RIPARIAN BASELINE DATA COLLECTION PRIOR TO OPENING THE PECOS RIVER TO FISHING ACCESS IN PECOS NATIONAL HISTORICAL PARK

Final Report

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Summary

This report presents the results of studies conducted along the Pecos River in Pecos National Historical Park (PECO) undertaken to provide baseline information regarding riparian condition prior to the opening of the river to the general public for fishing. Sixty two transects were evaluated as part of a systematic survey design. Survey points, spaced approximately 80 meters from one another along the channel center line, were evaluated for accessibility and habitat quality, and photo points were recorded to document vegetation structure. Vegetation was evaluated along transects placed perpendicular to stream flow at a subset of sample points. Additional metrics from existing rapid assessment methods were evaluated for use in PECO. Results provide a broad baseline from which to evaluate trends in riparian condition as fishing access increases. The report also presents general recommendations for future monitoring.

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Introduction

The National Park Service (NPS) manages an approximately 3 mile long section of the Pecos River in Pecos National Historical Park. The Pecos River and its associated riparian communities are an important resource regionally and a primary concern for managers. Riparian areas provide a range of essential ecosystem services including erosion control, sediment and nutrient removal, and material and energy inputs to aquatic ecosystems (National Research Council 2002). Particularly in arid and semi-arid regions, they provide critical habitat for a diverse range of plants and wildlife, many found nowhere else (Sabo et al. 2005; Stohlgren et al. 2005).

Alluvial Rivers like the Pecos are naturally in a state of dynamic equilibrium. Their channels migrate within their floodplains, erode banks at the outside of meander bends, and deposit material as point bars on the inside of meander bends (Bennett and Simon 2004; Gurnell et al. 1998). In stable streams, erosion is balanced by deposition of an approximately equivalent amount of sediment on point bars and other areas where sediment loads exceed transport capacity (Leopold et al. 1964; Madej 2001; Wohl 2000). Stream bank erosion typically occurs by fluvial entrainment or through mass movement of material (Harmel et al. 1999) and is primarily influenced by channel hydraulic conditions, discharge, and stream bank composition. A variety of human impacts can influence erosion rates including indirect effects (e.g. changes to contributing watersheds such as dams, diversions, or changes in the amount of impervious surfaces) and direct on-site impacts (e.g. bank destabilization due to human or livestock use)(Patten 1998).

Riparian vegetation provides important protection for stream banks by decreasing the velocity and erosive energy of flood waters. Roots of riparian vegetation bind soil particles together, thus contributing to stream bank stability by mechanically reinforcing soils (Abernethy and Rutherfurd 2001; Gray and Leiser 1982; Wynn et al. 2004). Disturbance from trampling, whether from humans, wildlife, or livestock, can negatively affect bank stability, directly through erosion and indirectly through reductions in plant cover and vigor (Cole and Spildie 1998; Flenniken et al. 2001; Kozlowski 1999; Kutiel and Zhevelev 2001). The severity of impacts will vary depending on the duration and intensity of disturbance.

In 1990, when Pecos National Historical Park (PECO) expanded and assumed management of a portion of the Pecos River, the NPS pledged to provide future recreational fishing access. PECO is implementing plans for opening access to the Pecos River for fishing, and the park anticipates that the park’s lottery based fishing permit system will be fully utilized. To prepare for the opening of access, PECO, with the support from the NPS Water Resources Division, sought to develop an assessment of current conditions in riparian areas along the Pecos River and to develop a baseline for future monitoring. This report presents an overview of the basic sampling design, data collection procedures, and results from fieldwork conducted in 2007. In addition, we present some considerations and suggestions for future monitoring of fishing impacts.

Objectives

Our specific objectives in this study included:

Evaluate existing datasets on riparian ecosystems along the Pecos River

Using a combination of GIS analyses and field data collection, develop a framework for sampling riparian resources along the Pecos River

Collect baseline information on the condition of riparian areas along the Pecos River

Develop recommendations for future monitoring of potential impacts to the Pecos River riparian corridor in response to changes in fishing management

Methods

The focus of this report is on riparian characterization work done along the length of the Pecos River flowing through PECO (Figure 1). We used a variety of approaches including the collection of vegetation cover and composition data, qualitative/semi-quantitative rapid assessments, and photo point sampling. GIS analyses were used to support and augment measurements in the field.

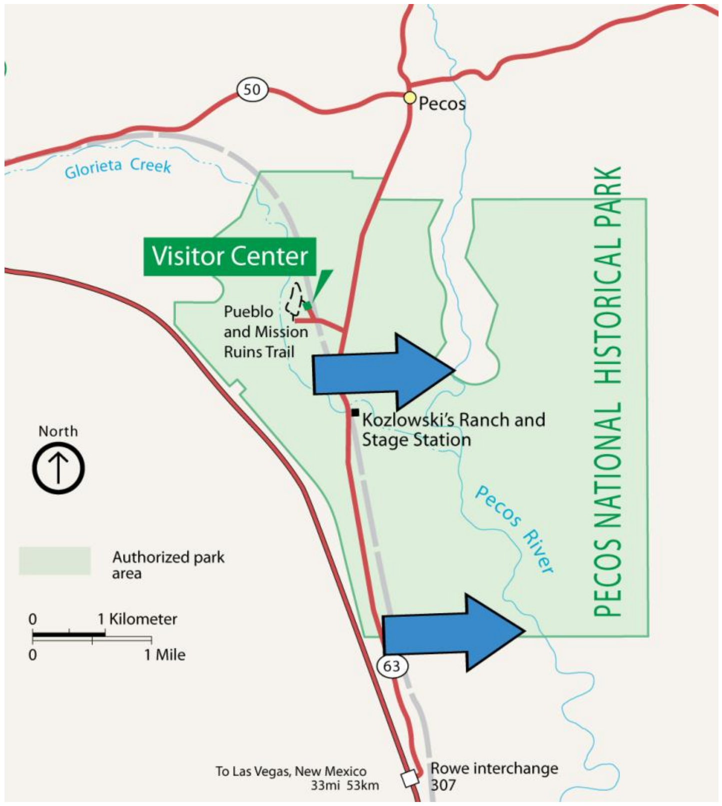

Figure 1. Study area along the Pecos River in Pecos National Historical Park, NM. Work was conducted along an approximately 3 mile stretch of river (bounded between the blue arrows in figure).

As part of baseline data evaluation, we reviewed past work on riparian resources in the park. Habitat characteristics along portions of the Pecos River upstream of the park have been relatively well documented as part of earlier studies and portions of the Pecos River has been sampled as part of broader riparian vegetation classification work conducted within New Mexico (Durkin et al. 1996; Milford et al. 2001; Muldavin et al. 2000; Muldavin et al. 1993; Muldavin 1991). Prior to collecting field data, we reviewed available aerial photographs, National Wetlands Inventory maps, and data products produced by the New Mexico Natural History Program (NMNHP). The riparian and wetland map produced the NMNHP (Muldavin 1991) and a variety of other existing GIS layers were evaluated for use in stratifying the study area into study reaches. These were useful for evaluating general composition of riparian communities. However, field investigations suggested that there was no reason to assume *a priori* that vegetation type is a good predictor of riparian area response to the type of impacts likely from fishing, as qualities likely to influence the behavior of individual fishermen such as the presence of quality fish habitat features such as pools were not correlated with riparian community types. Accordingly, we decided that a systematic sampling design would provide better spatial dispersion of sampling points than a stratified random sample drawn from vegetation associations or geomorphic landforms.

Working in ArcGIS, we used a random number as an offset from the intersection of the northernmost property line and the Pecos River, then established 62 points along the channel centerline. Points were equally spaced and located approximately 80 m apart (Figure 2). Sample points were uploaded to a GPS unit as navigation waypoints. All 62 points were visited and photographed and vegetation transects were established in a subset of points.

We expect that the impacts from fishing will be concentrated to a limited number of sites. Therefore, we evaluated stream reaches centered on each sampling point using a simple qualitative scale to assess relative accessibility and fishing habitat quality, two factors we thought would be useful predictors of visitation levels. Separate scores for bank access and fishing habitat quality were assigned to a 100 m long reach centered on each sampling point (n=62). Ratings for access and habitat quality were scored as follows: 1=poor, 2=fair, 3=good, 4=excellent. Stream reaches were given low scores for accessibility when either the nature of the terrain or vegetation prevented easy access to streambanks. Fishing habitat quality scores were determined by evaluating the presence of specific habitat features such as pools or overhanging banks. A synthetic metric was created by summing bank accessibility and fishing habitat quality scores, and is intended to provide a gross indicator of sites likely to experience greater traffic and impacts.

At a subset of stream reaches selected for vegetation sampling (Figure 2), a transect was established perpendicular to the direction of river flow, with endpoints typically just outside the boundary between riparian and upland vegetation. Along the stream reaches with very wide riparian areas, sampling was restricted to a zone approximately 12 m wide; the rationale was to focus sampling effort in areas near stream banks that are most likely to be impacted by foot traffic from fishing, and not provide an assessment of all riparian areas. We marked endpoints using rebar driven into the soil and logged the location of each endpoint using a GPS.

Along transects, we made ocular estimates of vascular plant cover by species in a series of contiguous 1x1 m plots centered on the transect line. In addition, we made ocular measurements of the % bare ground, % rock, % wood (branches measuring >3 cm along their intermediate axis), % litter, and the proportion of plot area supporting cryptobiotic crusts or nonvascular plant cover. Plots ran from the transect end to the edge of water. To provide a measure of regeneration, we tallied all seedlings and saplings of woody species.

Two rectangular macroplots, one on each side of the stream, were established along the main transect line. Macroplots had fixed area (100 m^2), but varied in plot dimensions based on the length of the baseline; narrower riparian zones (i.e. shorter baselines), had longer plots. These were surveyed for the presence of additional species, the presence of exotic species, and qualitative evidence of human disturbance. In addition, we measured the diameter at breast height (DBH) of trees >2 m tall and recorded the total number of saplings found in plots. Any evidence of trampling, erosion, or significant disturbance in plots was recorded.

As part of initial pilot work, we evaluated metrics included in existing rapid assessment approaches for assessing riparian condition. For a subset of sampling points, we applied methods presented in Pfankuch (1975), Kershner et al. (2004), Natural Resources Conservation Service's Stream Visual Assessment (SVA), and the Bureau of Land Management's Proper Functioning Condition (Newton et al. 1998; Prichard et al. 1999); however, after initial application to pilot reaches, we concluded that these methods were unlikely to respond to the particular impacts associated with fishing access and were dropped from subsequent sampling.

At all sampling locations, we collected a series of photographs upstream and downstream of the reach following general recommendations presented by Hall (Hall 2001, 2002). Photographs were downloaded to a PC and synced with GPS track logs using GPS photolinker software. This program populates the EXIF header of photographs with geographic information gathered from GPS track logs using time stamped data from both camera and GPS. Vegetation data were entered and checked for accuracy using Microsoft Access 2007. Plant taxonomy follows the USDA PLANTS database (NRCS 2009), although plants were generally keyed to species using the Flora of New Mexico (Martin and Hutchins 1980).

Basic statistical analyses of vegetation and other data were conducted in Minitab. Data used in analyses are provided in Access and Excel format on a data CD accompanying this report. All relevant spatial data, including locations of transects and photo points are archived in ESRI shapefile format along with appropriate metadata, and are included on the CD.

We calculated stream and valley gradients using a 10 m DEM data in ArcGIS 9.2. Sinuosity, calculated as the cumulative length of all line segments in the stream polyline layer, divided by the distance between the start and finish locations, was calculated in a GIS for the length of the Pecos River flowing through Pecos National Historical Park. Using data from the access and fishing quality assessment, we subjectively located 7 cross-sections with high access and habitat quality scores and measured the cross-sectional profile of the stream using a stadia rod and laser level.

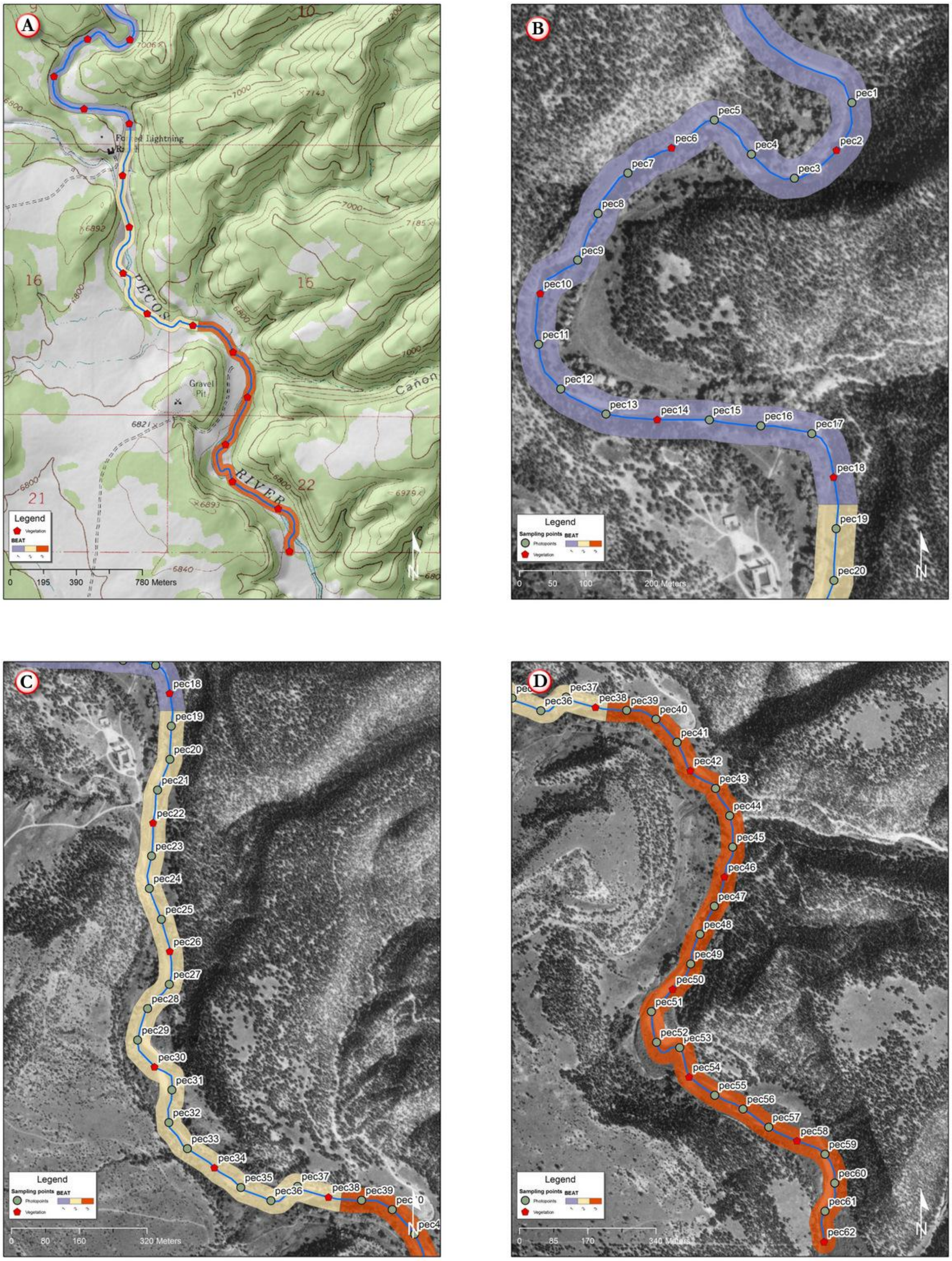

Figure 2. Overview of sampling point s along Pecos River (A), and zoomed into the three "beats" (B, C, D) used for fishing permit allocation.

Results

In PECO, the Pecos River is generally only moderately confined and the gradient is lower than steeper canyon reaches upstream of the Park. We calculated a sinuosity of 1.48, a stream gradient of 0.004. The river supports the development of limited mid and side channel bars within an active floodplain. Reaches with long riffles are common, and while less common, pools are distributed throughout the length of the river.

A total of 15 sample points were selected for vegetation analysis, for a total of 30 individual transects (left and right bank). A total of 154 species were recorded in plots (Appendix 2), falling into several different vegetation communities were commonly observed (Table 1). Sampled communities spanned a gradient of water table depth and flood frequency and included obligate hydrophytic species and upland species.

Small patches of hyrdrophytic vegetation occurred as linear strips adjacent to the channel and within the one to two-year floodplain. Sites supporting these species had fully saturated soils. Other species commonly observed included *Equisetum arvense* (field horsetail) and *Eleocharis parishii* (Parish's spikerush). Small communities dominated by *Typha* spp. (cattails), *Carex* spp., and *Eleocharis* were observed in the wettest sites, but were not typically captured in plots.

Table 1. Vegetation associations described by Muldavin (1993) encountered in transects.

Vegetation association
Emergent Herbaceous Wetland
Coyote Willow Shrub Wetland
Rabbitbrush Shrubland
Old Field/Disturbed Ground (Upland Toeslope)
Narrowleaf Cottonwood Forested Wetland
Juniper/Bluegrass Meadow
Plains/Narrowleaf Cottonwood forested Wetland

Communities dominated by *Salix exigua* (Coyote willow) were commonly encountered along transects. These phreatophytic shrubs often co-occur with riparian trees such as *Populus angustifolia* and *Populus x acuminata*. Common understory dominants included *Poa pratensis* (Kentucky bluegrass), *Juncus arcticus*, and a variety of herbaceous dicots. On the drier edges of transects, upland species such as *Juniperus monosperma (*one-seeded juniper) are common.

Riparian forests dominated by *Populus angustifolia* and *P. x acuminata* were common along sampled reaches. *Populus x acuminata*, the hybrid between narrowleaved and plains cottonwood, was the abundant tree species in most stands. *Populus deltoides* was much rarer, but was observed in a handful of locations. Tree cover was often high 90-100%, heavily shading the understory. *Poa pratensis* was particularly abundant in the understory; other common species included *Erigeron flagellaris* (fleabane) *Melilotus officinalis* (yellow sweetclover).

In the higher portions of floodplains, communities dominated by upland trees and shrubs were encountered. Common understory dominance included such upland species as *Bouteloua gracilis* (blue gramma), *Gutierrezia sarothrae* (snakeweed), *Bouteloua curtipendula* (side-oats gramma), and *Sporobolus spp. (dropseed).* Along the outer margins of the riparian zone, upland communities dominated by *Juniperus monosperma* are common.

Of the 154 species recorded along transects and in plots, 29 species (16.8% of the total list) are listed as non-native in the PLANTS database. Many of these were pasture grasses purposely introduced in the past to provide for forage for livestock. Other common exotics included species like *Phalaris arundanceae* (reed canary grass), *Melolitus officinalis* (yellow sweet clover), and *Taraxacum officinale* (common dandelion).

The portion of plot areas with bare ground varied widely, from <1% to over 50% (Figure 3). Given that likely impacts from fishing will include localized areas of soil disturbance, measures of bare ground may be responsive to disturbance and should be included in future monitoring efforts. Other ground surface characteristics such as % rock or % litter were also variable among plots and transects, although these are less useful for monitoring purposes. Only a small portion of plots in the driest sites had appreciable cover by cryptobiotic crusts or nonvascular plants.

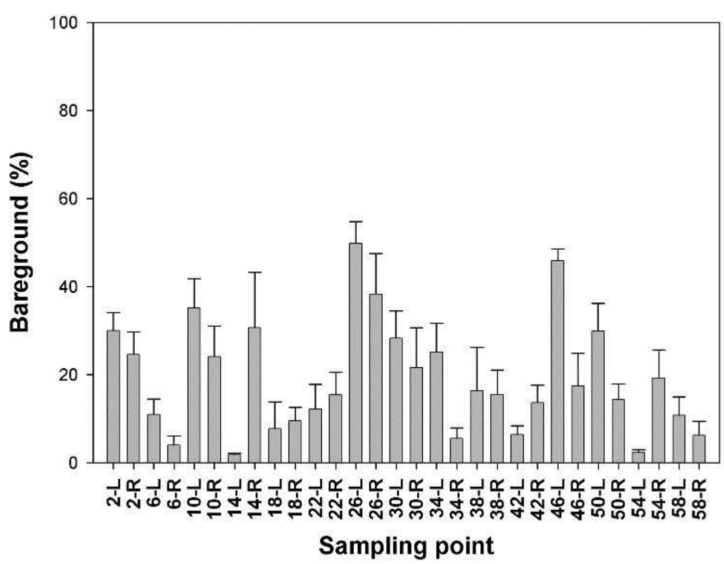

Figure 3. Mean percent baregound (+/- 1 SEM) for vegetation transects.

There was evidence of extensive woody plant regeneration across transects (Figure 4). *Populus angustifolia* seedlings and saplings, for example, were encountered in 60% of transects and associated macroplots (Figure 4). In general, the frequency of saplings in plots was greater than seedling, although seedlings were commonly observed as well.

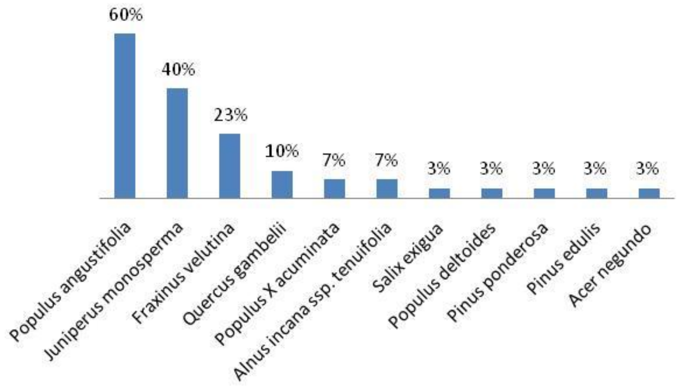

Figure 4. Proportion of total transects sampled (n=30) where tree regeneration was recorded.

Qualitative scores for relative bank access and fishing habit quality were variable. Habitat quality did not significantly differ among the three sections delineated by Park management for administration of fishing permits (i.e. “beats”)(ANOVA, F=0.53, p=0.39). Access scores were significantly different among reaches (ANOVA, F=5.35, p=0.006), with Beat #1 having statistically higher access scores than either Beats #2 or #3. Results were similar for the combined scores (ANOVA, F= 4.87, p=0.009), with Beat #1 having a small, but statistically significant greater score than Beats #2 and #3 (Figure 5).

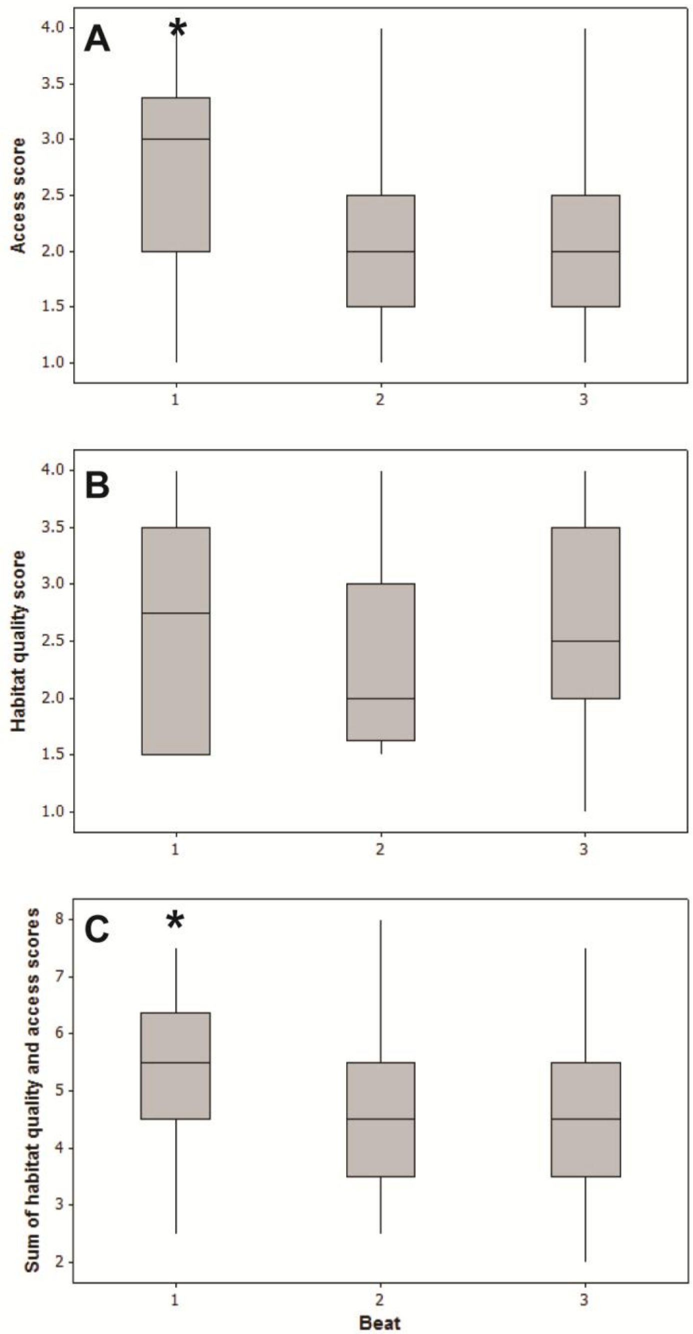

Figure 5. Boxplots of access (A) and fishing habitat quality scores (B), and their sum (C), for all transects (n=62). Rating for starred beats are significantly different (alpha=0.05, ANOVA, Tukey adjustment). Ratings for access and habitat quality are as follows: 1=poor, 2=fair, 3=good, 4=excellent.

Over 500 photographs were taken along sampled reaches (Figure 6). The utility of photos for monitoring is variable. Many reaches, for example those dominated by dense stands of *Salix exigua*, were difficult to effectively photograph.

Figure 6. Example of a series of photopoints taken along a sample reach. All photos have been geotagged and included on a CD as a supplement to the report.

Discussion and recommendations

The Pecos River in PECO supports a diverse and highly functioning riparian corridor. Riparian areas here have been subject to relatively few anthropogenic stressors for decades. Compared to most western rivers of comparable size or to sections of the Pecos River downstream of the park, the Pecos River upstream of PECO has experienced fewer systemic changes. The persistence of natural flow and disturbance regimes helps support a variety of different community types.

However, the river is by no means pristine. Historical cattle grazing has affected plant communities. The riparian corridor support large populations of several non-native plant species, including several pasture grasses purposely introduced as forage for livestock. Changes in the intensity of management and processes of Juniper encroachment have contributed to changing conditions. Localized areas of bank instability and erosion were observed, although it was generally not clear how much of this was the result of anthropogenic factors.

There are several challenges associated with effective monitoring of riparian resources. First and foremost is the high degree of variability typical of riparian ecosystems. Diverse hydrologic and geomorphic environments, coupled with spatially and temporally variable disturbance processes, help maintain a range of riparian community types. Effective monitoring must be able to detect actual trends in key variables, but not falsely attribute systemic change to natural patterns of variability. Additionally, monitoring objectives must be feasible with available resources, since the most carefully developed monitoring protocol is of little value if it cannot be implemented in the field.

Monitoring should be focused on the kind of impacts most relevant to the key ecological functions of interest and metrics selected should be those most likely to respond to specific agents of change. A variety of monitoring protocols have been developed for riparian assessment. While each has value, most have been developed for different purposes and are focused on different stressors. No existing method is tailored to the kinds of specific impacts likely to occur as a result of increased fishing access.

Impacts from increased public access for fishing can be separated into two general categories. Fishermen may indirectly impact areas by serving as vectors for exotic species. These effects are difficult to capture with monitoring, since many exotic species are already present in PECO riparian areas and it is hard to link changes in the distribution and abundance directly to fishing access. A second category includes direct impacts associated with increases in soil disturbance. Impacts from increases in visitor access will most visibly be manifested in the formation of trails and other eroded areas. These impacts can lead to a variety of ecological as well as aesthetic effects (Figure 7). During fieldwork, few observations of trailing were observed, all attributed to game. Incidences of trailing can be documented opportunistically during routine resource management activities. A few simple notes, photographs and GPS coordinates can provide useful information and need not require excessive commitment by Park staff. However, a more systematic approach to documenting these impacts should be undertaken periodically.

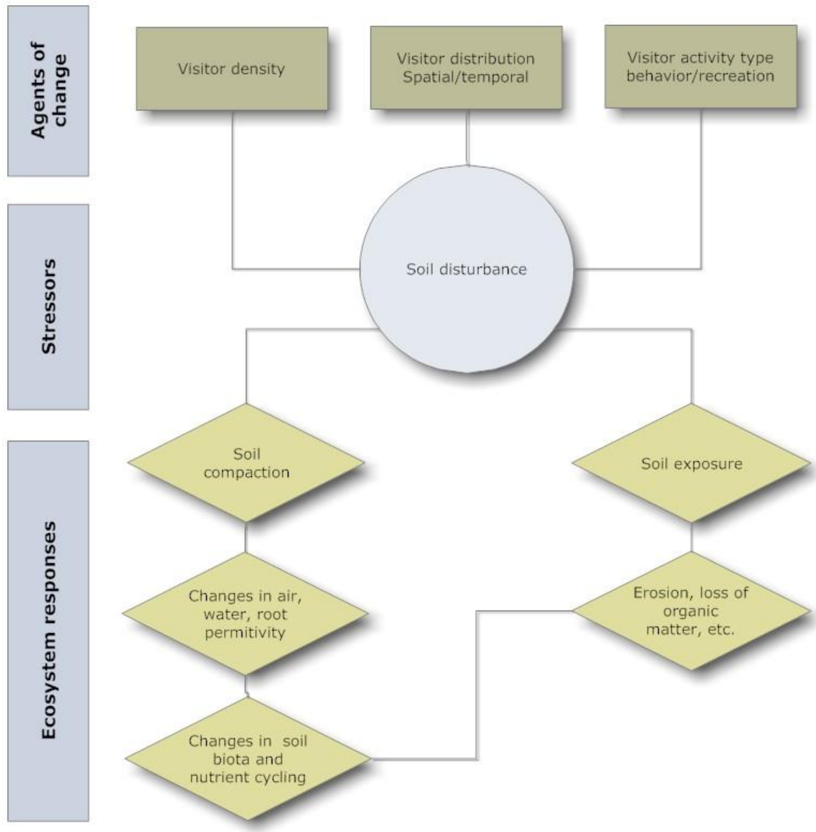

Figure 7. Conceptual model illustrating is the kinds of stressors and ecosystem responses that may be expected from an increase in soil disturbance accompanying increased visitor use (modified from Monz and Leung 2006). Note that this model deals with soil disturbance only; other impacts such the spread of exotic species may also occur with increased public access.

In our evaluation of existing rapid assessment protocols commonly used to evaluate wetland and riparian condition and function, we found that all have elements useful to riparian monitoring in PECO, but taken as a whole, no single approach is very well suited to the specific kinds of impacts likely from increased fishing. A key consideration in selecting metrics for monitoring is precision. All methods are subject to some inter-observer error; if this is too large, any meaningful trend information is lost, or trend can be falsely detected where there is none. A general weakness of most qualitative or semi-quantitative methods is that the specific metrics are so vague as to have different meanings to different individuals. To be really useful, all methods need to be precisely qualified with respect to location. Even if different observers make identical calls regarding the value of specific metrics, their outcomes will differ if they use different assessment areas (e.g. a 20 m versus 300 m stream reach).

Overall, Pfankuch's (1975) Stream Reach Inventory and Channel Stability Evaluation method is more appropriate for broader scale assessments and comparative assessments (e.g. different basins and streams). We found streambank stability indicators included in Kershner et al. (2004) were conceptually useful, but as a baseline for monitoring fishing impacts, they were too general to recommend for monitoring purposes. Attributes such as the presence of slump blocks or cracks in the streambank could indicate impacts from trampling, but also occur from natural erosional processes, so absent a specific frame of reference, which may not overlap with areas where fishing impacts are concentrated, the approach is not likely useful for trend detection.

The Natural Resources Conservation Service's Stream Visual Assessment (SVA), and Bureau of Land Management's Proper Functioning Condition (PFC) assessment were evaluated for possible inclusion with recommended monitoring protocols (Prichard et al. 1998; Ward et al. 2003). Metrics included with both the SVA and PFC methods were generally found to lack sufficient precision to be particularly useful for monitoring specific impacts from increased access for fishing. Neither method is likely sensitive enough to detect the localized impacts most likely to occur. Some attributes included in these methods such as the presence of undercut banks, slump blocks (i.e. partially or completely detached pieces of the streambank), are useful and can be included in general assessment and observation reports made by park staff.

A key objective of this research was to collect baseline data and recommend potential monitoring approaches for evaluating potential impacts of opening fishing access to the Pecos River. There are a significant number of factors that affect the ability of any particular monitoring strategy to detect and measure change. Limitations in resources for sampling must also be frankly recognized. As a consequence, the rather labor intensive methods used for baseline data collection are not appropriate for routine annual monitoring. The availability of monitoring personnel, particularly individuals with botanical training, is limited, so approaches should emphasize rapid assessment techniques such as photo points and semi-quantitative or qualitative assessments. The more extensive and intensive nature of sampling used for baseline data collection can be episodically revisited as resources become available.

Several characteristics make sampling likely impacts from fishing difficult. Impacts will tend to be highly localized and non-random, influenced by a variety of factors. The relative ease of travel, as influenced by the terrain (slopes, cliff-sections) and vegetation (dense willow, juniper), will tend to localize traffic in certain areas. Proximity to access points will also influence the spatial pattern of impacts. Presumably, sites closer to access points will receive greater use, and therefore will be more likely to experience measurable impacts. High water, early in the season will prevent most people from accessing the opposite banks during late spring and early summer. Fisherman behavior is also influenced by skill level, motivation, and equipment (e.g. waders), which may affect patterns of use and impact. For example, banks near large pools will likely see more traffic than densely wooded riffle sections difficult to access from the bank.

Monitoring is most effective when it can balance precision, accuracy, and efficiency. Likely impacts from fishing are dispersed and complex, making effective monitoring difficult given likely constraints on resources for sampling. The relationship between visitor use and impacts is often curvilinear, with much of the impact occurring with initial use (Cole and Monz 2003; Monz and Leung 2006). This, coupled with the fact that the area has been closed to public access for so long, suggests that many problems will be become apparent within the first couple years of use. Currently, the riparian corridor is largely free of trails and other visible signs of disturbance; this will inevitably change over time. We recommend that developing social trail networks should be periodically inventoried and mapped using a GIS (Marion et al. 2006). This information will allow Park managers monitor changing conditions and help define acceptable levels of impact based on on-the-ground observations.

Regardless of specific monitoring approaches adopted, management should be adaptive to conditions on the ground. Considering that the riparian area in PECO has been closed to public access for so long, it is inevitable that some minor trailing will occur, but most instances will not likely be actionable by Park managers because no significant resource damage is occurring. However, there may be areas where trailing leads to more significant impacts (e.g. causing significant hill slope erosion), necessitating some management action. Regular monitoring, even if only consisting of general reconnaissance of riparian areas, is important so these problems areas can be identified early. Whenever feasible, resource management staff should carry a GPS unit and camera; potential problem areas observed during unrelated job activities may be documented using geo-tagged photo points and flagged for follow up.

Good information regarding the spatial and temporal patterns of visitor use along the Pecos River can facilitate more efficient and effective use of limited monitoring resources. Many areas will see little use, while areas near access points may see high levels of use. By monitoring use patterns, problem areas can be identified early. The frequency of visits (i.e. visitor numbers) and the intensity of use will be one of the strongest correlates of resource impacts.

Basic information will be collected as part of the administration of the fishing permits. However, because fishing impacts will tend to be localized, absent more specific information on the spatial pattern of visitor use, these data will be too coarse to help locate potential problem areas. Several options exist for augmenting visitor use information, providing more effective ways of concentrating management efforts.

A variety of trail counters on the market are routinely used by recreation managers in National Parks and National Forests to develop recreational use statistics. Counters can be placed systematically along the river to help refine understanding of human traffic or in strategic locations where traffic naturally consolidates. Scouting cameras can be used in a similar fashion, and over the long-term, can be a cost-effective tool to monitor use. Both require little maintenance and can be revisited infrequently, minimizing time requirements by park staff.

GPS loggers can be an effective tool to develop an understanding of the spatial pattern of visitor use. Many low-cost data logging GPS transponders are on the market. These lack all of the navigation and other user features found in more sophisticated units, but can be purchased very inexpensively (<$60). It is probably not feasible to require visitors to carry these; many visitors might object for reasons such as privacy. However, the park can incentivize users by presenting clear information on how the data will be used and by offering a fee discount or waiver. Data from even a small fraction of total visits will still provide a much more refined picture of use patterns along the river.

Procedures used to sample vegetation were time-consuming and do not represent a viable approach for annual monitoring by parks staff. However, these data can be revisited less frequently, perhaps with the help of external resources. These more rigorous and quantitative approaches to monitoring complement information collected using more rapid approaches such as photopoint monitoring.

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Appendix 1. List and map of sampling points

Reach	UTM -X	UTM-Y	Beat	Sampling	Reach	UTM -X	UTM-Y	Beat	Sampling
1	439470.63	3933341.60	1	Photopoint	**32**	439440.94	3931754.03	2	Photopoint
2	439447.37	3933269.41	1	Vegetation	**33**	439484.81	3931692.14	2	Photopoint
3	439383.38	3933226.86	1	Photopoint	**34**	439549.24	3931647.15	2	Vegetation
4	439318.04	3933263.23	1	Photopoint	**35**	439611.46	3931599.74	2	Photopoint
5	439261.83	3933315.37	1	Photopoint	**36**	439683.00	3931568.36	2	Photopoint
6	439197.06	3933273.28	1	Vegetation	**37**	439746.52	3931602.56	2	Photopoint
7	439130.45	3933234.63	1	Photopoint	**38**	439820.02	3931577.18	2	Vegetation
8	439084.94	3933173.45	1	Photopoint	**39**	439898.17	3931569.33	3	Photopoint
9	439053.97	3933102.40	1	Photopoint	**40**	439971.07	3931547.31	3	Photopoint
10	438997.37	3933051.82	1	Vegetation	**41**	440023.93	3931489.20	3	Photopoint
11	438994.65	3932974.55	1	Photopoint	**42**	440057.66	3931418.69	3	Vegetation
12	439028.33	3932906.66	1	Photopoint	**43**	440120.47	3931373.79	3	Photopoint
13	439096.96	3932868.45	1	Photopoint	**44**	440156.01	3931305.25	3	Photopoint
14	439175.26	3932860.44	1	Vegetation	**45**	440163.13	3931227.20	3	Photopoint
15	439254.01	3932859.65	1	Photopoint	**46**	440142.71	3931152.76	3	Vegetation
16	439332.20	3932850.81	1	Photopoint	**47**	440117.29	3931078.87	3	Photopoint
17	439409.64	3932838.93	1	Photopoint	**48**	440081.45	3931008.77	3	Photopoint
18	439442.99	3932772.84	1	Vegetation	**49**	440058.04	3930934.59	3	Photopoint
19	439446.67	3932694.69	2	Photopoint	**50**	440013.09	3930871.69	3	Vegetation
20	439443.37	3932615.98	2	Photopoint	**51**	439959.81	3930815.46	3	Photopoint
21	439413.94	3932542.99	2	Photopoint	**52**	439972.82	3930738.32	3	Photopoint
22	439403.43	3932465.33	2	Vegetation	**53**	440030.65	3930724.99	3	Photopoint
23	439399.57	3932386.71	2	Photopoint	**54**	440054.58	3930651.80	3	Vegetation
24	439394.46	3932309.62	2	Photopoint	**55**	440118.64	3930606.03	3	Photopoint
25	439423.02	3932236.28	2	Photopoint	**56**	440189.06	3930571.33	3	Photopoint
26	439443.41	3932160.28	2	Vegetation	**57**	440253.29	3930525.92	3	Photopoint
27	439441.80	3932082.26	2	Photopoint	**58**	440324.28	3930492.18	3	Vegetation
28	439390.40	3932024.31	2	Photopoint	**59**	440394.12	3930458.15	3	Photopoint
29	439366.79	3931949.80	2	Photopoint	**60**	440418.54	3930385.96	3	Photopoint
30	439407.04	3931886.33	2	Vegetation	**61**	440394.10	3930315.66	3	Photopoint
31	439448.10	3931831.21	2	Photopoint	**62**	440392.35	3930239.41	3	Vegetation

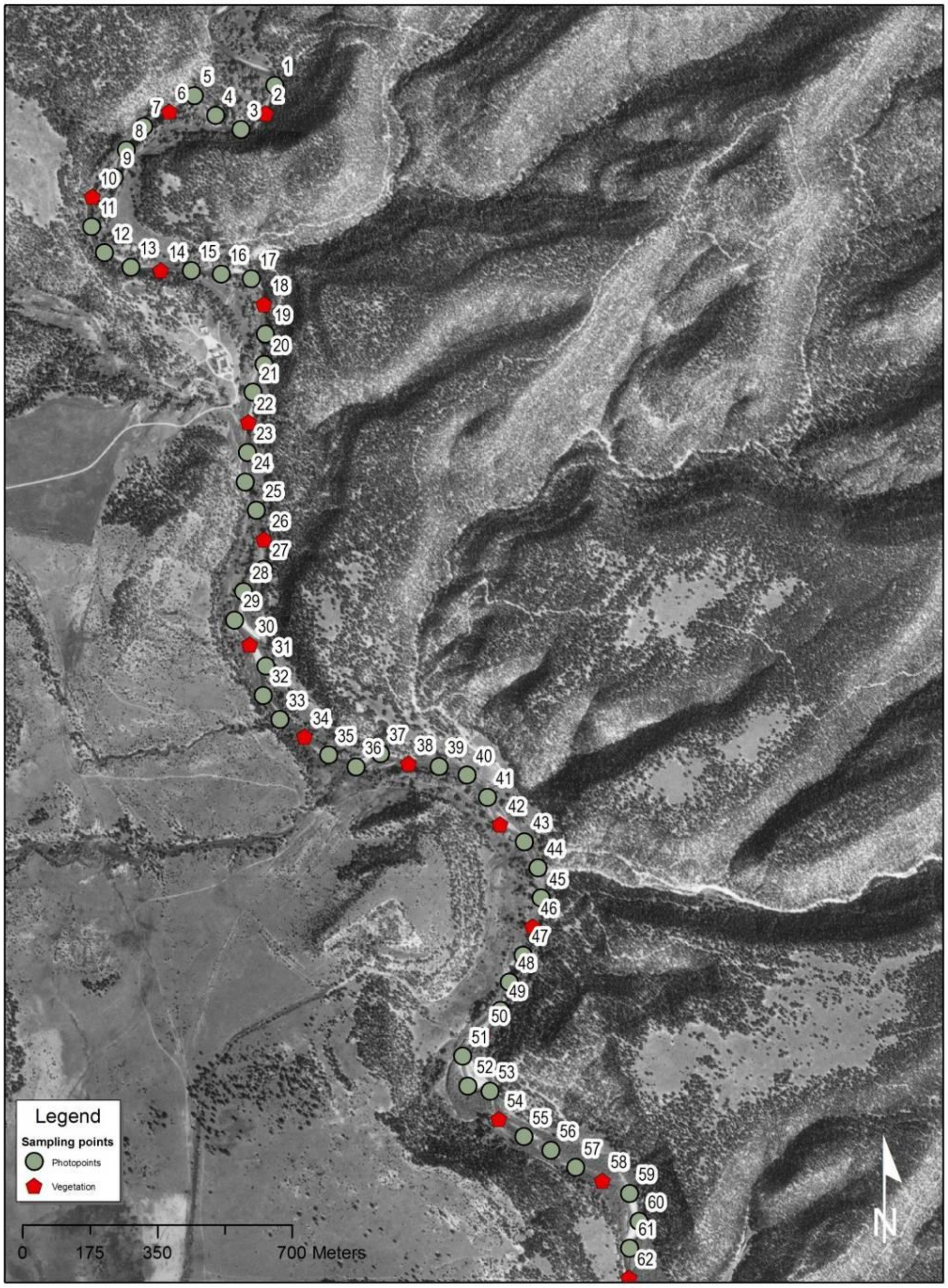

Figure 8. Locations of systematically placed sample reaches along the Pecos River.

Appendix 2. Plant list

Species recorded in vegetation plots. Species in bold are non-natives. Nomenclature follows the USDA PLANTS database.

species	Common Name	Accepted Symbol	Family
Achillea millefolium	common yarrow	ACMI2	Asteraceae
Actaea rubra	red baneberry	ACRU2	Ranunculaceae
Agrostis exarata	spike bentgrass	AGEX	Poaceae
Agrostis gigantea	**redtop**	**AGGI2**	**Poaceae**
Agrostis scabra	rough bentgrass	AGSC5	Poaceae
Allium geyeri	Geyer's onion	ALGE	Liliaceae
Alnus incana ssp. tenuifolia	thinleaf alder	ALINT	Betulaceae
Ambrosia acanthicarpa	flatspine bur ragweed	AMAC2	Asteraceae
Ambrosia artemisiifolia	annual ragweed	AMAR2	Asteraceae
Androsace septentrionalis	pygmyflower rockjasmine	ANSE4	Primulaceae
Apocynum cannabinum	Indianhemp	APCA	Apocynaceae
Arabis fendleri var. fendleri	Fendler's rockcress	ARFEF	Brassicaceae
Aristida purpurea var. longiseta	Fendler threeawn	ARPUL	Poaceae
Artemisia carruthii	Carruth's sagewort	ARCA14	Asteraceae
Artemisia frigida	prairie sagewort	ARFR4	Asteraceae
Artemisia ludoviciana	white sagebrush	ARLU	Asteraceae
Asclepias speciosa	showy milkweed	ASSP	Asclepiadaceae
Astragalus missouriensis	Missouri milkvetch	ASMI10	Fabaceae
Bahia dissecta	ragleaf bahia	BADI	Asteraceae
Berberis fendleri	Colorado barberry	BEFE	Berberidaceae
Bouteloua curtipendula	sideoats grama	BOCU	Poaceae
Bouteloua gracilis	blue grama	BOGR2	Poaceae
Bromus arvensis	**field brome**	**BRAR5**	**Poaceae**
Bromus inermis	**smooth brome**	**BRIN2**	**Poaceae**
Bromus lanatipes	woolly brome	BRLA6	Poaceae
Bromus tectorum	**cheatgrass**	**BRTE**	**Poaceae**
Carex emoryi	Emory's sedge	CAEM2	Cyperaceae
Carex occidentalis	western sedge	CAOC2	Cyperaceae
Chenopodium album	lambsquarters	CHAL7	Chenopodiaceae

Chenopodium leptophyllum	narrowleaf goosefoot	CHLE4	Chenopodiaceae
Cichorium intybus	**chicory**	**CIIN**	**Asteraceae**
Cicuta maculata	spotted water hemlock	CIMA2	Apiaceae
Cirsium arvense	**Canada thistle**	**CIAR4**	**Asteraceae**
Cirsium ochrocentrum	yellowspine thistle	CIOC2	Asteraceae
Clematis ligusticifolia	western white clematis	CLLI2	Ranunculaceae
Conium maculatum	**poison hemlock**	**COMA2**	**Apiaceae**
Conyza canadensis	Canadian horseweed	COCA5	Asteraceae
Crataegus erythropoda	cerro hawthorn	CRER	Rosaceae
Dactylis glomerata	**orchardgrass**	**DAGL**	**Poaceae**
Dianthus armeria	**Deptford pink**	**DIAR**	**Caryophyllaceae**
Dipsacus fullonum	**Fuller's teasel**	**DIFU2**	**Dipsaceae**
Eleocharis palustris	common spikerush	ELPA3	Cyperaceae
Eleocharis parishii	Parish's spikerush	ELPA4	Cyperaceae
Elymus canadensis	Canada wildrye	ELCA4	Poaceae
Elymus trachycaulus	slender wheatgrass	ELTR7	Poaceae
Epilobium ciliatum	fringed willowherb	EPCI	Onagraceae
Equisetum arvense	field horsetail	EQAR	Equisetaceae
Ericameria nauseosa	rubber rabbitbrush	ERNA10	Asteraceae
Erigeron divergens	spreading fleabane	ERDI4	Asteraceae
Erigeron flagellaris	trailing fleabane	ERFL	Asteraceae
Erigeron formosissimus	beautiful fleabane	ERFO3	Asteraceae
Euphorbia brachycera	horned spurge	EUBR	Euphorbiaceae
Euphorbia davidii	**David's spurge**	**EUDA5**	**Euphorbiaceae**
Fraxinus velutina	velvet ash	FRVE2	Oleaceae
Gaillardia aristata	common gaillardia	GAAR	Asteraceae
Gaillardia pinnatifida	red dome blanketflower	GAPI	Asteraceae
Gaura coccinea	scarlet beeblossom	GACO5	Onagraceae
Gaura mollis	velvetweed	GAMO5	Onagraceae
Geranium atropurpureum var. atropurpureum	western purple cranesbill	GEATA	Geraniaceae
Geranium caespitosum	pineywoods geranium	GECA3	Geraniaceae
Glyceria grandis	American mannagrass	GLGR	Poaceae
Glycyrrhiza lepidota	American licorice	GLLE3	Fabaceae
Gutierrezia sarothrae	broom snakeweed	GUSA2	Asteraceae
Hedeoma drummondii	Drummond's false pennyroyal	HEDR	Lamiaceae

Helianthus annuus	common sunflower	HEAN3	Asteraceae
Helianthus petiolaris	prairie sunflower	HEPE	Asteraceae
Hesperostipa comata ssp. comata	needle and thread	HECOC8	Poaceae
Hesperostipa neomexicana	New Mexico feathergrass	HENE5	Poaceae
Heterotheca villosa	hairy false goldenaster	HEVI4	Asteraceae
Hordeum jubatum	foxtail barley	HOJU	Poaceae
Ipomopsis aggregata ssp. formosissima	scarlet gilia	IPAGF	Polemoniaceae
Ipomopsis longiflora	flaxflowered ipomopsis	IPLO2	Polemoniaceae
Juncus arcticus	arctic rush	JUAR2	Juncaceae
Juncus bufonius	toad rush	JUBU	Juncaceae
Juncus tenuis	poverty rush	JUTE	Juncaceae
Juncus torreyi	Torrey's rush	JUTO	Juncaceae
Juncus tracyi	Tracy's rush	JUTR	Juncaeae
Juniperus communis	common juniper	JUCO6	Cupressaceae
Juniperus monosperma	oneseed juniper	JUMO	Cupressaceae
Lactuca serriola	**prickly lettuce**	**LASE**	**Asteraceae**
Leucanthemum vulgare	**oxeye daisy**	**LEVU**	**Asteraceae**
Listera cordata	heartleaf twayblade	LICO6	Orchidaceae
Lygodesmia juncea	rush skeletonplant	LYJU	Asteraceae
Machaeranthera canescens	hoary tansyaster	MACA2	Asteraceae
Machaeranthera pinnatifida ssp. pinnatifida	lacy tansyaster	MAPIP	Asteraceae
Medicago lupulina	**black medick**	**MELU**	**Fabaceae**
Medicago sativa	**alfalfa**	**MESA**	**Fabaceae**
Melampodium leucanthum	plains blackfoot	MELE2	Asteraceae
Melilotus officinalis	**yellow sweetclover**	**MEOF**	**Fabaceae**
Mentha arvensis	wild mint	MEAR4	Lamiaceae
Monarda fistulosa	wild bergamot	MOFI	Lamiaceae
Monarda pectinata	pony beebalm	MOPE	Lamiaceae
Muhlenbergia asperifolia	scratchgrass	MUAS	Poaceae
Muhlenbergia montana	mountain muhly	MUMO	Poaceae
Muhlenbergia torreyi	ring muhly	MUTO2	Poaceae
Nasturtium officinale	**watercress**	**NAOF**	**Brassicaceae**
Oenothera albicaulis	whitest evening primrose	OEAL	Onagraceae
Oenothera caespitosa	tufted evening primrose	OECA10	Onagraceae
Opuntia phaeacantha	tulip pricklypear	OPPH	Cactaceae

Oxalis alpina	alpine woodsorrel	OXAL2	Oxalidaceae
Parthenocissus vitacea	woodbine	PAVI5	Vitaceae
Pascopyrum smithii	western wheatgrass	PASM	Poaceae
Pennellia longifolia	longleaf mock thelypody	PELO3	Brassicaceae
Phalaris arundinacea	reed canarygrass	PHAR3	Poaceae
Phleum pratense	**timothy**	**PHPR3**	**Poaceae**
Phlox nana	Santa Fe phlox	PHNA2	Polemoniaceae
Pinus edulis	twoneedle pinyon	PIED	Pinaceae
Pinus ponderosa	ponderosa pine	PIPO	Pinaceae
Plantago lanceolata	**narrowleaf plantain**	**PLLA**	**Plantaginaceae**
Plantago major	**common plantain**	**PLMA2**	**Plantaginaceae**
Plantago patagonica	woolly plantain	PLPA2	Plantaginaceae
Poa pratensis	Kentucky bluegrass	POPR	Poaceae
Polygonum aviculare	**prostrate knotweed**	**POAV**	**Polygonaceae**
Populus angustifolia	narrowleaf cottonwood	POAN3	Salicaceae
Populus deltoides	eastern cottonwood	PODE3	Salicaceae
Populus X acuminata	lanceleaf cottonwood	POAC5	Salicaceae
Potentilla pensylvanica	Pennsylvania cinquefoil	POPE8	Rosaceae
Prunella vulgaris	common selfheal	PRVU	Lamiaceae
Quercus gambelii	Gambel oak	QUGA	Fagaceae
Ranunculus cymbalaria	alkali buttercup	RACY	Ranunculaceae
Rhus trilobata	skunkbush sumac	RHTR	Anacardiaceae
Rosa woodsii	Woods' rose	ROWO	Rosaceae
Rumex acetosella	**common sheep sorrel**	**RUAC3**	**Polygonaceae**
Rumex crispus	**curly dock**	**RUCR**	**Polygonaceae**
Salix bebbiana	Bebb willow	SABE2	Salicaceae
Salix exigua	narrowleaf willow	SAEX	Salicaceae
Salix gooddingii	Goodding's willow	SAGO	Salicaceae
Salix irrorata	dewystem willow	SAIR	Salicaceae
Salix lucida	shining willow	SALU	Salicaceae
Saponaria officinalis	**bouncingbet**	**SAOF4**	**Caryophyllaceae**
Schizachyrium scoparium	little bluestem	SCSC	Poaceae
Schoenoplectus acutus	hardstem bulrush	SCAC3	Cyperaceae
Schoenoplectus acutus var. acutus	hardstem bulrush	SCACA	Cyperaceae
Schoenoplectus americanus	chairmaker's bulrush	SCAM6	Cyperaceae

Sisyrinchium idahoense var. occidentale	Idaho blue-eyed grass	SIIDO	Iridaceae
Solidago canadensis	Canada goldenrod	SOCA6	Asteraceae
Sophora nuttalliana	silky sophora	SONU	Fabaceae
Sporobolus airoides	alkali sacaton	SPAI	Poaceae
Sporobolus contractus	spike dropseed	SPCO4	Poaceae
Symphyotrichum falcatum	white prairie aster	SYFA	Asteraceae
Symphyotrichum laeve	smooth blue aster	SYLA3	Asteraceae
Symphyotrichum lanceolatum	white panicle aster	SYLA6	Asteraceae
Symphyotrichum lanceolatum	white panicle aster	SYLA6	Asteraceae
Taraxacum officinale	common dandelion	TAOF	Asteraceae
Toxicodendron rydbergii	western poison ivy	TORY	Anacardiaceae
Tragopogon dubius	**yellow salsify**	**TRDU**	**Asteraceae**
Trifolium pratense	**red clover**	**TRPR2**	**Fabaceae**
Trifolium repens	**white clover**	**TRRE3**	**Fabaceae**
Typha latifolia	broadleaf cattail	TYLA	Typhaceae
Ulmus pumila	**Siberian elm**	**ULPU**	**Ulmaceae**
Verbascum thapsus	**common mullein**	**VETH**	**Scrophulariaceae**
Veronica americana	American speedwell	VEAM2	Scrophulariaceae
Vicia americana	American vetch	VIAM	Fabaceae
Xanthium strumarium	rough cocklebur	XAST	Asteraceae

Appendix 3. Field forms for rapid assessment techniques evaluated during pilot work

Field forms for Stream Reach Inventory and Channel Stability Evaluation method (Pfankuch 1975).

UPPER BANKS	**EXCELLENT**		**GOOD**		**FAIR**		**POOR**	
Landform slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%	4	Bank slope gradient 40-60%	6	Bank slope gradient >60%	8
Mass-wasting (existing or potential)	No evidence of post or any potential for future mass-wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.	6	Moderate frequency and size, with some raw spots eroded by water during high flows.	9	Frequent or large, causing sediment OR imminent danger of same.	12
Debris jam potential (floatable objects)	Essentially absent from immediate channel area.	2	Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing,	6	Moderate to heavy amounts, mainly larger sizes.	8
Vegetative bank protection	>90% plant density. Vigor and variety suggests a deep, dense, soil binding root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	6	50-70% density. Lower vigor and species form a somewhat shallow and discontinuous root mass.	9	<50% density plus fewer species and vigor indicate discontinuous and shallow root mass.	12
Channel capacity	Ample for present plus some increases. Peak flows contained. Width to Depth (W/D) ratio <7.	1	Adequate. Overbank flows rare. W/D ratio 8 to 15.	2	Barely contains present peaks. Occasional over-bank floods. W/D ratio 15 to 25.	3	Inadequate. Overbank flows common. W/D ratio >25.	4
LOWER BANKS								
Bank rock content	65% with large, angular boulders 30cm numerous.	2	40 to 65'%, mostly small boulders to cobbles 15-30cm.	4	20 to 401, with most in the 7.5-15cm diameter class.	6	<20% rock fragments of gravel sizes, 2.5-7.5 cm or less.	8
Obstructions (flow deflectors Sediment traps)	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	4	Moderately frequent, unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.	6	Frequent obstructions and deflectors cause bank erosion. Sediment traps' full channel migration occurring.	8
Undercutting	Little or none evident. Infrequent raw banks <150cm high.	4	Some, intermittently at outcurves and constrictions. Raw banks <30cm.	8	Significant. Cuts 15-30cm high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some >30cm high. Failure of overhangs	16
Deposition	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.	12	Extensive deposits of predominantly fine particles. Accelerated	16
STREAM BED								
Rock angularity	Sharp edges and corners, plane surfaces roughened.	1	Rounded corners and edges. Smooth and flat.	2	Corners and edges wel1 rounded in two dimensions.	3	Well rounded in all dimensions.	4
Brightness	Surfaces dull, darkened or stained. Not "bright".	1	Mostly dull, but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright i.e. 35-65%.	3	Predominantly bright, 65%, exposed surfaces.	4
Consolidation or particle packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.	4	Mostly a loose assortment with no apparent overlap.	6	No packing evident. Loose, easily moved.	8
Bottom size distribution & stable	No change in sizes evident. Stable materials 80-100%	4	Distribution shift slight. Stable materials 50-80%.	8	Moderate change in sizes. Stable materials 20-50%	12	Marked change. Stable materials 0-20%	16
Scouring and deposition	<5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and where steep. Pool deposition.	12	30-50% affected. Deposits and scour at obstructions, constrictions, and bends.	18	> 50% of bed in a state of flux or change nearly year-long.	24
Clinging aquatic vegetation (moss and algae)	Abundant, growth largely moss, dark green, perennial. In swift water too.	1	Common. Algal forms in low velocity and pool areas. Moss and swifter waters.	2	Present but spotty, mostly in backwater areas. Seasonal blooms	3	Perennial types scarce or absent. Yellow-green, short term bloom present.	4
COLUMN TOTALS								

Field data forms used in the habitat assessment field data protocol.

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS

STREAM NAME	LOCATION	
STATION #_ REACH ID# ________	STREAM CLASS	
UTM N UTM E	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME _ PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE __ _ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Parameters to be evaluated broader than sampling reach

PFC checklist field form

Standard Checklist

Name of Riparian-Wetland Area: ____________________

Date: __________ Segment/Reach ID: ____________________

Miles: ____________ Acres: ____________________

ID Team Observers: ____________________

Yes	No	N/A	HYDROLOGY
			1) Floodplain above bankfull is inundated in "relatively frequent" events
			2) Where beaver dams are present they are active and stable
			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
			4) Riparian-wetland area is widening or has achieved potential extent
			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
			6) There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
			7) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)
			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events
			10) Riparian-wetland plants exhibit high vigor
			11) Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows
			12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION/DEPOSITION
			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) are adequate to dissipate energy
			14) Point bars are revegetating with riparian-wetland vegetation
			15) Lateral stream movement is associated with natural sinuosity
			16) System is vertically stable
			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

(Revised 1998)

Stream Visual Assessment (SVA) field form

Stream Visual Assessment Protocol

Owners name ________________________________ Evaluator's name____________________________ Date _______________

Stream name ____ Waterbody ID number ________________________________

Reach location ____

____

Ecoregion ________________________________ Drainage area _____________________ Gradient________________________

Applicable reference site ____

Land use within drainage (%): row crop ______ hayland ______ grazing/pasture _______ forest ______ residential _______

confined animal feeding operations ______ Cons. Reserve ________ industrial _______ Other: ________________

Weather conditions-today ___________________________________ Past 2-5 days _______________________________________

Active channel width ____________________ Dominant substrate: boulder ______ gravel ______ sand ______ silt ______ mud ______

Site Diagram

Assessment Scores

Channel condition	
Hydrologic alteration	
Riparian zone	
Bank stability	
Water appearance	
Nutrient enrichment	
Barriers to fish movement	
Instream fish cover	
Pools	
Invertebrate habitat	

Score only if applicable

Canopy cover	
Manure presence	
Salinity	
Riffle embeddedness	
Marcroinvertebrates Observed (optional)	

Overall score (Total divided by number scored)	___________	<6.0	**Poor**
		6.1-7.4	**Fair**
		7.5-8.9	**Good**
		>9.0	**Excellent**

Suspected causes of observed problems____

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Recommendations____

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