CATALOG OF STREAM AND RIPARIAN HABITAT QUALITY FOR THE ROARING FORK RIVER AND TRIBUTARIES, CENTRAL COLORADO

INTRODUCTION

1.0 Project Overview

This project was born in early 2003 out of the realization that the Roaring Fork valley was rapidly losing its riparian forests to land development, and that there were noticeable problems with the stream environment in many areas, including algal blooms and sedimentation that seemed abnormal. We suspected that there were many undocumented problems with the river and riparian system in the valley, but we also knew that there were financial resources available for restoration and conservation projects. Unfortunately, there was no comprehensive data base of riparian and stream conditions in the valley with which to identify and prioritize key areas for protection or remediation. We believed that such a data base would be invaluable if not necessary for the citizens of the valley to be competitive in the acquisition of federal and state funding for river and riparian conservation and restoration. Thus, in the spring of 2003 we set out to finance and conduct a watershed-wide habitat assessment.

The purpose of the project has been to create a comprehensive inventory of in-stream and riparian habitat quality in the watershed; to identify stream segments in need of restoration and protection; and to assist local jurisdictions, non-government organizations, and private landowners in the development of sustainable management strategies for in-stream and riparian resources in their area. The main product of the project is this catalog, which documents the existing physical habitat conditions of the watershed's rivers and streams and identifies those reaches in need of restoration as well as those in need of protection. To facilitate the development of effective remediation strategies, constraints on stream and riparian habitat quality in the watershed were also identified and characterized in this assessment. This catalog provides government organizations, adopt-a-stream citizen groups, private companies, and individuals information to prioritize, develop and implement restoration projects for degraded sites and management plans for conservation sites. Additionally, this science-based inventory of the physical instream and riparian habitat establishes baseline conditions for future monitoring.

2.0 Background

The Roaring Fork Watershed, located on the Western Slope of the Southern Rockies in Colorado, encompasses diverse ecosystems from the alpine tundra at Independence Pass down through spruce-fir forests, aspen groves, oak and sage shrublands, and pinon-juniper woodlands. Elevations range from over 12,000 ft. above sea level along the highest peaks and ridges rimming the watershed to 5700 ft. at the confluence of the Roaring Fork with the Colorado River in Glenwood Springs. The Roaring Fork watershed drains 1,451 square miles with 1,962 total stream miles and contributes 943,000 acre feet (307 billion gallons) per year to the Colorado River.

Human alteration of the Roaring Fork River and its major tributaries has impacted the physical characteristics and consequently the health and function of the River system. Riparian habitat is one of the most endangered ecosystems; reported estimates indicate that 70 to 90 percent has been lost in the West due to human activities. Water conservation in the West is inherently dependent on a properly functioning river system, which is linked to healthy riparian habitat and instream physical habitat.

Historically, mining and ranching have variably affected different geological regions of the watershed. Ranching practices have degraded stream habitat especially on the lower reaches of the Roaring Fork and on lands surrounding tributaries such as Cattle and Snowmass Creeks. Degraded riparian habitat, bank instability, and homogenous instream habitat are a legacy of these ranching practices, which included elimination of riparian vegetation and construction of hay meadows, straightening of the stream channels, and intensive livestock grazing along stream banks. Mining impacts are mostly historical and the landscape is undergoing a process of regeneration. However, there is potential for new mining impacts in the watershed from marble mining and sand and gravel quarries.

Currently the Roaring Fork Watershed is experiencing unprecedented human population growth – in Pitkin County the human population is expected to double within the next 28 years – due, in part, to the area's popularity as a recreational Mecca. Activities such as fly fishing, rafting, skiing, hiking, mountain biking, and golf attract tourists year-round, and many visitors are choosing to stay. Impacts from development and urbanization to accommodate and promote tourism have been enabled by extensive road building –expansion of Colorado Highway 82 has the potential to bring increased population and urbanization to the watershed.

Rapidly increasing demands for the water in the Roaring Fork watershed is another threat to a healthy stream ecosystem. Much of the demand comes from increased urbanization, golf course development and snowmaking by ski areas. These water uses have supplanted much of the historical agricultural demand. However, a significant amount of water leaves the basin through two major high-elevation trans-mountain diversions. Reduced flows impair habitat quality and result in fundamental changes that diminish stream functions. High quality riparian ecosystems mitigate decreased flows, help to prevent degradation of water quality, and enhance in-stream habitat quality.

Although we have almost no single, large-scale development or point-source polluter in the valley, there are a huge number of small impacts that have a cumulative and negative effect that increases in the downstream direction along the river continuum. The accumulation of piecemeal small habitat modifications may pose the single greatest threat and endangerment to our valley's aquatic resources. The significance of these modifications to aquatic systems may best be understood when aquatic systems are viewed as being longitudinally linked, and it is especially important to recognize that conditions such as nutrient cycling, erosion, and pollution input in upstream reaches affect downstream areas (Windell 1992).

A stream is an integral component of the watershed through which it flows (Hynes 1975). The stream environment reflects the conditions of the surrounding landscape. Any alteration of watershed characteristics, whether natural or induced by humans, has an influence on the stream environment (Ward and Kondratieff 1992). Alteration of the physical structure of stream and riparian habitat is a major factor that degrades aquatic resources. Habitat is a major determinant of aquatic and riparian community potential, affecting the structure and composition of biological communities (Barbour and Stribling 1991). Stream habitat physical components function to dissipate energy during storm events – without these features erosion, flooding and dewatering can result. Riparian habitat plays a key role in water storage and cleansing – degraded riparian habitat can result in lower water quality and decreased flows. To assess the health and sustainability of stream ecosystems in the Roaring Fork watershed we evaluated the structure of aquatic and riparian zone habitats.

Many of the degraded stream reaches we have identified are amenable to adoption and restoration by community watershed groups. Other areas may only require altered management prescriptions. Pristine areas require management that ensures long-term protection. This project provides a science-based inventory of degraded and pristine areas with which to effectively prioritize restoration and protection management plans.

3.0 Objectives

The primary objective of this study was to document habitat conditions and create a comprehensive baseline inventory of the Roaring Fork and tributaries at the reach scale to identify areas for potential restoration and protection opportunities. This was accomplished by:

1. Conducting a physical habitat assessment of the Roaring Fork and at-risk tributaries using: 1) a modified version of the Environmental Protection Agency's Rapid Bioassessment Protocol for use in Streams and Wadeable Rivers; 2) Natural Resource Conservation Service's Riparian Assessment developed in Montana; 3) Bureau of Land Management's Proper Functioning Condition; 4) a rapid assessment of the benthic macroinvertebrate assemblage; and 5) a survey of the distribution and abundance of a biological indicator bird species, the American Dipper (*Cinclus mexicanus*).
2. Categorizing stream reaches by instream and riparian habitat quality, and
3. Developing a series of maps of the Roaring Fork watershed showing the location and extent of stream reaches in each habitat quality category.

Other objectives were: to identify major constraints to ecosystem integrity for each reach that would degrade stream functions; to recommend remediation strategies or protection measures for each reach in the assessment area; and to develop a list of critical at-risk areas of important habitat within the watershed in need of protection, with which to enlist conservation support from local jurisdictions, conservation organizations, businesses, and individuals.

4.0 Project Area

The project encompasses the Roaring Fork River and tributaries that were identified as being at-risk. This project has assessed approximately 182 stream miles, including the Roaring Fork River and lower portions of tributaries including Lost Man Creek, Castle Creek, Maroon Creek, Brush Creek, Snowmass Creek, Frying Pan River, Crystal River, Cattle Creek and Four-Mile Creek. The assessment was conducted during the field seasons of 2003 – 2005.

The Roaring Fork and tributaries were divided into 17 segments based on similar physical habitat characteristics including geology, channel type, entrenchment, width/depth ratio, sinuosity, gradient, and channel material. Based on these parameters the segments are as follows:

RF1 – Roaring Fork River, beginning at the headwaters of the Roaring Fork about 1.2 miles below Independence Pass and ending about 0.4 miles upstream of the Twin Lakes tunnel diversion; Total length 3.6 miles; Assessed July 2003

RF2 – Roaring Fork River, beginning about 0.4 miles upstream of the Twin Lakes tunnel diversion and ending about 0.9 miles below the USFS Weller Lake Campground; Total length 7.2 miles; Assessed August 2003

RF3 – Roaring Fork River, beginning about 0.9 miles below Weller Lake Campground and ending at the Slaughter House Bridge downstream of the City of Aspen; Total length 11.4 miles; Assessed September – November 2003

RF4 – Roaring Fork River, beginning at the Slaughter House Bridge and ending about 1 mile downstream of Old Snowmass; Total length 13.5 miles; Assessed November 2003 and August 2004

RF5 – Roaring Fork River, beginning about 1 mile downstream of Old Snowmass and ending at its confluence with the Crystal River, about 1.4 miles downstream of the Town of Carbondale; Total length 15.7 miles; Assessed September – October 2004

RF6 – Roaring Fork River, beginning at its confluence with the Crystal River and ending at the confluence of the Roaring Fork with the Colorado River at the City of Glenwood Springs; Total length 13.6 miles; Assessed November 2004

LM1 – Lost Man Creek, beginning at its confluence with Jack Creek, above Lost Man Reservoir, and ending at the confluence of Lost Man Creek with the Roaring Fork River; Total Length 1.9 miles; Assessed October 2003

CS1 – Castle Creek, beginning at its confluence with Cooper Creek, about 2.9 miles above Ashcroft, and ending at its confluence with Conundrum Creek; Total length 8.9 miles; Assessed June 2004

CS2 – Castle Creek, beginning at its confluence with Conundrum Creek and ending at its confluence with the Roaring Fork River; Total length 6.3 miles; Assessed June - July 2004

MA1 – Maroon Creek, beginning about 0.25 miles above the Silver Bar Campground and ending at its confluence with the Roaring Fork River; Total length 5 miles; Assessed July – August 2004

BR1 – Brush Creek, beginning about 1 mile above the Town of Snowmass Village and ending at its confluence with the Roaring Fork River; Total length 7.6 miles; Assessed July – August 2005

SN1 – Snowmass Creek, beginning at its confluence with West Snowmass Creek and ending at its confluence with the Roaring Fork River; Total length 14.1 miles; Assessed October 2005

FP1 – Frying Pan River, beginning at the outfall of the Ruedi Reservoir dam and ending at its confluence with the Roaring Fork River; Total length about 13.7 miles; Assessed June 2005

CR1 – Crystal River, beginning at Blue Lake above the town of Marble and ending next to the turnoff to Marble on Colorado Highway 133; Total length 6.7 miles; Assessed November 2004

CR2 – Crystal River, beginning at the turnoff to Marble on Colorado Highway 133 and ending at its confluence with the Roaring Fork River; Total length 24.4 miles; Assessed September 2005

CT1 – Cattle Creek, beginning at its confluence with the North Fork of Cattle Creek and ending at its confluence with the Roaring Fork River; Total length 16.6 miles; Assessed August 2005

4M1 – Four-mile Creek, beginning at its confluence with Beaver Creek in Four-mile Park, and ending at its confluence with the Roaring Fork River; Total length 12.1 miles; Assessed October 2005

Each segment was further subdivided into reaches. Reaches were mapped with a hand-held GPS. Reach designation was based on field observations of similar instream, riparian and upland characteristics. Characteristics that were evaluated to determine the boundaries of a reach included riparian vegetation characteristics, riparian zone characteristics, stream channel type, confinement, gradient, sinuosity, instream habitat, management changes, structures that impact the stream, and the occurrence of human impacts to the stream or to the riparian zone and vegetation. Figure 1 shows the stream segments that are documented in this Catalog.

5.0 Methods

5.1 Stream Habitat Quality: ability of the habitat to support optimal biological conditions of the region.

The ecological integrity of a stream system is closely tied to the quality of the surrounding stream and riparian habitat. Alteration of the physical structure of habitat degrades aquatic resources and quality of the physical habitat is a limiting factor to biological community potential (Karr 1991, Barbour and Stribling 1991). Because habitat and biological diversity are closely linked (Raven et al. 1998) an evaluation of habitat quality is essential to any determination of biotic potential or ecosystem integrity.

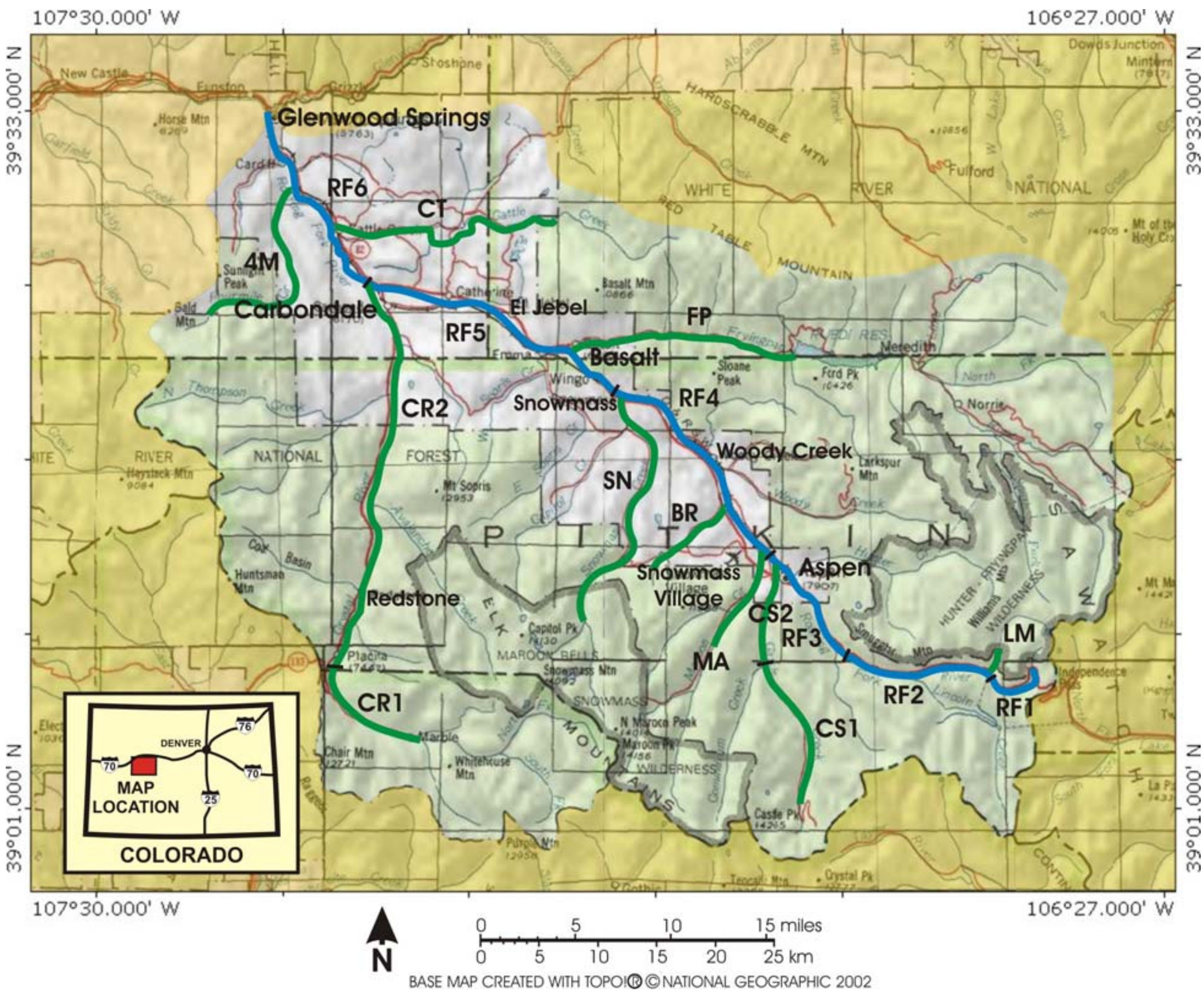

Figure 1. Map of the Roaring Fork Watershed showing stream segments documented in this catalog.

We used the habitat characterization matrix in EPA's Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers (RBP) as a means of evaluating and documenting habitat quality of each reach. The habitat quality evaluation was accomplished in two parts: 1) characterization of physical parameters and water quality, and 2) a visual-based Habitat Assessment which is a rapid, systematic assessment of the physical structure of the stream.

Physical characterization included documentation of general land use, physical stream characteristics including width, depth, flow and substrate, and a summary of riparian vegetation features. Water quality was evaluated by assessing turbidity, surface oils and odor. More in-depth, quantitative water quality data were obtained from published data provided by the US Geological Survey and may be obtained at their web site. This information was useful in providing insights as to potential stream impacts. An example of the field data sheet is provided in the appendix.

EPA's RBP for habitat assessment evaluates the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the aquatic community. Each evaluated parameter impacts aquatic life and potentially limits the biological community potential. Ten parameters are characterized and include macro-scale features such as channel morphology, stream micro-scale habitat such as embeddedness, and riparian and bank structure features that influence stream characteristics. Each parameter was evaluated at each designated reach and rated on a scale of 0 (worst) to 20 (best). The scores were totaled and then compared to a regional reference site to provide an assessment of habitat quality. Higher scores indicates higher quality instream habitat. Evaluation of EPA's parameter #10, which evaluates riparian zone width, was altered to score the potential width of the riparian zone rather than an absolute width. An example of the field data sheet along with a detailed description of each evaluated parameter is provided in Appendix A.

Habitat evaluations were first made on instream habitat, followed by channel morphology, and finally on structural features of the bank and riparian vegetation. The entire reach was surveyed to make a comprehensive assessment that incorporated features of the whole reach.

A regional reference reach, against which other reaches in that were compared, was established in each segment where possible. The reference reaches were selected to be characteristic of each segment and unimpaired by human activities. Some stream segments have been so altered by human impacts that establishing an unimpaired reference was not possible; in these instances historical habitat conditions were inferred from existing conditions. Because stream classes vary dramatically along the river continuum, a reference with which to scale each reach in a region is important in determining if the test reach had attained its potential condition. The ratio between the score for the reference reach and the test reach provided a comparability measure with which to classify the test reach regarding the "best attainable" situation. This percent comparability measure accounts for regional and stream-size differences that affect flow, substrate and channel morphology.

Stream habitat condition, as determined by the RBP Habitat Assessment score, was assigned to each reach. Categories for a range of scores were developed and are listed below:

High Quality – Habitat scores of 180 or greater. The reach exhibited little evidence of disturbance. Most habitat parameters from the RBP scored in the optimal category; physical habitat provided excellent opportunity for aquatic life. These areas warrant strong protection measures.

Slightly Modified – Habitat scores of 160 to 179. The reach exhibited some evidence of disturbance. Most habitat parameters from the RBP scored in the optimal or suboptimal categories; physical habitat still provided excellent opportunity for aquatic life. These areas should be protected from further degradation. Some restoration actions or better stream and riparian management policies are likely to improve the habitat quality in these areas.

Moderately Modified – Habitat scores of 140 to 159. The stream habitat has been noticeably altered. The habitat parameters were rated from optimal to poor; the physical habitat still provided good opportunity for aquatic life. Habitat quality is likely to be improved by instream and or riparian restoration.

Heavily Modified – Habitat scores of 120 to 139. The stream habitat has been substantially modified resulting from channelization, limited riparian vegetation, bank instability and other problems. Habitat quality is likely to improve by moderate to extensive instream and/or streamside restoration measures.

Severely Degraded – Habitat scores of less than 120. The stream habitat exhibited highly disturbed segments that are likely to be restored only through intensive and expensive instream and stream bank measures. Most of the habitat parameters were rated poor or marginal; the habitat severely limits or precludes aquatic life.

5.2 Riparian Habitat Quality

Riparian habitat, when considered as part of stream ecosystems, performs functions essential to the maintenance of stream sustainability. Stream stability in many areas of this watershed is dependent on healthy riparian systems. Sustainable stream-riparian systems are able to perform physical and biological functions that enable their stability including sediment trapping, energy dissipation, water storage and ground water recharge, bank protection, providing habitat for native biological diversity and facilitating primary production.

Riparian vegetation also plays a fundamental role in the development of the structure of the stream benthic macroinvertebrate community. Riparian vegetation provides an important energy source in the form of leaf detritus, provides resting and oviposition sites for aerial stages of aquatic insects, decreases sediment and nutrient losses to adjacent streams, and moderates annual and diel water temperature fluctuations. Since aquatic insects are an essential component of food pyramids forming the transition between primary producers and higher-up consumers, their community health is essential to the health of the entire stream ecosystem.

We used the Natural Resource Conservation Service's (NRCS) Riparian Assessment method to assess sustainability of stream ecosystems and to identify recovery strategies that could be used to reverse a downward trend in site stability. The NRCS evaluates riparian habitat condition and functionality – the ability to maintain a sustainable ecosystem – by characterizing eleven parameters. These parameters encompass the amount of riparian cover and its condition, type of riparian cover with regard to its stabilizing ability, and stability of the stream channel. Field-based visual assessments over each entire reach were made of riparian, flood-prone and upland vegetation, and of the condition of stream banks and the channel. Native plant species were recorded in order of abundance, condition assessed, and then classified according to soil stabilizing ability using a Plant Stability Rating Table which can be found in Appendix A. Weedy plant species were also identified and evaluated for degradative potential. A visual assessment of stream bank stability and channel alteration was used to make a determination regarding balance between sediment and water, which is a product of riparian-stream system function. An example of the field data sheet along with a detailed description of each evaluated parameter is provided in Appendix A.

Parameters were evaluated and scored in the field. Scores were totaled and compared against a regional reference reach. Reference reaches were used as a comparison against which to evaluate the condition of other reaches in a segment. Use of the reference reach ensured that each site was evaluated with respect to its own potential (highest ecological state possible without significant human interference). Riparian habitat condition, as determined by the NRCS assessment score, was assigned to one of five categories. The five categories used with this assessment are listed below:

High Quality – Habitat scores of 55 or better indicates a functioning sustainable system. Stream and associated riparian vegetation have certain expected attributes in place and processes are working to create a stable system.

Slightly Modified – Habitat scores of 49 or better indicate habitat that is stable but somewhat impaired. Although all characteristics are in place some are degraded and not completely functional.
Moderately Modified – Habitat scores of 43 or better indicate a system that is at risk. Most characteristics are in place and functioning. However, certain characteristics that are essential to system function and stability are lacking.
Heavily modified – Habitat scores of 37 or better indicate habitat that is not functioning
Severely Degraded – Habitat scores below 37 indicate habitat that is not sustainable. Stream and riparian area are lacking essential characteristics and will not be able to perform key functions that enable stream-riparian stability.

NRCS assessment parameters are weighted and variably scored (refer to appendix). To report these scores in chart form we normalized each parameter's score so that the maximum achievable score for each parameter was "1".

Vegetative community structure and composition plays an important role in determining wildlife community composition and providing ecosystem stability. We collected additional vegetation information regarding structure and composition at each of the designated reaches. Our methods involved estimation of stand characteristics and were modeled from a method developed by Bruce Bingham and C.J. Ralph (Ralph et al. 1993). Vegetation characteristics were estimated along a transect that ran parallel to the stream reach and was as wide as the riparian zone. We determined the number of major vegetation layers by their dominant growth form: tree layer, shrub layer, and herbaceous layer. We then determined the average height and percent cover of each major layer. Finally, dominant species in each layer were identified and recorded. Refer to Appendix "E" for detailed structure information.

5.3 Macroinvertebrate Assemblage

Benthic macroinvertebrates can be used as an indicator of stream health. Benthic stream macroinvertebrates consist mostly of the immature (larval or nymph) stages of aquatic insects, such as mayflies, stoneflies, caddisflies, and midges, and are an important food for fish. Because many are herbivores that feed on mosses and algae growing on submerged cobbles, boulders, and large woody debris, they are an important part of the food chain. Although stream macroinvertebrate communities can be affected by chemical water pollution, temperature, flow, and substrate are the most important factors structuring benthic macroinvertebrate communities in mountain streams (Ward and Kondratieff 1992). Generally, a stream with a wide diversity of macroinvertebrates that are intolerant of extreme ecological conditions characterizes a healthy stream (Windell 1992). Our objective in sampling benthic macroinvertebrates was to distinguish impaired and non-impaired reaches from potentially affected reaches by using macroinvertebrate community assemblage as an indicator of stream health.

We used methods based on EPA's Rapid Bioassessment Protocol for Use in Streams and Wadeable Rivers: Periphyton, Benthic macroinvertebrates, and Fish, Second Edition. Specifically we used a Biosurvey approach that enabled the sampling of a large number of sites in a relatively short period of time and provided a general picture of the ecological condition of the stream. Areas identified as impaired or at-risk can then be evaluated using more rigorous Bioassessment techniques.

Benthic macroinvertebrates were sampled during one index period: low flow season from July through the end of October. Samples were taken directly from natural substrates only. We used a single habitat approach to sampling. Although there are multiple habitat types throughout the stream, each designated reach had only one type of stream habitat. One sample was collected in each reach in a site representative of that entire reach. In each reach, riffle/run habitat was sampled because the most productive areas are those with cobble substrate. Reaches in the watershed where cobble substrate represented less than 30% of the area were designated as a separate reach and had a separate reference reach against which samples were compared. An alternate method to the single-habitat sampling procedure was used where point-sources of organic pollution occurred. In these cases three samples were collected: one sample was taken upstream from the input; one immediately below the effluent; and one downstream in the recovery zone. All samples were taken at least 100 meters upstream from road or bridge crossings.

The sample site was mapped with a hand-held GPS. The sample site was approached from the downstream to upstream direction. A single sample was taken with a Surber sampler having a frame dimension of 0.3 m x 0.3 m. The frame was placed on the stream substrate. All surface substrate material (cobbles, gravel etc.) within the boundary of the frame was picked up, and carefully brushed off with a facial cleansing brush, while still holding the substrate material in the water and upstream within the confines of the frame's dimension, so that dislodged organisms were captured in the sampler's net. Brushed-off substrate was then placed downstream of the Surber sampler.

Organisms captured in the net were transferred to a plastic container that had previously been filled with stream water. Using a forceps and eyedropper, samples were placed in a smaller pan for identification. Using a hand lens, organisms were identified to the family level, separated into "species groups", but not identified to species, and the numbers in each group were counted. After identification was completed the organisms were returned to a quiet place in the stream. After sampling was completed, nets and sample containers were rinsed thoroughly and picked free of debris.

Community composition was used as an indicator of potential disturbance or impairment in streams. Macroinvertebrate family groups were assigned to one of three tolerance categories: pollution intolerant, facultative and pollution tolerant. We used EPA's Regional Tolerance Values for Macroinvertebrates to determine category assignment. Tolerance values are on a scale of 0-10, 0 being extremely sensitive and 10 for tolerant organisms. We categorized those families with a tolerance of 0-3 as pollution intolerant, 4-6 as facultative and 7-10 as pollution tolerant. We then compared the ratio of pollution intolerant, facultative and pollution tolerant individuals. Samples from each test reach were compared against the reference reach condition.

5.4 Abundance and Distribution of an Indicator Species, the American Dipper

The American dipper is an aquatic song bird that has evolved to be a top-level predator-specialist in fast-flowing mountain streams of western North America. Dippers integrate and are dependent upon a suite of environmental characteristics that are found only in healthy mountain stream ecosystems. Three primary factors determine the presence and abundance of dippers: prey abundance, foraging ease and nesting habitat.

Figure 2. The American dipper, also known as the water ouzel, is common on streams throughout the watershed where healthy stream habitat and appropriate nesting sites exist.

In a study conducted on Boulder Creek in Colorado, dippers rarely chose to breed if food density or nest site quality was below a certain threshold. However, if resources were just above threshold, breeding dippers were present and defended a relatively large territory size; if food resources were abundant, territory size decreased (Price and Bock 1983).

Prey abundance, foraging ease, and nesting habitat are dependent on other environmental variables. The dipper diet consists almost exclusively of macroinvertebrates and fish (Vickery, 1992). Dippers prey selectively on caddisfly and mayfly nymphs and only rarely on stoneflies, so dipper abundance is strongly correlated with the abundance of caddisflies and mayflies (Tyler and Ormerod 1994). Members of both macroinvertebrate groups are generally intolerant of pollution or extreme ecological conditions. Pollution or sedimentation can destroy macroinvertebrate populations causing dippers to abandon the site (Sibley 2001).

High quality instream habitat is essential for dipper foraging success. Foraging strategies require stream habitat structure that provides riffles in which to forage, and boulders on which to perch while preening, eating their catch, resting or singing. Aggraded streams or cobbles that are embedded will not support benthic macroinvertebrate. Streams that do not have a variety of velocity/depth combinations, frequent riffles, or natural channel morphology cannot provide the habitat features required by dippers.

Adequate nest sites are the primary criterion for selection of breeding territory. High quality riparian habitat is required for breeding and nesting success. Dippers nest in banks, cliff edges above streams or under bridges. Healthy riparian vegetation is required to stabilize banks where nests are built amidst large roots and snags and to provide security from predators. Riparian vegetation also provides protection and cover while foraging, and strongly influences the macroinvertebrate community.

In essence, dippers integrate three environmental variables when selecting habitat to determine site suitability: water quality, stream habitat quality and riparian habitat quality. If any of these variables are impaired, dippers will not select the site. Although dippers can compensate for a degraded resource by increasing territory size, past a certain point energetics dictate against selecting an impaired territory.

Water quality, riparian habitat and instream habitat interact to form the template upon which the American dipper has evolved. Dippers have integrated these environmental variables into their life history. In so doing the dipper has become a recipient and gauge of ecosystem characteristics and environmental change. Physical and behavioral adaptations have made the dipper perfectly adapted but also completely dependent on the environmental conditions with which they have evolved. Dippers cannot easily adjust to altered stream systems. Consequently, the presence of dippers is an especially good indicator of healthy mountain stream ecosystems. Another factor that makes dippers an attractive indicator in the Rocky Mountains is that they are present year-round, even in the winter so long as the streams are ice-free and permit foraging.

All stream reaches were extensively surveyed for the presence of dippers. Surveys were done on foot during the early spring, after streams were ice-free but before young had fledged. Dipper presence was recorded with a hand-held GPS. Nests were located and also recorded. Dipper presence and abundance was correlated with instream and riparian habitat characteristics and with benthic macroinvertebrate diversity. The survey area was a linear transect along the stream that ran 500 m. Transect sites were selected randomly but were characteristic of the reach.

5.5 Breeding Bird Intensive Point Count Surveys

Riparian breeding bird point count surveys were conducted on specific reaches during the 2005 field season. We modified an Intensive Point Count protocol (Ralph et al 1993) with regard to the shape of the surveyed area so that we surveyed a line rather than a grid. Points were conducted along a transect that ran parallel to the stream corridor. In each transect five points were surveyed for 10 minutes each. Points were 100m apart. Total transect length surveyed equaled 500m. All birds heard and seen within 50m of a point count site were identified to species and recorded.

5.6 Landowner outreach:

Landowners along each stream in the assessment area were identified, parcels were mapped and letters were sent explaining the project and requesting access to the stream. Responses (yes, no, need more information) were recorded and mapped. If the landowner requested more information before granting access, follow-up phone calls or personal visits were conducted. A copy of a sample landowner outreach letter is included in the appendix. If we did not receive permission from the landowner to access a specific property along the stream, we did not visit the property, although we frequently assessed such properties from the opposite bank where we had permission for access from a different landowner.

5.7 Maps and catalog descriptions:

The catalog descriptions amplify what we're showing on the maps and charts and are based on observations in field notes as well as the information recorded on the data sheets for each reach. Information on the habitat quality classification is based on the available mileage in the reach, which varies according to access permission; the characterization represents what we consider to be the typical conditions of the reach and is not tied to any specific parcel of land or owner. In some cases we might have had permission to assess only as much as 30% of a