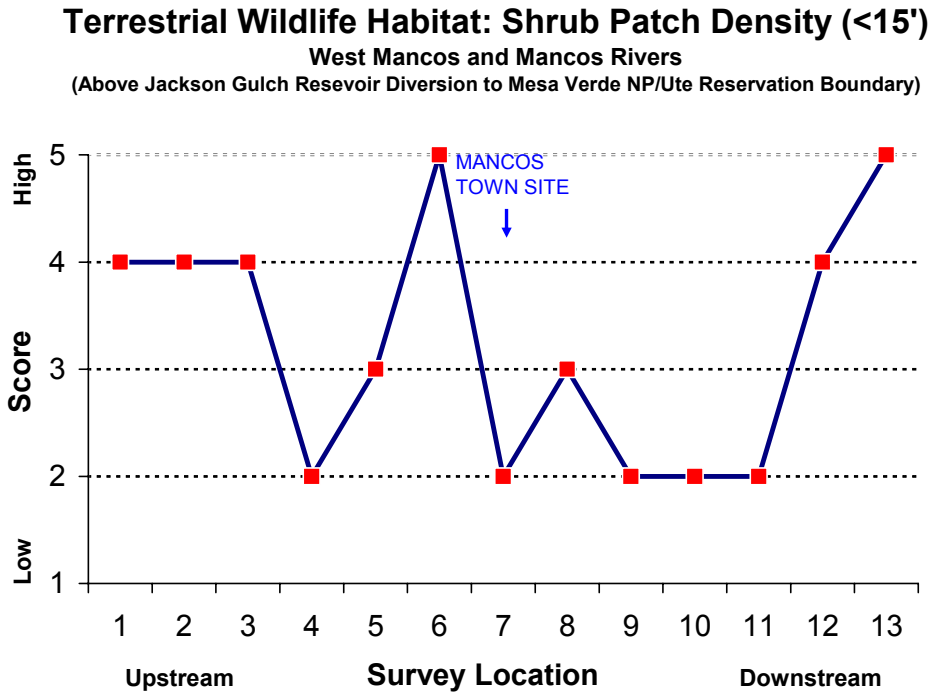

Figure 74. Scores for Shrub Patch Density for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

longer be able to breed or survive in the impacted areas. As shown in Figure 74, the density of shrub patches (primarily willows) was very good or excellent in some reaches, but such patches were almost entirely absent in other reaches, particularly in the lower parts of Mancos Valley. These reaches would not be suitable habitat for species that depend upon such patches, like many duck species that need dense willows to hide their nests from predators. However, seedling shrubs are now growing in many of these areas (Figure 67, above). This suggests that these areas can improve as wildlife habitat with appropriate management of both the wild ungulates (deer and elk) and of domestic livestock, as well as the maintenance of the moist soil conditions that allow for seed germination and vigorous plant growth within the flood plain.

Figures 75-76 give the scores for patch density and connectivity in the Middle and Upper Canopy tree layers. Reaches above the town of Mancos generally score high on these two variables, while those below the town scored lower. In some reaches, there were only isolated individuals of middle and upper canopy trees, and as a result, there were no patches of this type of vegetation. These reaches would not be suitable habitat for the wildlife species that require dense habitat patches in these two layers. In other reaches, patches of one layer were present, but none of the other layer (e.g., reach number 6). This type of variation is usually the result of past land use practices on that particular reach: for example, seedling recruitment may have occurred during one period in the past, but may have ended at a subsequent date when the use of the reach changed. As a result, there might be a number of large trees present along the stream in that area, but no mid-sized individuals (or visa versa). However, as with the shrub component, there were seedling cottonwoods present in almost all of the reaches in Mancos Valley and the adjacent areas. This again suggests that these components of wildlife habitat will improve in the future with appropriate management of native and domestic ungulates, and the maintenance of a healthy flood plain.

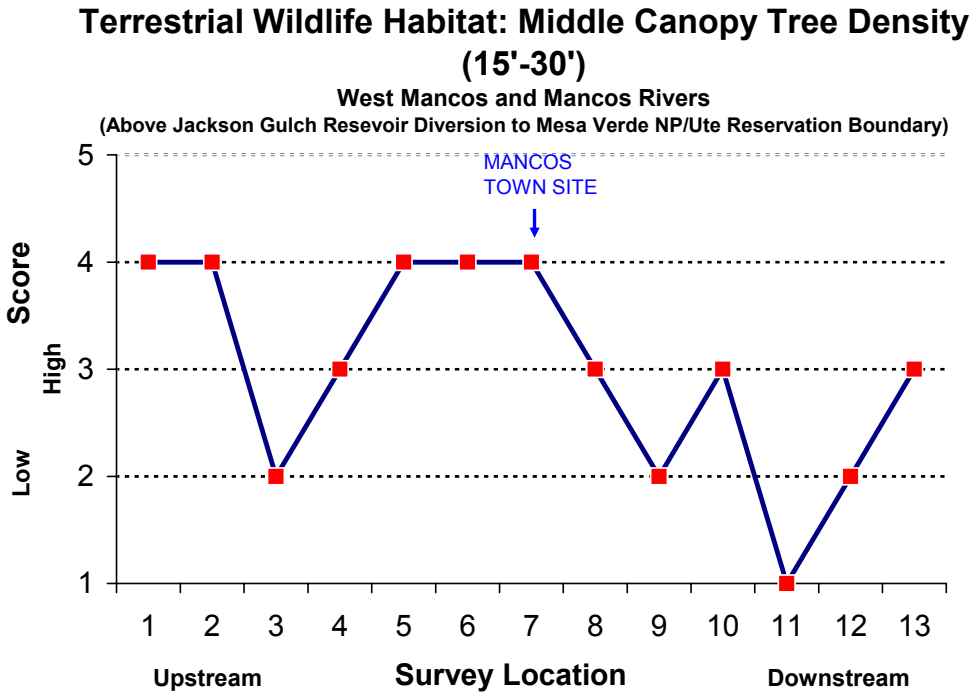

Figure 75. Scores for Middle Canopy Tree Patch Density for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

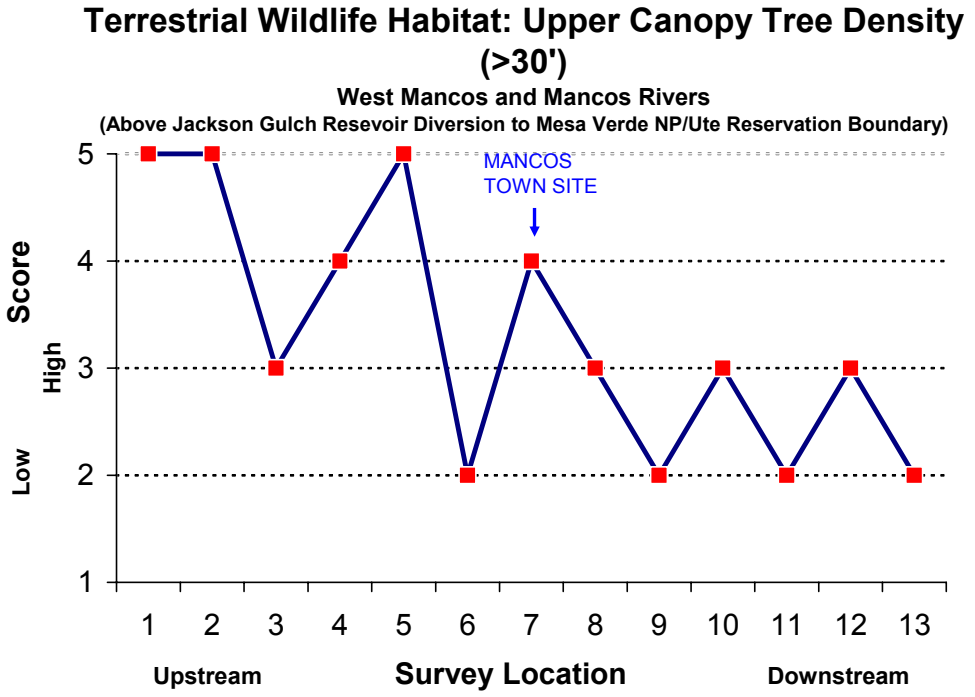

Figure 76. Scores for Upper Canopy Tree Patch Density for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

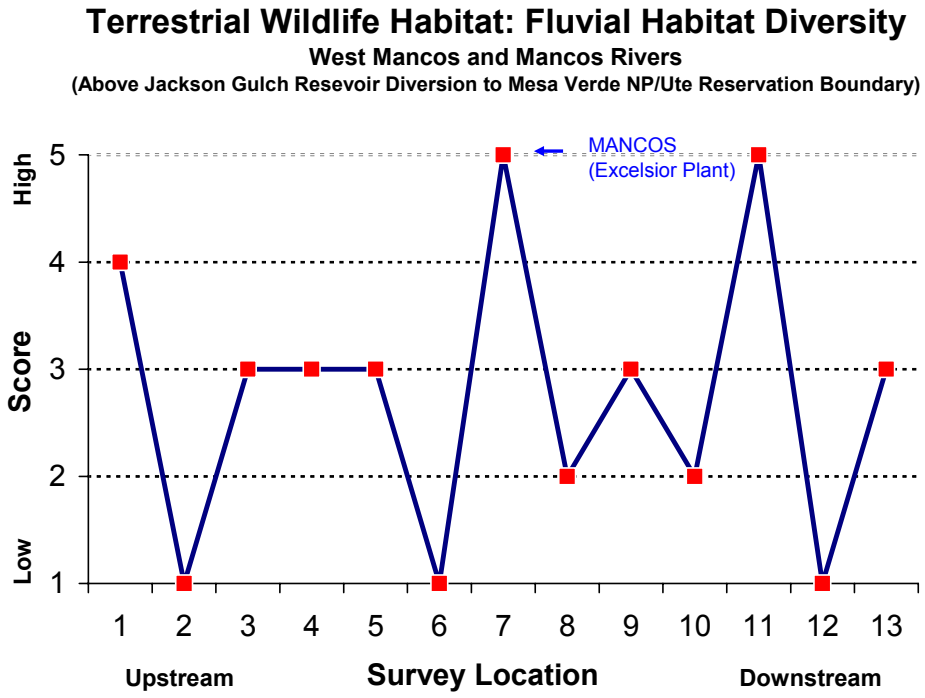

Figure 77. Scores for Fluvial Habitat Diversity for reaches in the Mancos Valley and adjacent upstream and downstream areas (see text).

The final component of wildlife habitat section is shown in Figure 77, which gives the scores for the diversity of fluvial, or above-water, habitats within the stream and flood plain on each reach. Natural hydrological, geological and ecological processes create a variety of fluvial landforms, including terraces, bars, oxbows, wet marshes, and fluvial marshes, which provide the habitats needed by many different species of terrestrial riparian wildlife. For example, Spotted Sandpipers (*Actitis macularia*) will only nest in stream-riparian habitats with exposed sand or gravel bars, and northern leopard frogs (*Rana pipiens*) normally occur only in areas with standing water such as marshes and ponds. In contrast, in highly degraded systems with extensive erosion and downcutting, there may be only a single fluvial landform: a straight and single-depth channel, steep sided banks without vegetation, and a flat and dry flood plain. Many species of terrestrial wildlife that may have been originally present along the reach may be unable to reproduce or survive under those conditions. As seen in Figure 77, the scores for fluvial habitat diversity varied widely throughout the survey area, from excellent (high diversity) to poor (no diversity). This variation occurred even between adjacent reaches (reach numbers 6 and 7, as well as numbers 11 and 12). The lack of diversity of fluvial habitats generally was the result of the past channelization of the stream within a reach, along with the presence of levees that has prevented new channel meandering and overbank flooding. In many of the reaches, some of the fluvial habitats that were present, for example, many of the wet meadows, marshes, and backwaters, were the direct result of water flows from the irrigation ditches in the upland areas adjacent to the flood plain.

CONCLUSIONS

The RSRA surveys described previously constitute the basic unit of analysis for this study, and they should be used to understand the current condition and any potential problem area(s) for each of the reaches examined. The surveys can also serve as benchmarks. When they are repeated at some point in the future, they make it possible to accurately track changes over time, either from maintaining the current management practices within the reach, or as the result of an active restoration program. It is beyond the scope of this project to provide specific and detailed recommendations for possible restoration efforts and programs that would help increase the functionality of either individual reaches or for the entire watershed. This will need to be done on a case by case basis. However, as discussed earlier, this study used the same methodology to examine a number of different reaches within the survey area. As a result, it is possible to consider patterns in the condition of various reaches throughout the area, including the trend data within the Mancos Valley that were presented earlier. These summary observations should be useful to the Mancos Conservation District, to individual land owners, and to other interested public and private organizations and individuals, and can help identify those areas where the functionality of the Mancos River and its tributaries is lower than would be expected or desired, and where the system might respond positively to restoration programs. This analysis also makes it possible to determine which of the components of the stream-riparian ecosystem are functioning well at the present time, and therefore where further action or management changes may not be necessary or desired.

Like most of the streams and rivers in the American Southwest, the Mancos River has had a long history of human use and modification. As a result, all of reaches examined in this study exhibited a complex set of characteristics, some of which indicated that that particular reach was in good condition for one or more variables in a specific functional area, while others indicated that the reach was in only fair or poor condition for other components of that category. There are, however, several clear patterns that emerge from the surveys when they are considered together.

First, when examined from a geographic perspective, the data indicate that the reaches that were located on the major tributaries of the Mancos River (the East, Middle and West Mancos Rivers), were generally in very good condition either upstream from, or just as, they entered the Mancos Valley itself. The primary impact that was observed in the main tributary reaches were changes in the channel morphology that resulted from past construction activities, either from road-building, water diversions and pipelines, or for other unknown purposes. As a result, some of these reaches were bounded by cobble levees, and the flood plain was isolated from the channel. This was particularly true of the three West Mancos River reaches. In addition, the absence of beavers in the tributary reaches was notable. Their presence there (as elsewhere) would have a positive impact on the overall condition of these rivers, particularly with respect to fish habitat, overbank flooding and terrestrial wildlife habitat. However, there are currently active beaver colonies in some areas adjacent to the survey reaches, and natural colonization may occur at some point in the future. Other than these two issues, the major upstream tributary reaches generally scored high in all functional categories.

A major exception to this pattern was the finding that there were no aquatic macroinvertebrates in the East Mancos Reach, and that no fish were observed in this stream during the survey. This was the case even though the habitat both for aquatic macroinvertebrates and for fish rated as very good or excellent. We also found that there were very few macroinvertebrates in the East Mancos River further downstream in the Valley, including just upstream from where it joins the West Mancos River. Aquatic macroinvertebrates were still rare in this part of the East Mancos even though the area examined was less than 50 meters distant from the West Mancos River (see Figure 16, above), where macroinvertebrate abundance and diversity was high (score of 5, Above Weber Diversion Reach survey). These results

suggest that there is something in the water in the East Mancos River that is preventing aquatic invertebrates and fish from be present in otherwise apparently suitable habitat. Problems with water quality on the East Mancos River have apparently been reported previously (F. Broennan, personal communication). We recommend that this situation be examined further.

Within the Mancos Valley itself, the functional condition of the Mancos River generally declined as the river moved downstream, although there were some exceptions. This pattern would be expected, both because the river in the lower part of the Valley experiences the cumulative impact of any human activities that originate further upstream, and also because the type of land use on the flood adjacent to the river tends to change as one moves downstream within the valley. In the upper valley, most of the flood plain is occupied by houses and small pastures (many of which were inactive during the survey period), whereas in the lower parts of the Valley large open and actively grazed pastures are more prevalent.

Several additional patterns emerged from the survey results. First, the historic flood plain adjacent to the river channel was in very good to excellent shape throughout almost all of Mancos Valley. The riparian vegetation within the flood plain was generally vigorous. This was case both for overall cover, which is a measure of productivity, and for the recruitment of new individuals (i.e., the germination of seedlings and their subsequent survival). This indicates that the amount of vegetation in each structural layer is likely to remain the same or increase within the Valley over time. In addition, some or most components of terrestrial wildlife habitat scored well, and riparian area soil integrity was rated as very good in most reaches. Finally, and perhaps most remarkable, the extent to which non-native or exotic woody species like saltcedar and Russian olive have invaded the riparian zone was very low, particularly in the middle and upper portions of the Valley. The absence of exotic vegetation is usually a good indicator of a healthy riparian flood plain with moist soils. There were a few locations where exotic woody species were present in relatively low numbers, particularly in some of the lower reaches where the flood plain was being actively grazed by livestock. But this could be reversed easily in these reaches by appropriate management actions such as the removal of the exotic plants, and fencing off the flood plain.

A healthy and vigorous riparian zone is not often observed in similar sized rivers at similar elevations in the American Southwest. The channels of many streams and rivers in this region have become entrenched through erosion of the banks and the downcutting of the channel bottom. The stream often becomes wide, shallow and straight, and the meanders that would normally be present in most geomorphic settings disappear. In these situations, the channel becomes isolated from its flood plain, and overbank flooding rarely, if ever, occurs. All of these factors work together to lower the level of the local water table and the amount of moisture in the soil, and the historic floodplain usually dries out. Once this happens, the vigor and recruitment of native riparian vegetation declines, and many riparian dependent species of plants and animal disappear. The flood plain is also often invaded by upland native species like sagebrush (*Artemisia* spp.) and saltbush (*Atriplex* spp.) that can tolerate dry conditions, as well as various exotic or non-native species like saltcedar and many weedy “pest” species of forbs and grasses.

We found that the flood plain of the Mancos River within Mancos Valley is in very good condition, even though the river channel is actually isolated from it adjacent flood plain throughout most of the valley (Figure 44, above). Although there is little active downcutting or erosion of the stream banks at the present time, the river in most reaches is wide and shallow, and the bottom and the sides of the channel are lined with medium to large cobbles. The wide and shallow channel shape, which would usually be indicative of poor conditions, is due in the Mancos Valley primarily to the presence of levees along the river, particularly both immediately upstream and downstream from the town of Mancos itself. However, constructed levees are generally absent from some of the reaches in the lower part of the Valley, and in those areas the river is starting to exhibit the type of meandering pattern that would be expected to occur naturally.

The apparent paradox of the existence of a healthy flood plain in a situation where the river is not actually connected to the flood plain can be resolved by the presence of the extensive agricultural irrigation delivery system in Mancos valley. There are a large number of unlined irrigation ditches that flow above the flood plain and parallel to the river through out the Valley. Water draining from these ditches moves downslope, often under the ground, and then enters the upper edge of the flood plain. This water creates the moist soil conditions that would normally be found only in situations where the river itself is connected to the floodplain, and soil moisture is derived from the combination of regular overbank flooding and underground water flow from the river.

The importance of the irrigation system to the riparian vegetative communities has been noted previously. For example, Yochum found in his study of the hydrology and salinity of the Mancos Valley that "Wetlands that are likely the result of leakage from unlined irrigation canals can be found in the lower valley." (Yochum 2004, page 3). We also found that wetlands, including even cat-tail marshes, occurred throughout the entire valley wherever there was drainage from agricultural fields and unlined irrigation ditches and canals. An example of this phenomenon is shown in Figure 78. It is likely that, in the absence of this leakage, many of the wetlands and moist areas in the riparian zone in Mancos Valley would dry up and disappear. This has already happened in many riparian areas in the Southwest where the

Figure 78. An illustration of the role played by leakage from unlined irrigation ditches in maintaining moist conditions throughout the riparian zone of the Mancos River in Mancos Valley. The wet meadow at the bottom of the picture is located in the upper and normally drier part of the flood plain. However, it is present because of water leaking from the ditch that runs just above it. The river in this reach (Perry Ranch) is not channelized and does not have levees. As a result, there are also the wet areas that would normally be expected to be present immediately adjacent to the stream, and which result from both overbank flooding and underground water flowing next to the channel. Between the two wet areas is a dry zone with very little vegetation (*photo by Pete Cruser).*

channel is as isolated from its flood plain to the same degree as currently exists for the Mancos River.

Another major factor that will impact the condition of riparian vegetation is the level of grazing and browsing on the plants. Browsing is particularly detrimental when it occurs on seedlings and the smaller individuals that would otherwise grow and eventually replace the plants that naturally become old and die. Although most attention on over-grazing and browsing has been focused upon domestic livestock, native ungulates can also have a significant impact on the health and recruitment of riparian species. We found that grass and forb cover was very good in most reaches throughout the Valley, particularly for the cover in the upper riparian zone. In addition, the amount of actual grazing impact on individual plants was low in most reaches, except in situations where the flood plain was being actively used by livestock (Figure 71, above).

In contrast, the amount of woody shrub and tree cover was variable: in some reaches shrubs and trees were fairly dense, whereas in others there were very few woody plants in the flood plain, and large trees were almost completely absent. It is likely that this pattern reflects the past history of land use along the reach, as areas that have been historically used for intensive grazing by domestic livestock in the southwest usually loose their woody plant species cover. However, we also found that recruitment of willows and cottonwoods was very good or excellent throughout the Valley and on the major tributaries. In all but one reach, seedling of woody plants were present and growing well, and if an age class of the plants were absent, it was usually the older and larger individuals. This indicates that the riparian woody plant community in the Mancos Valley has the potential to recover rapidly in areas where it is not currently present. The only potential problem that we observed was that there was a relatively high level of browsing on the younger plants in many reaches (Figure 72, above). Since continued browsing eventually kills a woody plant, the current high levels of browsing have the potential to retard or eventually prevent the re-establishment of a healthy, sustainable and structurally diverse community of shrubs and trees along the Mancos River. It is important to note that heavy browsing occurred in reaches that were not actively being grazed by livestock during the surveys, and that showed no signed of recent livestock presence. This included the reaches near the town of Mancos. As noted earlier, we encountered numerous mule deer in many of these reaches, and it is likely that they are responsible for the high levels of browsing. Deer populations have increased in and near many towns and cities in the southwest, and throughout the United States, as their native predators have been removed, the activities of dogs are restricted, and hunting patterns have changed. It is likely that if these trends continue, native ungulates like deer and elk will have a major negative impact of the health and sustainability of the riparian ecosystem in the Mancos Valley.

A third general finding from this project concerns the quality of the Mancos River as native fish habitat. Several of the characteristics that would enable the river to maintain health fish populations are present in most reaches, particularly those in the middle and upper parts of Mancos Valley and the upstream tributaries. These include excellent aquatic macroinvertebrate diversity in all except the most downstream reaches, relatively low levels of silt and cobble embeddedness, again excepting the most downstream areas, and good or better overhanging bank vegetation, which provides for insect drop into the stream as an additional source of food for fish. However, according to several residents, fish that were apparently once common in the Mancos within the Valley, including cold water species like trout, are no longer present in the numbers that they once were. One possible explanation for this situation is the relatively low scores that most reaches received for other physical features of the stream channel that are important for good fish habitat. There were limited or no riffle and pool habitat on most reaches, and very little underbank cover that would allow fish to hide from predators. There was also very limited woody debris in most reaches. Large pieces of wood in the channel not only provides hiding and resting cover for fish, but, by interrupting the flow of the water and producing both local erosion and sediment deposition, it creates the structurally diverse underwater habitat need by most fish (e.g., Bisson et al. 2003). As mentioned above, the river channel in most of the reaches in Mancos Valley was both straight and

uniformly wide and narrow. It is likely that these reaches could be substantially improved as fish habitat simply by adding large woody debris into the channel. An example of woody debris that has fallen into the channel and possibly led to the creation of a small riffle and pool system is shown in Figure 21B, the downstream reference photo for the Excelsior/Sewage Plant Reach. This reach has considerable woody debris throughout it length, as well as very good hydraulic habitat diversity.

A second factor that may influence native fish populations is the annual hydrograph, or pattern of water flow, and whether downstream reaches go dry during some periods of the year. It was beyond the scope of this study to examine this possibility, as all of the reaches except Mud Creek had some water flow in them during the survey period. Limited water flows may be the reason for the higher levels of cobble embeddedness observed in the most downstream reaches in the Valley, and this factor could have some affect on fish reproduction in those areas. However, as discussed earlier, most streams and rivers in the American Southwest that are the size of the Mancos River historically experienced periods of low flows during some parts of the year (see the hydrograph in Figure 2). In such cases, native fish would move into the deeper pools, and would use them as places of refuge until water levels rise again in the spring or late summer. We found during the surveys that there was an almost total absence of pools in the Mancos River in Mancos Valley that would be deep enough to provide this type of refugia for fish during low water periods (either natural or as the result of water diversions). An exception was a very deep pool located just upstream of Reach 11, above the Lazy F/W Ranch.

The creation of such pools, either through active excavation or ones that would develop naturally with the addition of large woody debris and natural erosive processes, could help native fish population survive and perhaps increase in numbers within the river. Although increasing the total amount of water that flows through the system might increase the total amount of habitat that could be occupied by fish in the most downstream portions of the Valley, particularly during periods of naturally low flows, unless additional habitat features such as deep pools, woody debris and underbank cover are also present in the downstream reaches, this action would probably not be very effective in improving fish population numbers.

With respect to the smaller tributaries, the reach that was surveyed on Chicken Creek where it enters Mancos Valley was in very good overall condition. There is an established beaver damn just downstream from the reach, and this has created natural wetland habitat that was not seen elsewhere in the Valley. The flood plain in this reach is recovering rapidly from past overuse as a pasture. The only major riparian vegetation element that is still missing is the woody shrub and tree component. Willow and cottonwood plantings in this area could be very effective in speeding up the recovery of this area.

In contrast, the reach on Mud Creek received the lowest overall score of any of the areas examined in this study, and was rated at 2.2, or in just fair condition. The creek and the surrounding areas have been used for livestock grazing for many years, and this has impacted the amount of vegetation cover that is now present in the riparian zone of Mud Creek. There historically may also have originally been some irrigated agriculture along parts of the creek, but at a much smaller scale than in Mancos Valley itself. There was a sprinkler irrigated field on the east side of the creek above the current flood plain, but runoff from this field appeared to have minimal, if any, impact on the riparian zone itself. The watershed that is drained by Mud Creek is relatively small, and is lower in elevation than those of the other major tributaries in the upper Mancos Watershed. As a result, Mud Creek receives less runoff from snow melt, and normal water flows tend to be lower here than in the other tributaries. Mud Creek, does, however, flood during periods of heavy summer rains. We found that there has been extensive downcutting of the channel in Mud Creek, which now rests on Mancos Shale bedrock in portions of the survey reach and elsewhere, as illustrated in the photograph in Figure 37A. Because the Mancos Shale formation contains considerable salt, there has been concern that the exposure of the shale and the erosion of surrounding fine alluvial soils in Mud Creek may be contributing inordinately to the salinity problem in the Mancos

River (e.g., Yochum 2004). The results of our survey support this hypothesis. We observed a lack of healthy riparian vegetation in the flood plain of Mud Creek that would absorb and hold back some of the high flows. We also found that current levels of ungulate use of the riparian zone are likely to prevent the development of good vegetation cover in the future. Thus the functional condition of Mud Creek at the present time is such that it is likely to amplify the problems of erosion, and subsequent sediment and salt deposition into the Mancos River. Our survey suggests that Mud Creek would be an excellent area to undertake a riparian restoration program, including both actively planting willows and cottonwoods, and fencing the flood plain itself to encourage the recruitment and survival of the woody plants. The restoration of Mud Creek to a healthy condition would be very likely to reduce the amount of salt loading into the Mancos River in the future.

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