PACFISH INFISH Biological Opinion Effectiveness Monitoring Program For Streams and Riparian Areas

USDA Forest Service

2009 Annual Summary Report

Fish
& Aquatic
Ecology Unit

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ABSTRACT

The primary objective of the PACFISH INFISH Biological Opinion Effectiveness Monitoring (PIBO EM) program is to answer the question: “Are key biological and physical components of aquatic and riparian communities being improved, degraded, or restored within the range of steelhead (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*)?” We address this question for portions of the upper Columbia River Basin on USDA Forest Service lands designated within INFISH and PACFISH (21 National Forests), and on BLM lands within PACFISH (7 BLM districts) or containing bull trout. In 2001, we began the first 5-year sampling rotation with the program at half implementation. Approximately 150 sub-watersheds were sampled in both 2001 and 2002. At full implementation (which began in 2003), we sample approximately 250 sub-watersheds per year or 1250 every 5 years. An additional 50 sub-watersheds (sentinel sites) are sampled annually when possible. The 2006 field season marked the first year of return visits to sites originally sampled in 2001 and every subsequent field season will provide PIBO EM with additional repeat data, which will continually increase statistical power to effectively address the primary objective stated above. The PIBO EM study design and sampling methods were expanded in 2006 to National Forests within the upper Missouri River Basin (MRB) in Montana. This includes the Gallatin, Custer, Lewis and Clark, and the eastern portions of the Helena and Beaverhead-Deerlodge National Forests. Every subsequent field season will increase the total number of repeated sites by approximately 250 and by 2012, all 1,300 sites in the PIBO EM study design will have been sampled at least twice. In addition to sampling efforts used to fulfill the PIBO EM objectives, we have completed several other monitoring projects funded by local field units to identify trends related to management actions.

Within this document, we provide an overview of research and monitoring efforts that currently being conducted by PIBO personnel and other collaborators (pages 35 – 41). These and previous efforts (pages 42 – 43) are an integral part of this project, with specific goals of addressing the overall objectives of the PIBO Effectiveness Monitoring Project and advancing our understanding of how management activities and landscape attributes affect aquatic ecosystems.

Here, we present preliminary status and trend analyses for some of the instream habitat, macroinvertebrate, and riparian attributes collected at all PIBO sites (pages 18 – 34). Preliminary results of the first four years of repeat-sampled suggested that present management may be meeting the intent of the 1998 Biological Opinion for bull trout, salmon, and steelhead. Within managed sites, we found significant positive trends in 6 attributes, no change for one attribute, and a significant negative trend for one attribute evaluated at sites repeat sampled during this period. However, status assessments using an index of physical, instream habitat still indicated significant differences in the status of physical habitat between reference and managed sites. The differences between reference and managed sites were considerably less when considering biological assessments of sites through macronivertebrate data. Finally, our assessments of riparian attributes indicated a relatively low status of riparian

conditions at Designated Management Areas (DMAs) when compared to reference sites, as DMAs had considerable higher (i.e., more obtuse) bank angles and increased relative cover of non-native species. This information is based on preliminary analysis and should be viewed as such until more complete analyses and scientific review are completed.

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INTRODUCTION

This report is a review of PACFISH INFISH Biological Opinion Effectiveness Monitoring (PIBO EM) and our sampling efforts to date. Summarized data for each USDA Forest Service Region, National Forest, Bureau of Land Management (BLM) State Office, and BLM District within our monitoring area are provided on our website (www.fs.fed.us/biology/fishecology/emp/) and on our ftp site (http://fswebgstc.gscwo.fs.fed.us/services/data_management/PIBO/). Preliminary results from analyses of data collected at integrator and Designated Monitoring Area (DMA) sites are presented in this document. Additional data summaries, analyses, and interpretation are presented in peer reviewed publications (see below). The "2009 PIBO EM Report files" folder on our ftp site includes this report and stream habitat, riparian vegetation, stream temperature, and aquatic macroinvertebrate summary data.

The information provided in this report is intended to assist National Forest and BLM office land managers in their monitoring efforts. Within this document, we present the average values for attributes collected across all of the PIBO sites. Thus, our analyses are presented at the PIBO study area level, and provide benchmarks for which the status and trends of individual sites, Forests, and Regional scales can be measured. We encourage individuals to contact PIBO personnel for any assistance in interpreting results at these smaller scales. However, this report is not intended to be a complete interpretation of the results and we recognize that further analyses need to be conducted. We make no attempt to evaluate the implications of the data. When using these data it is the responsibility of the reader to understand limitations imposed by the study design and sampling techniques. Please contact any of the personnel listed on our website with questions or comments.

BACKGROUND

The decline of steelhead trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) in the upper Columbia River Basin (CRB) prompted interest in the condition of habitat throughout these species' range and the effect of forest management activities on spawning and rearing habitat is under increasing scrutiny. Forest management activities such as timber harvest, road construction, and livestock grazing can potentially have negative impacts on stream habitat. However, recent large-scale conservation strategies may protect habitat and promote recovery of degraded habitat throughout the range.

There are several documents that provide guidance for protecting anadromous fish habitat in the Columbia River Basin. Each National Forest within the range of steelhead trout in the Columbia River Basin has completed a forest plan that guides protection and management of aquatic and riparian resources on the forest (USDA NFMA 1976). The Forest Service and BLM developed an aquatic and riparian area management strategy to protect habitat for Pacific anadromous salmonids (PACFISH 1994). This strategy was intended to provide consistent, interim guidance to National Forests, and to develop interim management objectives for fish habitat prior to the revision of forest plans. The Interior Columbia Basin Ecosystem Management Plan (ICBEMP) was developed to provide a long-term strategy to manage resources within the Columbia River Basin. As part of this plan: 1) aquatic and riparian management guidelines will be developed to replace the more general guidance of PACFISH; 2) data collected will be used to provide information on the status and trend of stream habitat on Federal lands within the upper Columbia River basin; and 3) status and trend information will be used to guide habitat restoration on Federal lands throughout the basin.

The 1998 listing of steelhead and bull trout under the Endangered Species Act prompted a review of current habitat management practices on federal lands by the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), United States Department of the Interior (USDI), and United States Fish and Wildlife Service (USFWS). As part of the Section 7 consultation process with the BLM and Forest Service, NMFS and USFWS issued Biological Opinions on the adequacy of land and resource plans to protect anadromous fish habitat. One of the commitments identified in the Biological Opinions was to monitor managed lands, specifically those grazed by livestock, to determine if current management practices were meeting PACFISH riparian management objectives.

The interagency effectiveness monitoring team (Forest Service, BLM, NMFS, and USFWS) convened in April of 1998 to develop a plan for monitoring the condition of steelhead and bull trout habitat on Federal lands (Kershner et al. 2004a). The team developed a draft monitoring plan in May 1998. Goals for this plan (from the Biological Opinions) include: 1) developing a coordinated effort with a defensible sample design; 2) maximizing the effectiveness of limited monitoring funds; 3) identifying appropriate scales and levels of monitoring; and 3) identifying how monitoring results should be used to make management adjustments. The group recognized that a variety of management activities affect aquatic and riparian systems and effects from one or more activities can be cumulative. An approach to monitoring that considers these relationships and attempts to track their effects will ultimately provide the kind of feedback needed to adapt specific management activities on federal lands.

At the request of Forest Service Region 4, the Forest Service National Fish and Aquatic Ecology Unit conducted pilot efforts in 1998 and 1999 within the Salmon River drainage in central Idaho. The primary goal was to determine the feasibility of an extensive approach to address the following question: *Are key biological, chemical, and physical attributes, processes, and functions of riparian and aquatic systems degraded, maintained, or restored in the range of the steelhead and bull trout as a result of land management within the CRB* (Kershner et al. 2004a). We defined the effectiveness monitoring component of this program with the following three objectives:

1) Determine whether key biological and physical attributes, processes, and functions of upland, riparian, and aquatic systems are being degraded, maintained, or restored across the PIBO EM study area.
2) a) Determine the direction and rate of change in riparian and aquatic habitats over time as a function of management practices.
   b) Determine whether riparian and aquatic habitat conditions at integrator sites are reflective of conditions throughout the watershed.
3) Determine whether specific Key Management Practices (KMPs) for livestock grazing are effective in maintaining or restoring riparian structure and function.

In 2001, the effort was expanded from sampling on grazed and unmanaged lands only, to include all managed lands within the study area.

METHODS

Study Area

The original study area included portions of eastern Oregon and Washington, Idaho, and western Montana (Figure 1). It is bordered by the Cascade Mountains on the West, Canada to the North, the continental divide on the East from Canada south to the Beaverhead Mountains, and the headwaters of the Snake, John Day, and Deschutes Rivers to the south. The Snake River Basin upstream of American Falls in Idaho was excluded. The study area includes major spawning areas for steelhead and bull trout, as well as Chinook (*O. tshawytscha*) and sockeye salmon (*O. nerka*), which are also listed under the Endangered Species Act.

The lands within the study area are highly diverse and include the high mountains in central Idaho and western Montana, basalt plateaus in eastern Oregon and Washington, and high desert in southern Idaho. The landscape has been heavily influenced by continental ice sheets, mountain glaciers, and several cataclysmic floods (Quigley and Arbelbide 1997). Elevations range from less than 500m along the lower Columbia River to over 3000m in the mountains.

Precipitation in the study area predominately falls as snow from October to May (Quigley and Arbelbide 1997). Some precipitation falls as rain during the spring, summer, and fall months. Temperatures within the study area are highly variable with short, cool summers in the mountainous areas and longer, extended growing seasons in the montane valleys and lower elevations. Winters are typically cold with sub-freezing temperatures from mid-November to April.

Valley bottom types are characterized as steep confined valleys, moderately steep/moderately confined valleys, and flat moderately confined valleys (Quigley and Arbelbide 1997). Streams within grazed systems represent a full variety of stream types from steep, confined streams to highly braided, meandering meadow streams.

Forest vegetation within the study area is dominated by dry forests (douglas fir, ponderosa pine, grand fir, white fir) and cold forest (mountain hemlock, spruce-fir, aspen, white bark pine, lodgepole pine, alpine larch). Range vegetation groups include dry grass (fescue, wheatgrass), dry shrub (bitterbrush, sagebrush, juniper), cool shrub (mountain big sage, mountain shrub), riparian shrub (willows), riparian herb (sedges), and riparian woodlands (cottonwood, aspen) (Quigley and Arbelbide 1997).

Livestock grazing has occurred in the study area since the late 19th century. Range integrity ratings are low-moderate throughout most of the study area (Quigley and Arbelbide 1997).

In 2006, the PIBO EM rotating panel study design was applied to National Forests within the upper Missouri River basin (MRB) in Montana (Figure 2). This includes the

Lewis and Clark, Gallatin, and Custer along with eastern portions of the Helena and Beaverhead-Deerlodge National Forests.

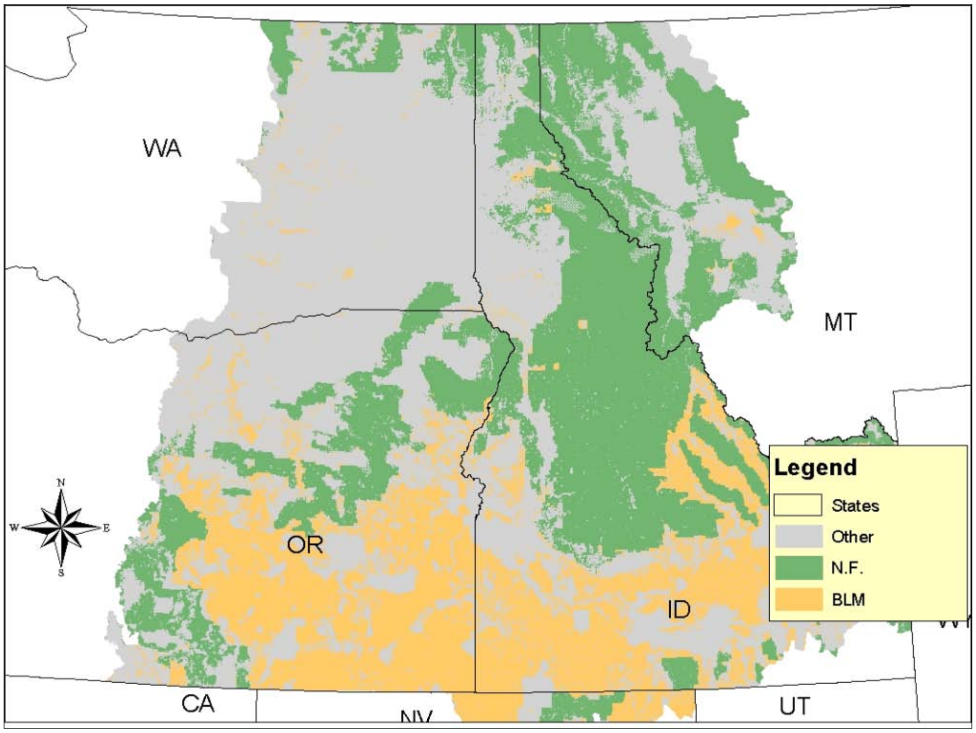

Figure 1. Map of the upper Columbia River Basin (original study area). Specifically, the area includes Forest Service land within INFISH and PACFISH and BLM land within PACFISH or containing bull trout.

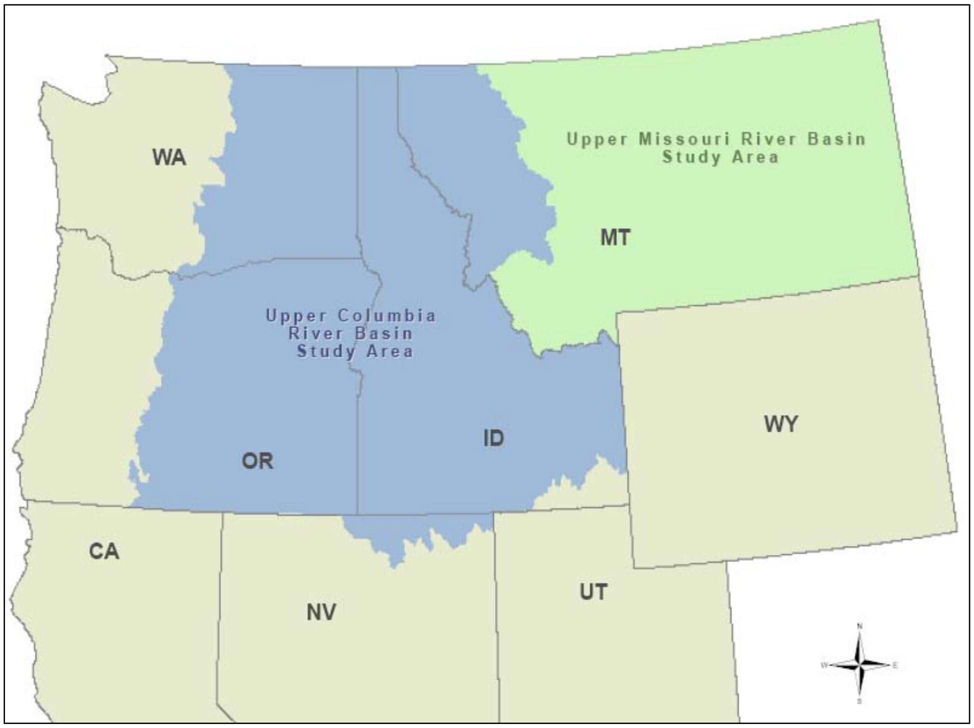

Figure 2. Map of the current PIBO EM study area. The study area originated in the upper Columbia River Basin and was expanded in 2006 to include the portion of the upper Missouri River Basin (MRB) in Montana.

Sample Site Selection and Description

Site Selection: Integrator – Beginning In 2001, PIBO EM implemented a 5-year, rotating panel design described in the PIBO Monitoring Plan (Kershner et al. 2004a; Table 1a/b). With this design, one third of all sub-watersheds within the study area are sampled within a 5 year period.

We used the 3547 U.S. Geological Survey, Hydrologic Unit - 6th field sub-watersheds within the study area as a list of potential sample sub-watersheds (Quigley and Arbelbide 1997). These sub-watersheds were first combined geographically into 177 groups of approximately 20 sub-watersheds. Groups were then randomly assigned to a panel year (1-5) for sampling using a generalized random tessellation stratified design (GRTS) (Stevens 1997). This design is used to achieve a random selection of groups within each panel that are evenly distributed both spatially and temporally. Ultimately, 35 or 36 groups (one fifth) are sampled within each year or panel. Within each group, 7 out of 20 (one third) sub-watersheds are sampled following a random order established using the GRTS design.

A sub-watershed must meet two criteria in order to be sampled. First, it must contain an "integrator" site with a channel gradient less than 3%. This site type was chosen because it displays the greatest response to upstream impacts from management activities (Montgomery and McDonald 2002). Secondly, the watershed upstream of the sample site must have greater than 50% Forest Service or BLM ownership. Sub-watersheds that meet these two criteria are then categorized as either "managed" or "reference". Sub-watersheds are categorized as "reference" if: 1) they had minimal timber harvest; 2) they were not grazed by livestock within the last 30 years; 3) watershed road densities were less than 0.5km / km^2; 4) riparian road densities were less than 0.25km / km^2; and 5) no historic dredge or hard rock mining is associated with riparian areas. Biologists, hydrologists, and range conservationists from local Forest Service and BLM offices were contacted to help categorize each watershed within their management area. We then randomly selected managed and reference sub-watersheds to sample, using the GRTS design (Stevens and Olson 2004).

Integrator sites are established using specific criteria. An integrator site is the most downstream stream segment within an ICBEMP 6th field hydrologic unit (HU) with minimal side-channels, no tributaries, or current beaver activity. Integrators are at least 20 bankfull channel widths in length (160 m minimum length) as measured along the thalweg. From 2001 through 2002, the minimum reach length was 80 m. When these "short" reaches were re-sampled in 2006 and 2007, most sampled lengths were extended to a minimum of 160 m.

In 2003, we began adding integrator sites with stream gradients between 3% and 5%. Data from these sites will enable us to test the assumption that sites with gradients less than 3% are more sensitive to management activities (more likely to change) than steeper gradient sites. Therefore, one integrator site with a gradient of 3-5% was sampled within each group of 20 sub-watersheds. Thus, approximately 15% of our integrator sites are located in steeper gradient channels.

Table 1a. Rotating panel design with the number of sub-watersheds sampled within the CRB each year for the first 5 years and then repeating. The sampling effort for the 50 sentinel sites is also displayed. The actual number of sub-watersheds sampled is shown in parentheses. This table does not include "additional sampling" projects.

	2001	2002	2003	2004	2005	2006	2007	2008	2009
	panel year 1	panel year 2	panel year 3	panel year 4	panel year 5	panel year 1	panel year 2	panel year 3	panel year 4
Sentinel	50(38)	50(26)	50(48)	50(50)	50(24)	50(50)	50(37)	50(50)	50(50)
Group 1	250(149)					250(253)			
Group 2		250(105)					250(218)		
Group 3			250(233)					250(249)	
Group 4				250(244)					250(244)
Group 5					250(228)				

Table 1b. Rotating panel design with the number of sub-watersheds sampled within the MRB each year for the first 5 years and then repeating. The actual number of sub-watersheds sampled is shown in parentheses. This table does not include "additional sampling" projects.

	2006	2007	2008	2009	2010	2011	2012
	panel year 1	panel year 2	panel year 3	panel year 4	panel year 5	panel year 1	panel year 2
Group 1	50(49)					50	
Group 2		50(52)					50
Group 3			50(54)				
Group 4				50(59)			
Group 5					50		

Site Selection: Sentinel – In addition to sites established using the GRTS design, 50 "sentinel sites" were established starting in 2001. These sentinel sites were established in randomly selected sub-watersheds throughout the study area, and are sampled annually in most cases. Data collected at sentinel sites will be used to examine annual variability and rate of change of each measured attribute (objective 2a).

Site Selection: Grazing Designated Monitoring Area – The third objective of the program is to evaluate the effectiveness of present grazing management strategies and to ensure compliance with the 1998 Biological Opinion. The information collected at Designated Monitoring Areas (DMAs) will be used to evaluate riparian and stream habitat trends within grazing allotments throughout the CRB and to develop cause-and-effect relationships, which will be useful for adaptive management decisions regarding grazing practices. DMAs are sampled within grazed sub-watersheds that have been selected for the establishment of an integrator site. The Interagency Implementation Team (IIT) chose to gather information on stream characteristics that are altered by livestock grazing only and not altered by other management activities. Therefore, we measure a subset of the stream characteristics sampled at integrator sites. These include all vegetation and streambank parameters, gradient, sinuosity and bankfull width. Channel cross-section and pool data were collected at DMA sites starting in 2007 (See Figure 3a/b for a map display of Integrator (Figure 3a) and DMA (Figure 3b) sample site locations. See Table 2 for a site count listed by Forest Service Region and BLM State Office since 2001).

Table 2. Summary of all PIBO EM sites sampled within the jurisdiction of each Forest Service Region and BLM State Office since 2001. The number of sites sampled in the current year is shown in parentheses. This table does not include "additional sampling" projects.

	Integrator managed	Integrator reference	DMA
Region 1	523(137)	182(55)	26(6)
Region 4	272(59)	72(27)	103(11)
Region 6	263(46)	24(6)	125(23)
Idaho BLM	41 (13)	0	36(5)
OR-WA BLM	16(5)	0	36(7)
Montana BLM	3 (0)	0	0
Total	1118(260)	278(88)	326(46)

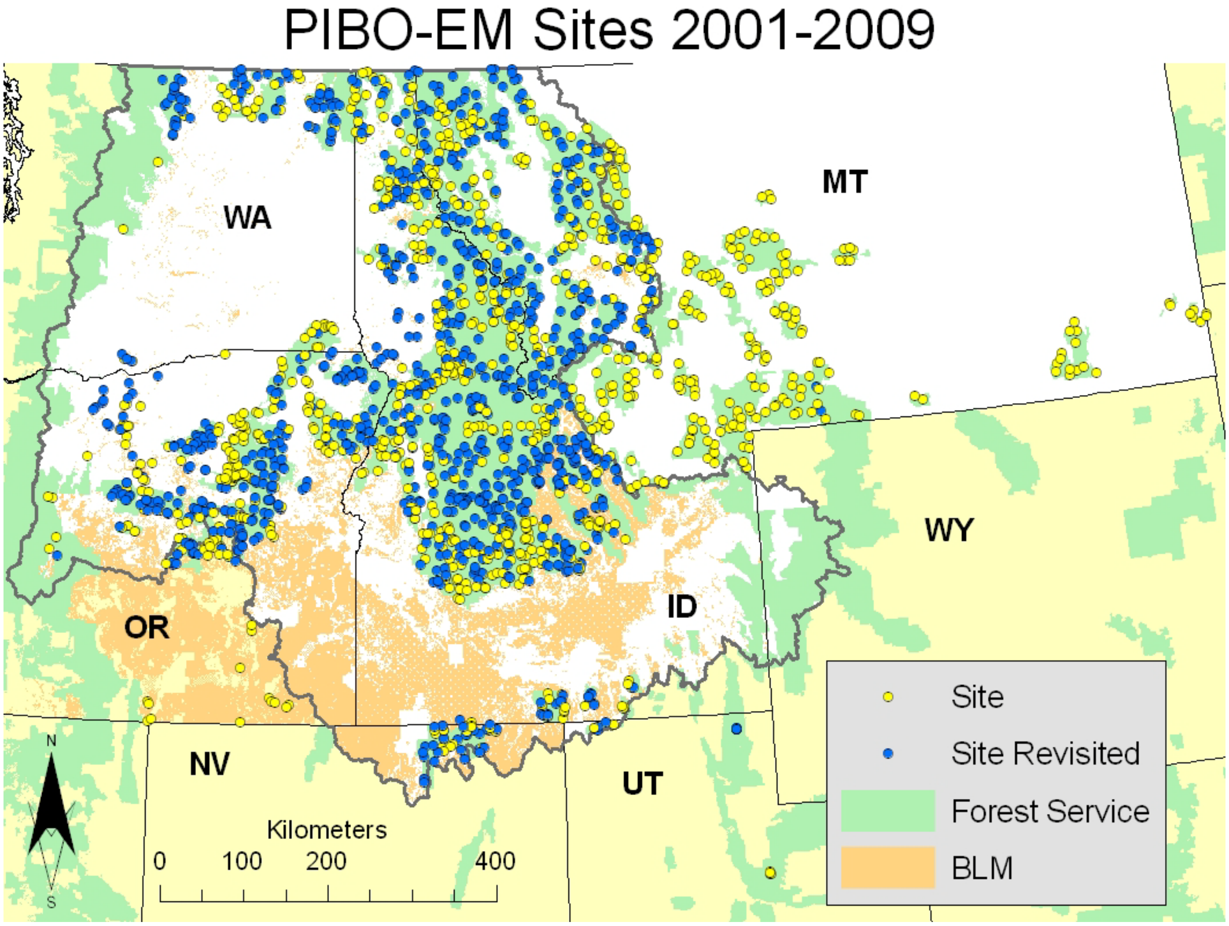

Figure 3a. Map of the PIBO EM study area with integrator sites sampled since 2001. This map does not include points for “additional sampling” projects.

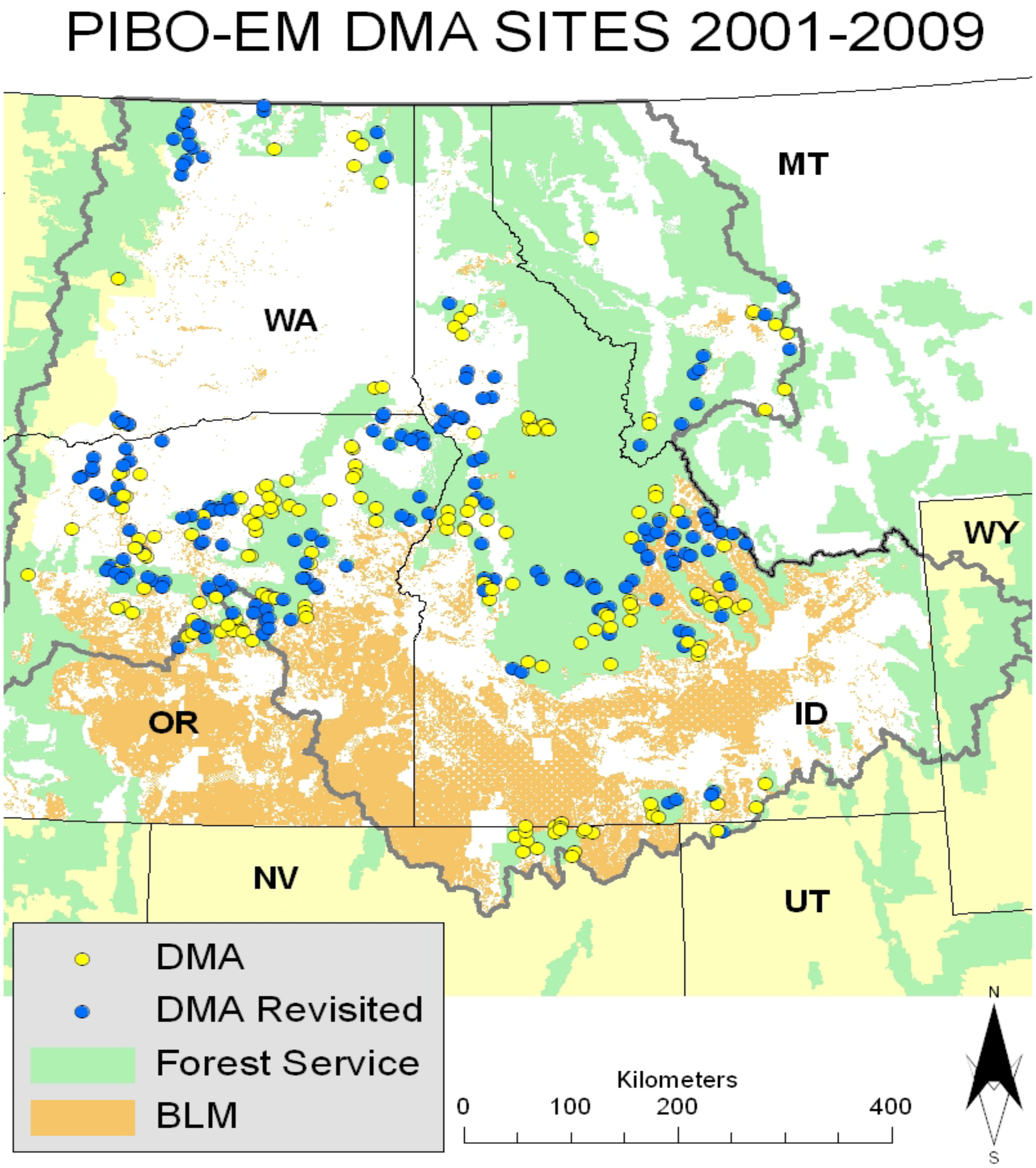

Figure 3b. Map of DMA sites sampled since 2001. This map does not include points for “additional sampling” projects.

Site Location Information – We used several methods to describe the location of each site to ensure accurate relocation. Written directions were recorded and a map was drawn that included both the stream and riparian area for each reach. Maps described the shape of the stream channel, major in-channel features, vegetation, location of tributaries, roads and other recognizable features (Harrelson et al. 1994). The Universal Transverse Mercator (UTM) coordinates using North American Datum (NAD) 1927 were acquired at the bottom and top of each reach using a handheld Global Positioning System (GPS) unit (accuracy of +/- 30 m).

Photograph documentation is performed each time a site is sampled. Photographs were taken of the top and bottom of each reach (facing upstream and downstream), channel cross-sections, marker locations, and any unique characteristics. The location and orientation of photographs were recorded so they can be repeated during subsequent sampling.

Beginning in 2003, a marker tag was installed at each site. Marker tags were not placed at sites within wilderness areas; a distinct natural feature was used as the marker. The distance and compass bearing from the marker to the beginning of the reach were recorded.

After a site is established, a mapping program is used to display a point that shows the location of a site on a topographic map.

Data Collection

A combination of 18 commonly measured in-channel, 11 riparian vegetation, six stream temperature, and 10 macroinvertebrate variables are reported for each integrator site (Kauffman et al. 1983, Platts et al. 1983, Myers and Swanson 1991 and 1992, Karr and Chu 1997, Winward 2000). For more information, the sampling protocols are available on our website.

Since the inception of the PACFISH INFISH Effectiveness Monitoring program (1998), several methods have been modified. Many of the modifications were implemented to decrease observer variability by removing subjectivity and potential observer bias. We recognize that additional modifications to our present methods may become necessary with further research of stream and riparian monitoring.

Stream Channel – Stream gradient and sinuosity were measured to characterize the stream channel at each reach. Percent gradient was calculated by dividing the elevation drop by the sampled length measured along the thalweg. Elevation drop of the water surface was measured to the nearest centimeter with a surveyor's level, tripod, and stadia rod. When the entire reach could not be surveyed from one location, we divided the reach into sections.

Bank characteristics were measured at a series of transects within the stream reach. The location of the first transect was derived by choosing a random number (k) between zero and seven. The first transect was then established (k) meters upstream from the start of the reach. Subsequent transects were located at intervals of one bankfull width category working upstream until a minimum of 21 transects was reached. All bank characteristic variables were measured on both the right and left banks.

Bank angle was measured using the procedures described by Platts et al. (1987). A clinometer and rod were used to measure the angle formed by the downward sloping bank as it met the stream bottom. The angle of undercut banks extended from the deepest point of the undercut to the outer edge. All angles were measured to the nearest degree with undercut banks having values less than 90° and non-undercut banks greater than 90°. The average bank angle and percent undercut banks were calculated.

Bank stability measurements were collected at each transect by observing an area of the bank 15 cm to either side of the transect location and vertically from the scour line to either the crest of the first flat depositional feature (bankfull), or to twice maximum bankfull depth (two times the distance from the deepest point in the stream channel along the cross section to the bankfull elevation). The methodology was developed by Platts et al. (1987) and modified by Bauer and Burton (1993). This method uses bank cover and the presence of instability indicators to describe bank stability. The bank was considered "covered" if it contained greater than 50% live vegetation, roots, rocks greater than 15 cm, wood greater than 10 cm in diameter, or any combination of the above. Banks were considered stable if they did not show indications of breakdown, slumping, or fracturing, or consisted of bare soil, but had an angle greater than 100°. A dichotomous key was used to categorize each location into one of six categories: covered stable, uncovered stable, false banks, covered unstable, uncovered unstable, or unclassified. The percent of stable banks was calculated by dividing the total number of covered stable, uncovered stable, and false banks by the number of measurements.

We measured the bankfull width of the channel at each transect. The information is summarized as the average bankfull width from transects.

The length, maximum depth, and tail crest depth were measured for each "primary" pool in the sample reach (Kershner et al. 2004a). These methods were modified versions of those described by Lisle (1987) for residual pool depth, and the original method described by Overton et al. (1997) for pool length. Primary pools are defined as: 1) concave depressions in the streambed bound by a head and tail crest; 2) the thalweg runs through the pool; 3) the pool feature must occupy at least half of the wetted channel; 4) the maximum depth is at least 1.5 times the pool-tail crest depth; and 5) the pool feature must be as long as it is wide. Pool lengths were measured by stretching a measuring tape along the thalweg from the pool-tail crest to the head of the pool. Measurements were recorded to the nearest 0.1 m. Maximum depths were measured by locating the deepest point of the pool and recording the depth to the nearest cm, while pool-tail crest depths were determined by measuring the deepest point on the pool-tail. Residual depths were calculated as the difference between the maximum depth and the pool-tail crest depth. The results were summarized as the percent of the reach composed of primary pool habitats, the number of pools per kilometer, and average residual pool depth.

Channel cross-sections were measured to determine bankfull widths and width to depth ratios. Ten cross sections were measured at even numbered transects two through 20. A minimum of 10 depth measurements were recorded at equal distances along each cross-section. Additional depths were measured at the left and right wetted edges and at the deepest point. When islands that were higher than the bankfull elevation were present, the two channels were measured separately. Bankfull width to depth ratio, and wetted width to depth ratio were calculated.

Substrate composition was measured using modified Wolman pebble counts (Wolman 1954). Different methods of selecting pebbles have been used. Starting in 2004, particles were sampled at channel transects. They were collected at evenly spaced intervals across the bankfull channel. The diameter of the 50th percentile particle (D50), excluding bedrock was reported.

The percent surface fines (6 mm) was measured at a subset of pool-tails in each reach using methodologies originally described in the Forest Service R5 SCI Guidebook Procedures (1998) and Bauer and Burton (1993) in all years except 2001. Starting in 2003, we began to measure percent surface fines less than 2 mm in addition. Measurements were recorded for the wetted, flowing area of the first four scour pools between 2001 and 2003. In 2004, we increased the minimum number of pool-tails in which fines were measured from four to 10. The sampling area in all years extended from the pool-tail crest upstream a distance equal to 10% of the pool length, but no more than 1 m. A 49-intersection grid was placed at 25%, 50%, and 75% of the distance across the pool-tail. The number of intersections (and the upper right corner of the grid frame) underlain with fine sediments was recorded for a total possible count of 50. The percent surface fines was calculated for each pool-tail and then averaged for each reach. In 2001 we used particle counts to assess the percent fines in pool-tails. This information is not reported because we feel the data did not accurately reflect the amount of fines present.

Large wood (LW) was tallied and the volume computed for all pieces greater than or equal to 1 m in length and 0.1 m in diameter that extended into the bankfull channel. The length and diameter was measured with a staff or tape measure in order to calculate volume. In 2001 all pieces were measured. In 2002 and 2003, a subset of LW was measured and the rest tallied and categorized. Starting in 2004, a subset was measured, while all pieces were estimated. The results were summarized as counts and volumes of category large wood per km.

Water Temperature – Stream temperature data was collected following procedures outlined by Dunham et al. (2005). Hourly temperature data were summarized from July 15th through August 31st using 6 attributes. These attributes were selected after an extensive literature search to: 1) be reflective of current research; and 2) to satisfy DEQ standards.

Macroinvertebrates – Macroinvertebrates were sampled using the protocol recommended by the Center for Monitoring and Assessment of Freshwater Ecosystems, Utah State University (Hawkins et al. 2003). Two kick net samples were collected at randomly chosen locations within the first 4 fast-water habitats in each reach. The sample area extended the width of the net 31.12 cm (12.25 in) and 31.12 cm upstream from the net, and to a depth of 10 cm (4 in). All 8 samples were combined for each reach for a total sample area of 0.744 m^2.

Samples were analyzed and summarized by the BLM/USU National Aquatic Monitoring Center using 10 metrics (Karr and Chu 1997). One summary attribute was developed by the Center for Monitoring and Assessment of Freshwater Ecosystems in cooperation with the National Aquatic Monitoring Center. This attribute was calculated using a predictive model that provides an index of biological condition for each reach. Specifically, The River Invertebrate Prediction and Classification System (RIVPACS) describes the similarity of the invertebrate species composition at a reach (Observed) to the species composition predicted to occur at a reference site within similar environmental conditions (Expected). The constructed model predicted probabilities of capture for 80 operational taxonomic units (i.e., unique taxa) across 174 reference calibration reaches. The calibration model had a mean of 1.0 and a standard deviation of 0.15, which did not significantly differ from the validation data set (0.95 and 0.16, respectively). We used the 10th and 90th percentiles of calibration RIVPACS values as threshold to determine significant departures from reference condition. Thus all values below a threshold of 0.78 have a high probability of being biologically impaired.

Water Chemistry – Two water chemistry attributes were collected at each location, alkalinity and conductivity.

Riparian Vegetation – The sampling protocol used to collect riparian vegetation data is based on the methods described by Winward (2000). Those methods used community types in published classifications to describe the vegetation along 110 m of stream (the greenline) and along 5 cross-sections. However, because of the limited ways to summarize reach level community type data that would allow comparisons of all sites, species cover rather than community type data were collected.

Greenline species cover data were recorded using Daubenmire quadrat frames (0.5 x 0.2 m) at channel transects on both sides of the stream. The foliar cover of plant species was recorded for each species with greater than 5% cover at each quadrat. Species cover was estimated separately in two layers: 1) less than or equal to 1 m above the quadrat; and 2) greater than 1 m above the quadrat. This limited the species cover in a layer to 100%, but allowed the total cover for all species in a quadrat to be up to 200%. Specimens of unknown plants with greater than 5% cover were collected for identification in the office. Ground cover categories were used to record the cover of unvegetated areas in the lower layer. Ground cover categories included: bare, litter/moss, log or stump, rock >2.5 cm, and massive rock feature (see methods from past years in metadata; http://fswebgstc.gscwo.fs.fed.us/services/data_management/PIBO/).

Cross-section species data were recorded at 5 equally-spaced transects on each side of the stream. Each cross-section is oriented perpendicular to the valley bottom direction and includes 3 quadrats located at 3, 6, and 9 m from the greenline, resulting in a total of 30 cross-section quadrats. At each quadrat, the foliar cover of plant species was recorded for each species with greater than 5% cover. Cover estimates were collected in 2 layers, as explained above. Effective ground cover for cross-sections was calculated using the ground cover category “not vegetation: bare” . The average bare ground cover was subtracted from 100 percent to calculate the Effective Ground Cover value (methods from past years in metadata).

Nativity designations for species were based on information in the USDA Plants database. Taxa identified to genus were assigned a nativity when it could be done with confidence. The proportion of cover coming from non-native plant species was calculated as Relative Alien Cover (RAC), which was the sum of non-native plant cover, divided by total plant cover, and multiplied by 100 (Magee et al. 2008). Designation of species as noxious weeds was based on the University of Montana’s INVADERS Database (Rice 2007; http://invader.dbs.umt.edu/).

The species cover data were used to calculate the following summary variables:

1) Total species cover for greenline and cross-section
2) Relative alien cover for greenline and cross-section
3) Richness and cover of native and introduced species for combined greenline and cross-section
4) Effective ground cover for cross-section
5) Noxious weed cover by species for greenline and cross-section

ANALYSES AND SUMMARIES

Development of index of physical habitat integrity – We used physical stream habitat and landscape data from reference reaches as the basis for an index of physical habitat condition (Al-Chokhachy et al. *In press*). Under this framework, we identified candidate attributes from the 17 total attributes collected at PIBO sample sites using a three-step sequence. First, we selected those physical habitat attributes that exhibited relatively low sampling variation based on reaches repeat-sampled within a year, which enabled empirical estimates of signal/noise (S/N; Kaufmann 1999). Next, we tested whether attributes with low sampling variation were responsive to management actions;

given that our goal was to quantify differences in the overall condition of physical habitat in streams, we wanted to include attributes that differed as a function of land-management activities. As such, we evaluated the responsiveness of each attribute to management activities by comparing the means of each candidate attribute from reference reaches and managed reaches. We used road density as a surrogate for management effects, and for this comparison we constrained our analysis to managed reaches with high levels of management (i.e., > median road density for managed reaches in the segment scale; 2.2 km/km^2). Finally, we minimized redundancy of those attributes that met the specific criteria in the first two steps to avoid over-weighting certain components of the physical instream habitat represented in the overall index. Here, we calculated Pearson correlation coefficients for all remaining candidate attributes and considered attributes redundant if correlation coefficients exceeded 0.70.

Once attributes were selected, we used our reference sites to construct the index. Specifically, we incorporated landscape and climatic covariates into multiple linear regression analyses to control for inherent differences in physical habitat attributes among reaches. We used the residuals from these analyses to score individual attributes and summed the 8 attributes retained in the index for an overall index of abiotic condition (range = 0-100). We incorporated the data from managed sites (both landscape and field data) into the regression models used to develop the index (from reference sites) to calculate and score the residuals and overall index for managed sites (again ranging from 0-100). We used the resulting index scores to evaluate potential differences in the condition of physical habitat between reference and managed reaches within our study area.

Preliminary trend data –We evaluated trends in habitat attributes (see appendix A for attribute descriptions; Table 5) using data collected at sites repeated under the 5-year rotating panel. In this preliminary analysis, we included 705 integrator sites (150 reference and 655 managed) that were originally sampled in 2001, 2002, 2003, and 2004 and re-sampled 5 years later (2006, 2007, 2008, and 2009 respectively). Using these data, we evaluated the following components for this document: 1) overall change in the status of habitat attributes in reference and managed sites when pooled across all repeated samples; 2) overall change in the status of habitat attributes in reference and managed sites within each group of 5-year repeat sites; 3) yearly means of habitat index scores and the RIVPACS macroinvertebrate index.

We evaluated potential differences in RIVPACS scores and overall condition of physical habitat across all reference and managed reaches (i.e., a management effect) within our study area. In addition to the comparisons of overall means we investigated temporal patterns and trends for both managed and reference sites. We used management as a fixed effect and tested for equality of both intercepts and slopes using linear mixed models (Proc MIXED; SAS Institute 2004).

PRELIMINARY RESULTS

Habitat trends — Our evaluations of an interaction effect between sites experiencing different management levels enabled us to assess whether managed sites changed differentially than reference sites over this period. Within managed sites, we found significant trends in 7 of the 8 attributes evaluated in this analysis, and 6 attributes showed significant changes with positive trends in habitat status (Figures 4 and 5). Of these, we found positive changes in bank stability and d_{50}, which were consistent with changes observed in reference sites, and a significant decrease in the percent of reaches as pool habitat, which again was consistent with results from reference sites (Figure 5). Managed sites exhibited a significant decrease (mean change = -2.4%, SE = 0.8) in percent fine sediment in pool tails, which differed from the positive change (i.e., more fine sediment) observed in reference sites (mean change = 2.0%, SE = 1.1). We found a significant increase in residual pool depth in managed sites (mean change = 1.1 cm, SE = 0.5), but no apparent change in reference sites. We found significant positive change in LWD frequency in managed sites (mean change = 31.4 pieces/km, SE = 4.9), but this change was significantly lower than observed in reference sites (mean change = 82.4 pieces/km, SE = 18.7). Both managed (mean change = 6.6 m^3/km, SE = 4.9) and reference (mean change = 13.4 m^3/km, SE = 16.5) sites exhibited increases in the volume of LWD at sites, but reference sites exhibited substantially higher variability. Overall, we observed no significant change in the percent of undercuts at managed sites during this period, but again this pattern was similar to that observed at reference sites.

Table 4. The number of managed and reference sites repeat-sampled under each 5-year rotation within the PIBO sample design.

5-year rotation	Managed	Reference
2001-2006	134	28
2002-2007	80	16
2003-2008	221	42
2004-2009	219	64

Our evaluations of the change in habitat status at sites repeated within each of the 5-year rotations provided more resolution of the patterns of change observed to date at PIBO sample sites (Figures 6 and 7). The number of sites repeat-sampled varied considerably across the 5-year groups during this period due to funding limitations in 2001 and 2002 (Table 4). We found consistent patterns in the 5-year sample groups for bank stability and LWD frequency, which both illustrated positive trends in each of the 5-year rotation groups. For all of the other 6 attributes, we found considerable variability in the direction and significance of change in habitat status across the different 5-year rotation groups. The variability through time is likely due to temporal differences in climate, particularly where trends for managed sites mimicked those for reference sites (e.g., Figure 7c and 7d). However, formal analyses which include climate have not been conducted at this time; we are currently evaluating temporal variability and factors affecting this variability through data collected at PIBO sentinel sites (see *Ongoing and Recent Efforts* section).

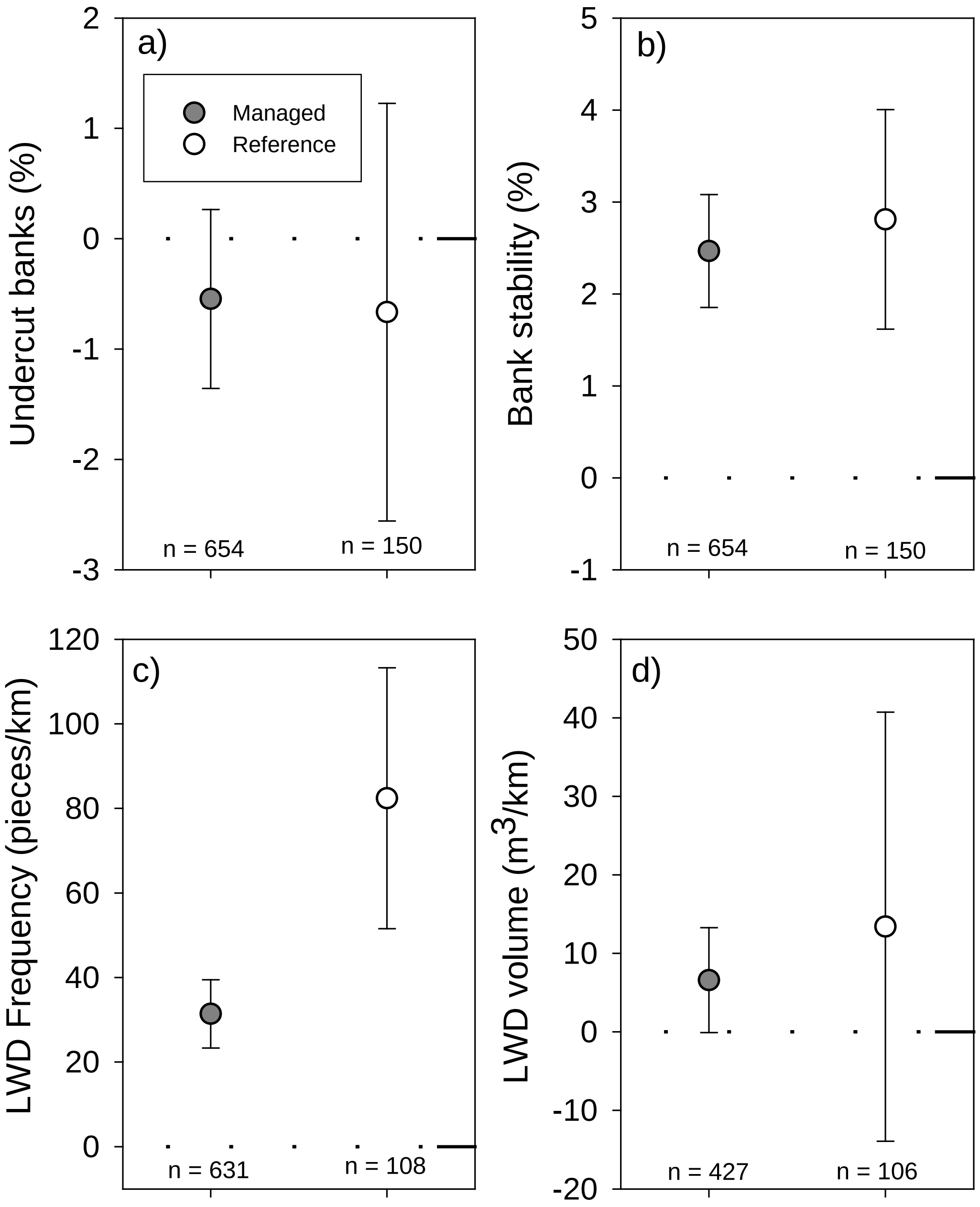

Figure 4. Mean changes in status (90% CIs) of percent undercut banks (a), bank stability (b), LWD frequency (C), and LWD volume (d) at managed (grey) and reference (hollow) sites for all sites resampled under the 5-year rotating panel design. Sample size for each attributes is noted below each plot. The dashed line represents a reference of no change over this period; overlap of the dashed lines with the confidence intervals suggests no statistical change.

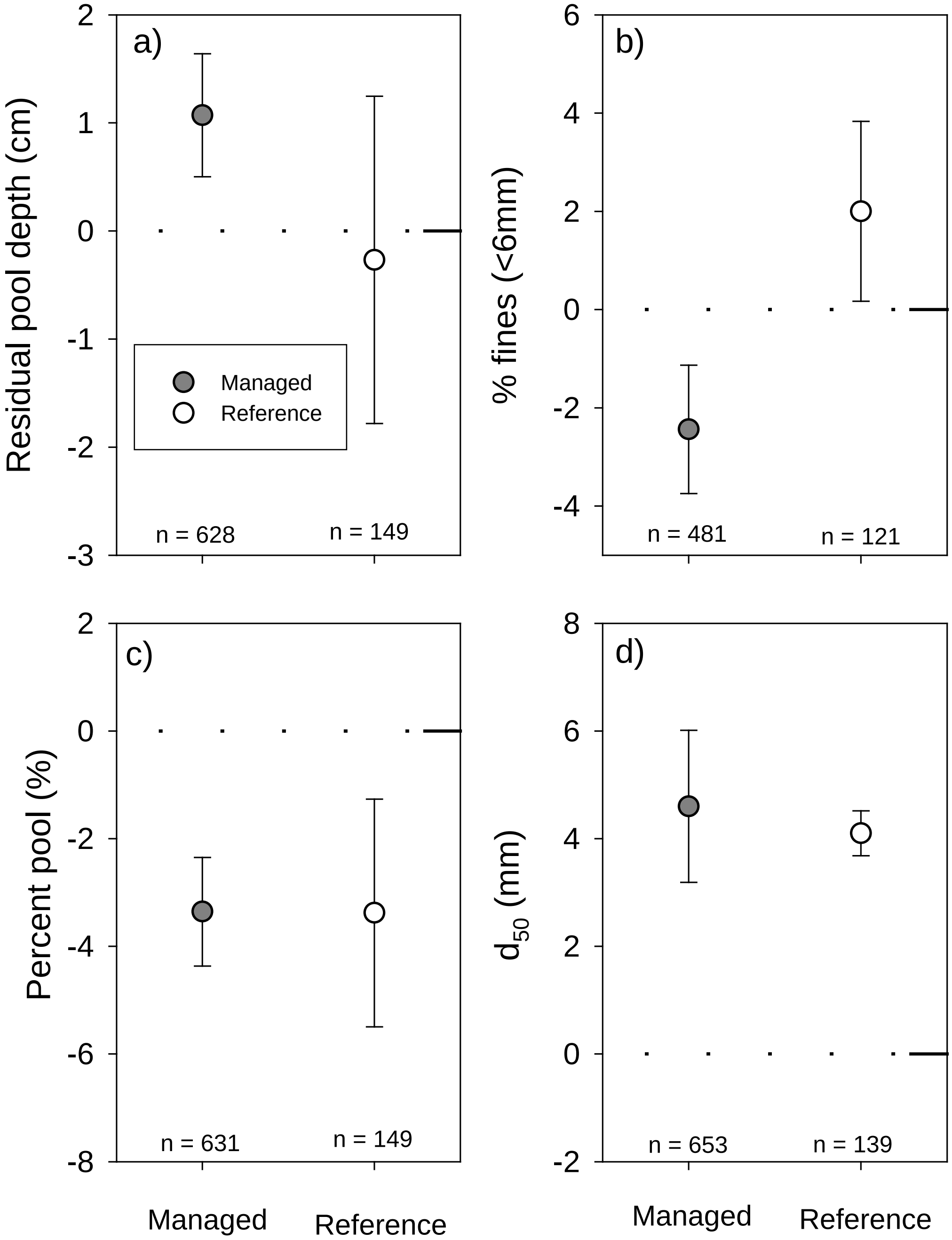

Figure 5. Mean changes in status (90% CIs) of residual pool depth (a), fine sediment (<6mm) (b), percent pool habitat (c), and d_{50} (d) at managed (grey) and reference (hollow) sites for all sites resampled under the 5-year rotating panel design. Sample size for each attributes is noted below each plot. The dashed line represents a reference of no change over this period; overlap of the dashed lines with the confidence intervals suggests no statistical change.

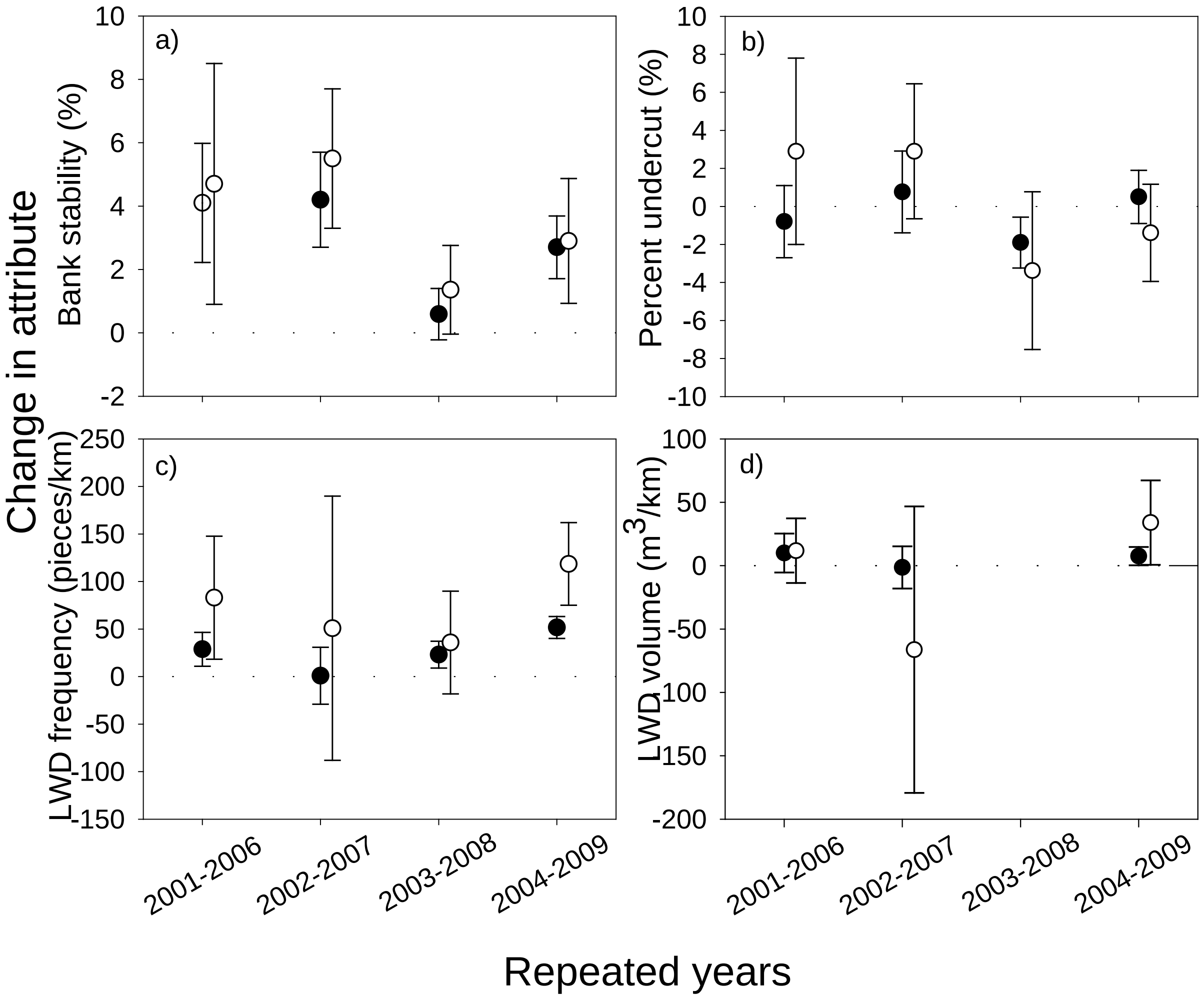

Figure 6. Mean changes in status (90% CIs) of percent undercut banks (a), bank stability (b), LWD frequency (c), and LWD volume (d) at managed (black) and reference (hollow) sites by repeat-sample group under the 5-year rotating panel design. Sample size for each attributes is reported in the results. The dashed line represents a reference of no change over this period; overlap of the dashed lines with the confidence intervals suggests no statistical change.

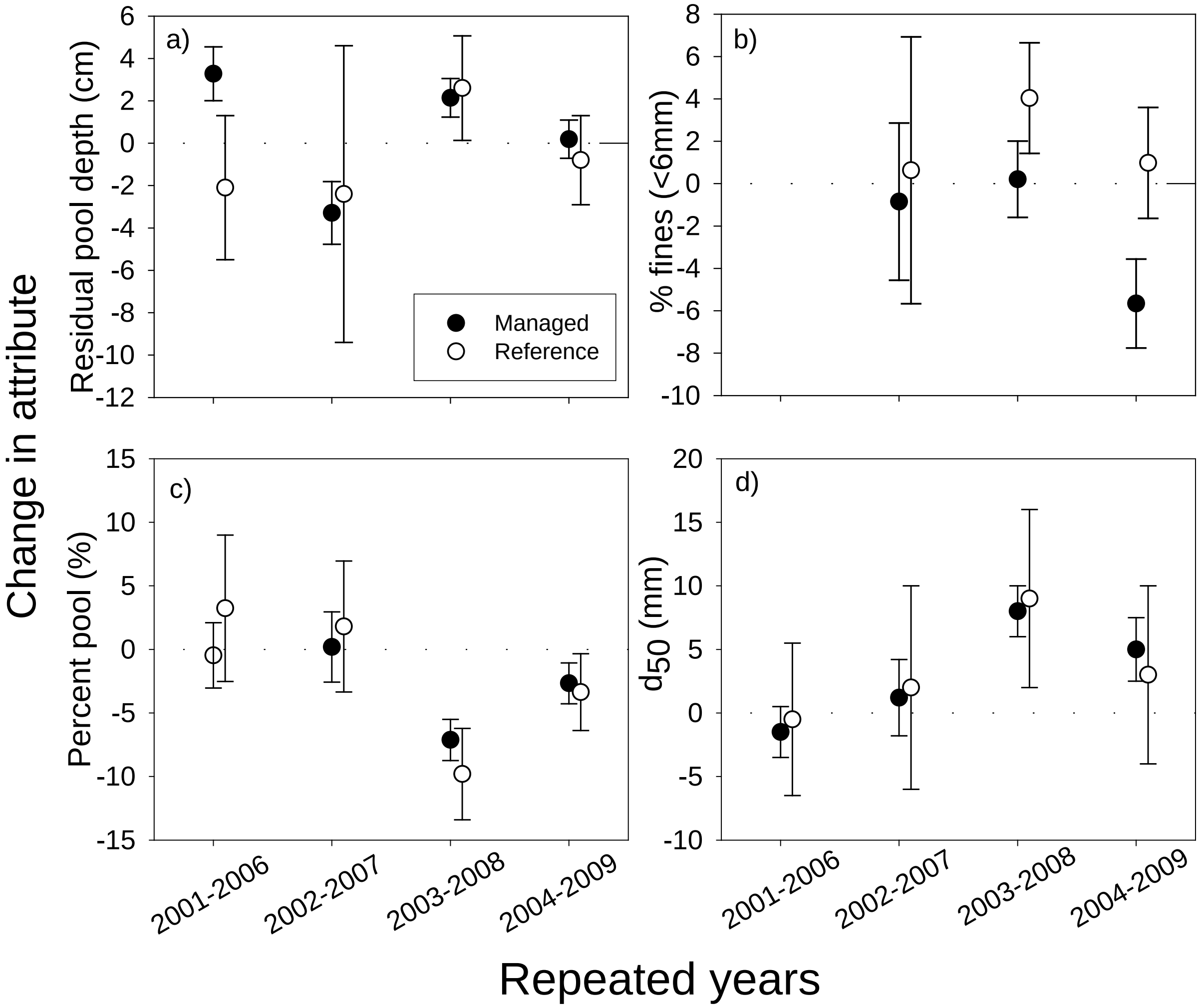

Figure 7. Mean changes in status (90% CIs) of residual pool depth (a), fine sediment (<6mm) (b), percent pool habitat (c), and d_{50} (d) at managed (black) and reference (hollow) sites by repeat-sample group under the 5-year rotating panel design. Sample size for each attributes is reported in the results. The dashed line represents a reference of no change over this period; overlap of the dashed lines with the confidence intervals suggests no statistical change.

Yearly status of habitat index — Results from the linear mixed model indicated a significant management effect (*P* = <0.0001), and we found the average habitat index scores in managed sites (46.1, SE = 0.60) were significantly lower than observed in reference sites (62.3, SE = 1.2) (Figure 8). We did not find significant differences between the linear slopes of managed and references sites (i.e., no interaction effect) during this time period (*P* = 0.39). Our results also indicated no apparent additive linear trend in habitat index scores over this time period (*P* = 0.72), which suggests the overall integrity of physical habitat for managed and reference sites remained stable over the time period of this analysis.

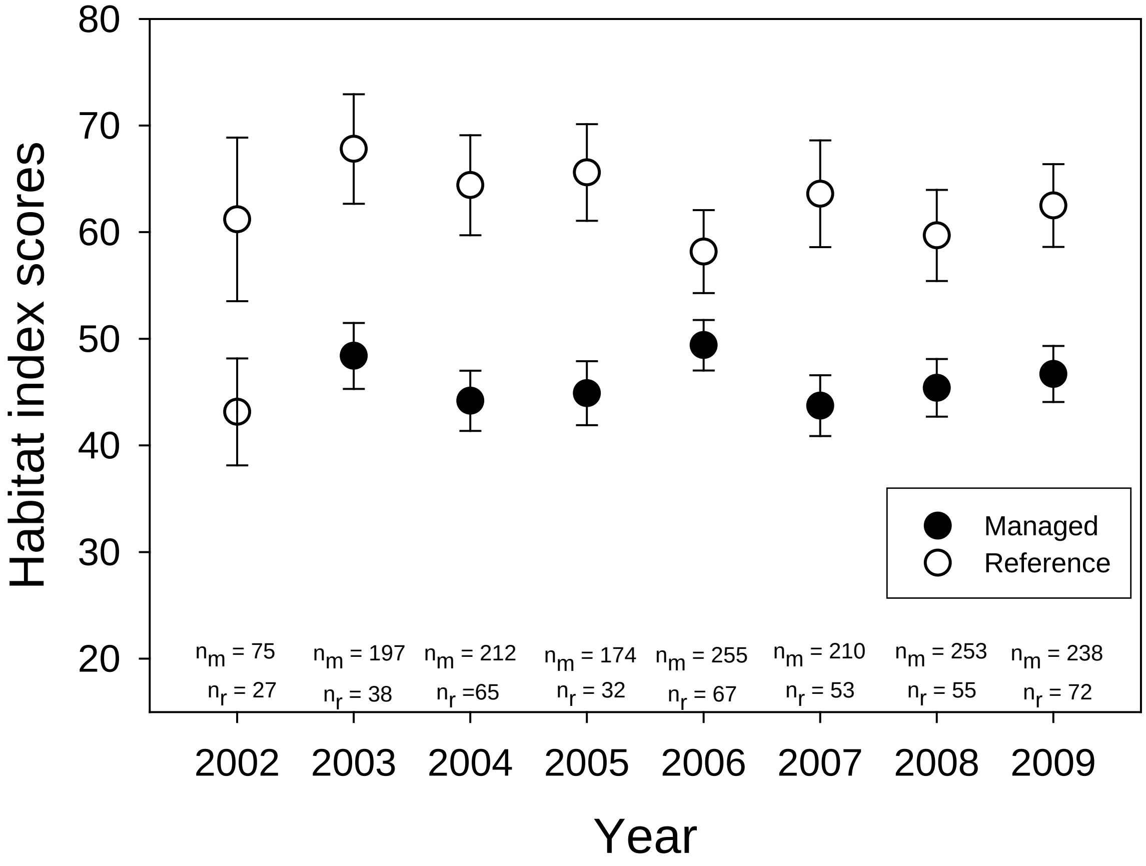

Figure 8. Mean habitat index scores (90% CIs) for managed (black) and reference (hollow) sites from 2001 to 2009. Sample size for each year and management category is reported in figure (n_m = managed, n_r = reference).

Yearly status of RIVPACS macroinvertebrate scores — Overall, we collected macroinvertebrates and computed RIVPACS scores for 1,690 sample reaches in the PIBO study area. Results from the linear mixed model indicated a significant management effect (P = <0.0001), and we found the average RIVPACS scores in managed sites (0.91, SE = 0.006) were significantly lower than observed in reference sites (0.96, SE = 0.01) (Figure 9). During the time period of this analysis (2001-2009), we did not find significant differences between the linear slopes of managed and references sites (i.e., no interaction effect) (P = 0.11). Our results also indicated no apparent additive linear trend in RIVPACS scores over this time period (P = 0.97), which suggests the biotic condition for managed and reference sites remained stable over the time period of this analysis.

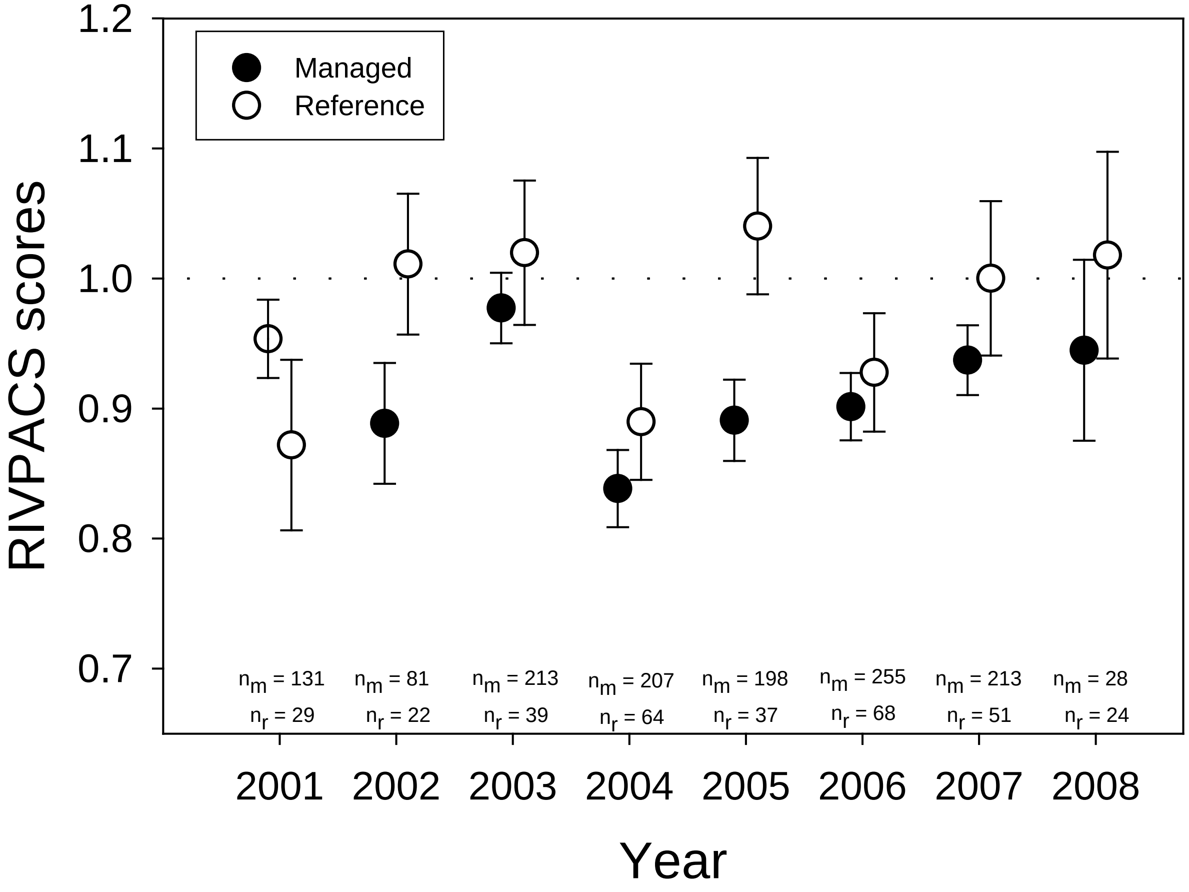

Figure 9. Mean RIVPACS scores (90% CIs) for managed (black) and reference (hollow) sites from 2001 to 2008. Sample size for each year and management category is reported in figure (n_m = managed, n_r = reference). The dashed line represents a reference where 'observed' macroinvertebrate assemblage is equal to that 'expected' from model (see methods for specific details). Overlap of confidence intervals with dashed line indicates no significant difference from 'expected'.

Yearly status of riparian conditions

Bank conditions.—In 2009, we found average bank angles in reference sites (mean = 105.4, SE =2.2, n = 75) were considerably lower (i.e., more vertical) than observed in DMA (mean = 118.8, SE = 3.2, n = 44) and managed (mean = 111.2, SE = 2.0, n = 258) sites. This pattern is consistent with most years of this study (Figure 10). Sites repeat-sampled in 2009 indicated significant increases in bank angles (i.e., more obtuse) for reference and managed sites, with substantially larger increases for reference sites than managed sites, but no change for DMA sites (Figure 11).

Despite the observed patterns for bank angle, we did not find any apparent differences in bank stability across the different management classes in 2009 (Figure 12). The mean estimates of bank stability for reference, managed, and DMAs were 96.7% (SE = 0.6), 96.4% (0. 3), and 96.5% (SE= 0.8), respectively. Similar to bank angle, however, we did find significant increases in bank stability for reference and managed sites, but no apparent change in stability for DMA sites in sites repeat-sampled in 2009 (Figure 13). There was no apparent difference in the amount of change observed in reference in managed sites.

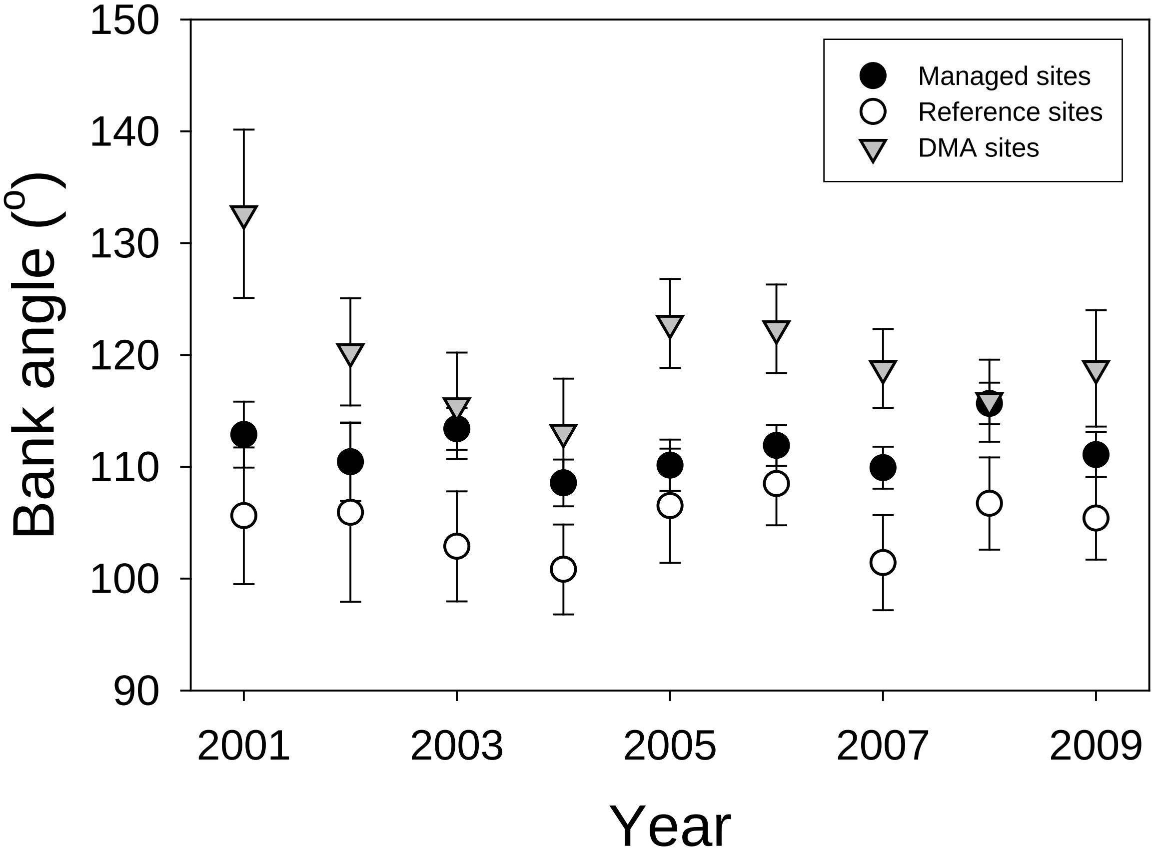

Figure 10. Mean estimates of bank angles (90% CIs) for managed (black circles), reference (hollow circles), and DMA sites (grey triangles) from 2001 to 2009.

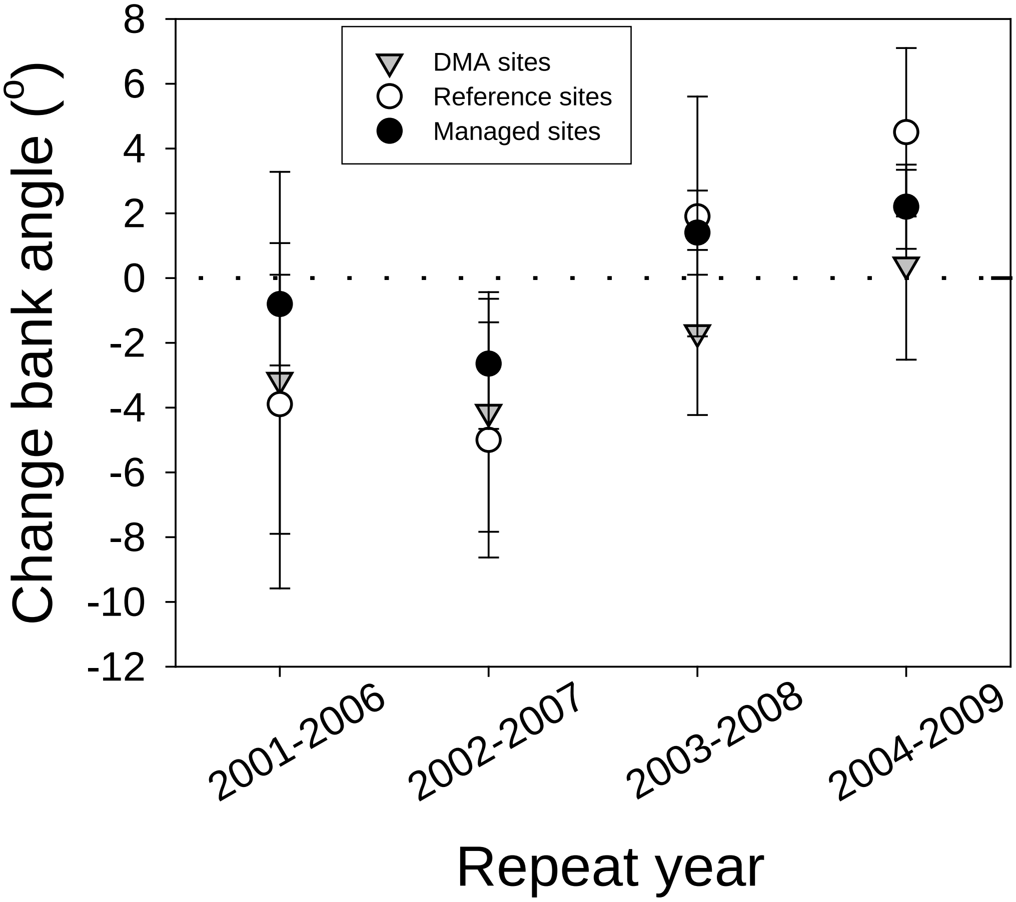

Figure 11. Mean change in bank stability for sites repeat-sampled (90% CIs) for managed (black circles), reference (hollow circles), and DMA sites (grey triangles) from 2001 to 2009. Dashed line indicates a reference of no change, and overlap of confidence intervals with dashed line indicates no significant change.

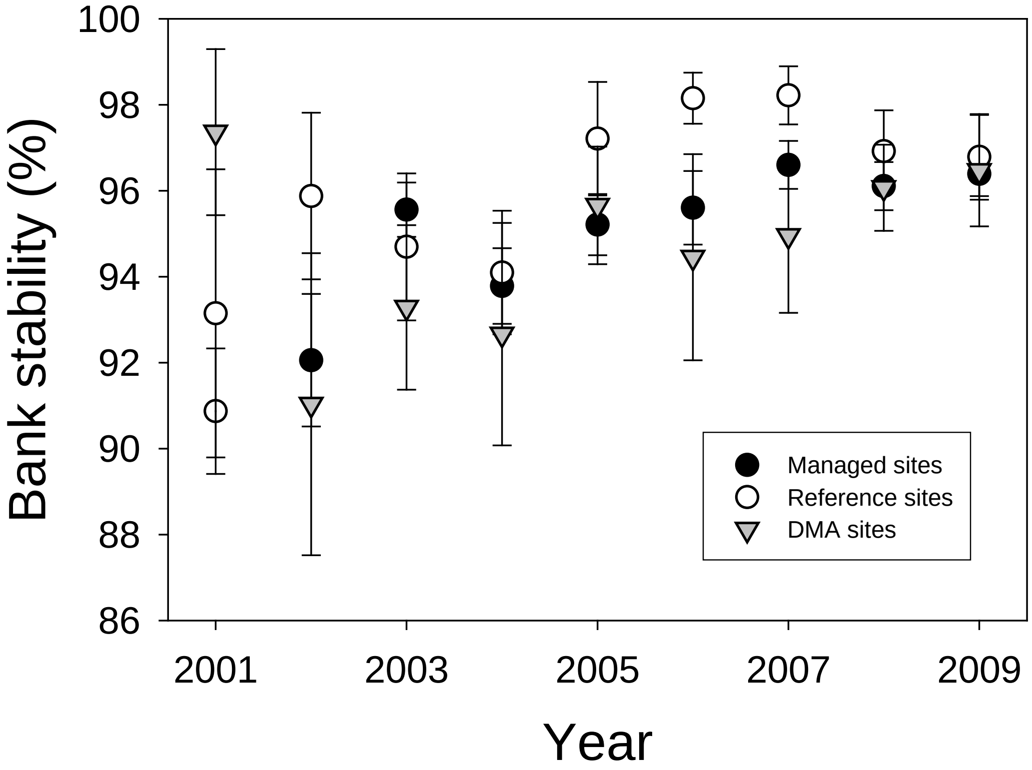

Figure 12. Mean estimates of bank stability (90% CIs) for managed (black circles), reference (hollow circles), and DMA sites (grey triangles) from 2001 to 2009.

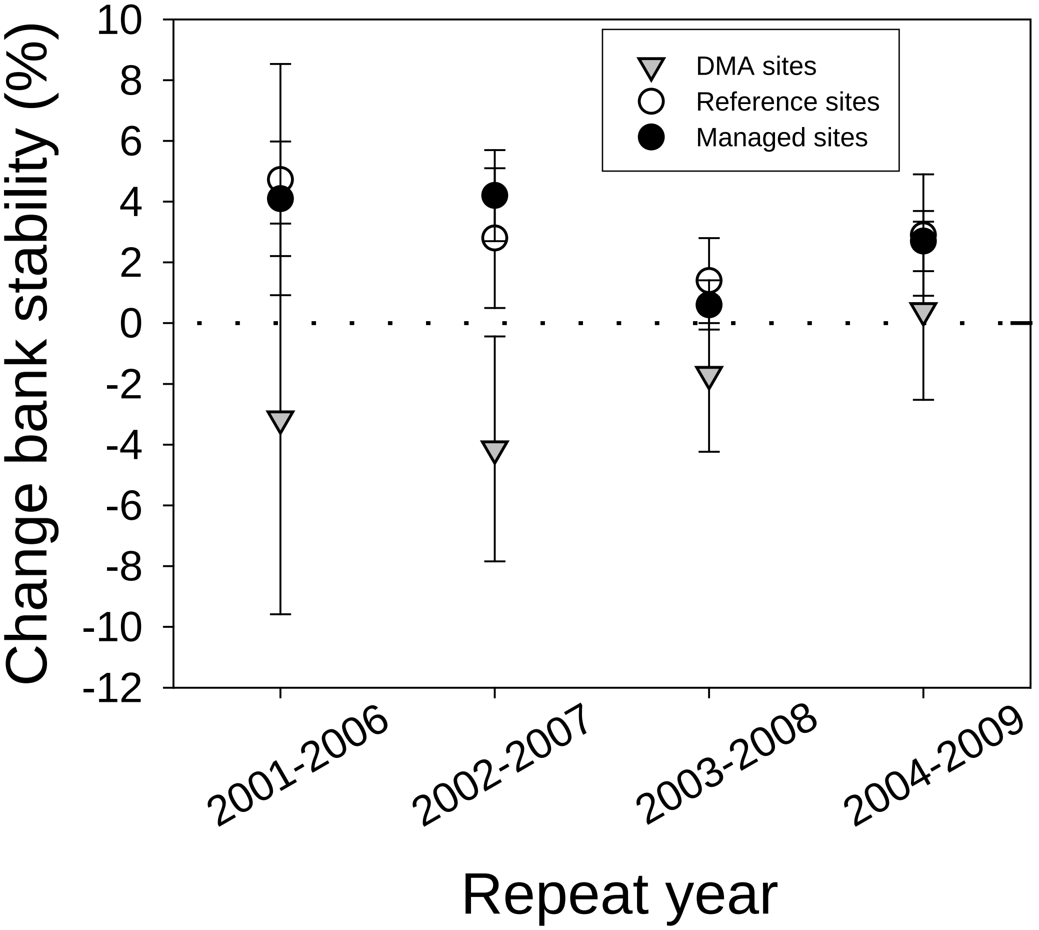

Figure 13. Mean change in bank stability for sites repeat-sampled (90% CIs) for managed (black circles), reference (hollow circles), and DMA sites (grey triangles) from 2001 to 2009. Dashed line indicates a reference of no change, and overlap of confidence intervals with dashed line indicates no significant change.

Vegetation.—We observed little differences in effective ground cover (EGC) across management categories (Figure 14). On average across years, EGC for reference sites (mean = 96.1%) was very similar to estimates for managed sites (mean = 94.1%), and only slightly higher than observed in DMA sites (Mean = 91.8%). However, we did observe considerable differences in vegetative cover between management categories Figure 15). In particular, greenline vegetative cover in reference sites (mean = 88.5%) was found to be slightly higher than managed sites (mean = 85.4 %), but 13% higher than observed at DMA sites (mean = 75.5%). At cross sections, we observed similar patterns but greater differences across management categories (Figure 16). Again, we found the highest cover at reference sites (mean = 80.7%), slightly lower vegetative cover at managed sites (mean = 76.8%), and considerably lower vegetative cover at cross sections at DMA sites (mean = 64.1%).

We found the amount of cover by non-natives (i.e., relative alien cover, see methods) differed considerably across management categories. At the greenline (Figure 17), relative alien cover at reference sites (mean = 1.7%) was four times lower than observed at managed sites (mean = 6.2%) and the highest measures of relative alien cover occurred at DMA sites (mean = 9.9%). These patterns were consistent at cross-section vegetation plots (Figure 18). At cross sections, the relative alien cover at managed (mean = 8.7%) and DMA (mean = 13.8%) sites was substantially higher than observed at reference sites (mean = 2.1%).

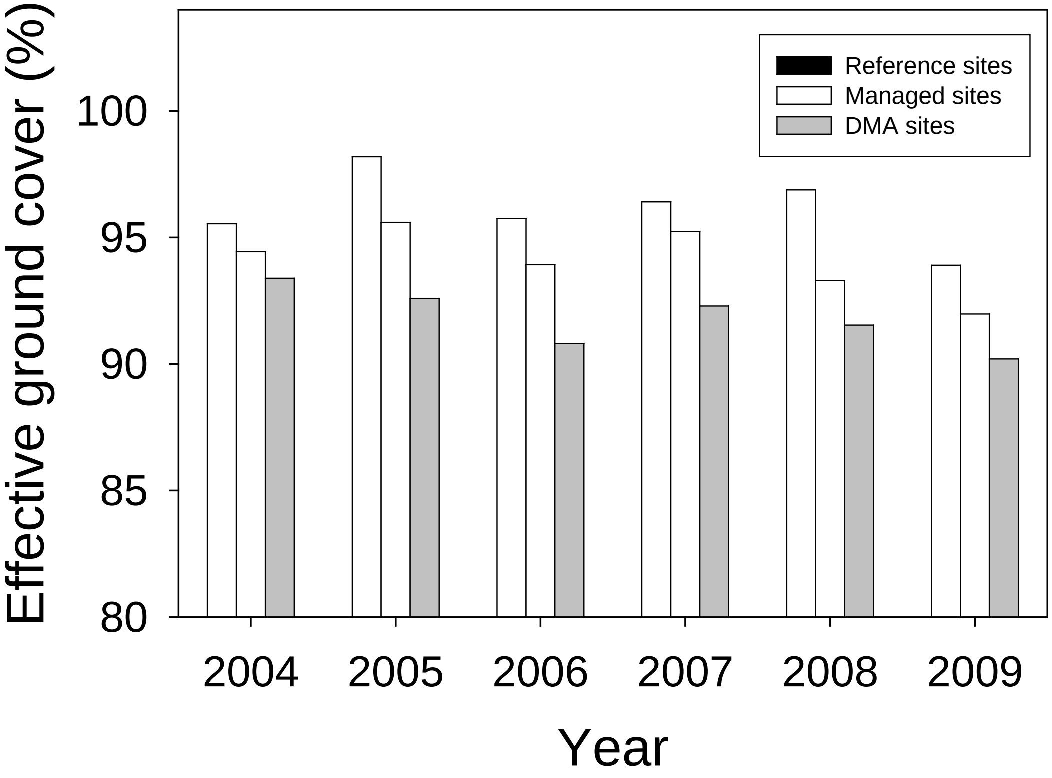

Figure 14. Average estimates of effective ground cover for reference (black), managed (hollow), and DMA sites (grey) from 2004 – 2009.

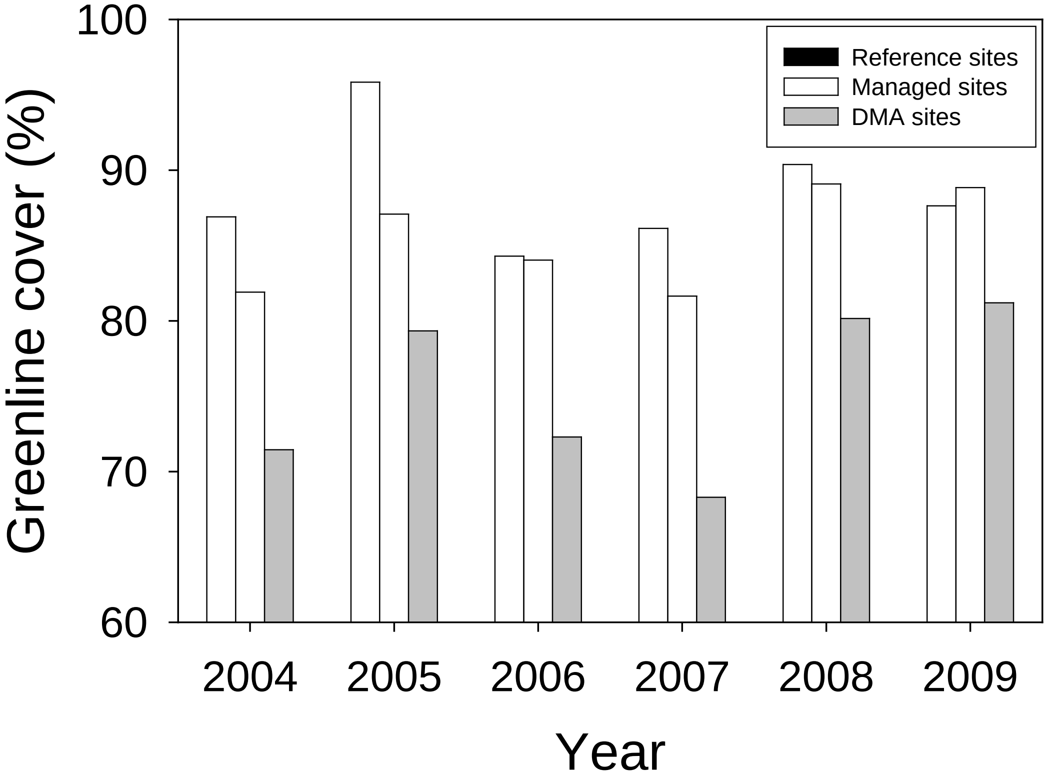

Figure 15. Average estimates of vegetative cover at the greenline for reference (black), managed (hollow), and DMA sites (grey) from 2004 – 2009.

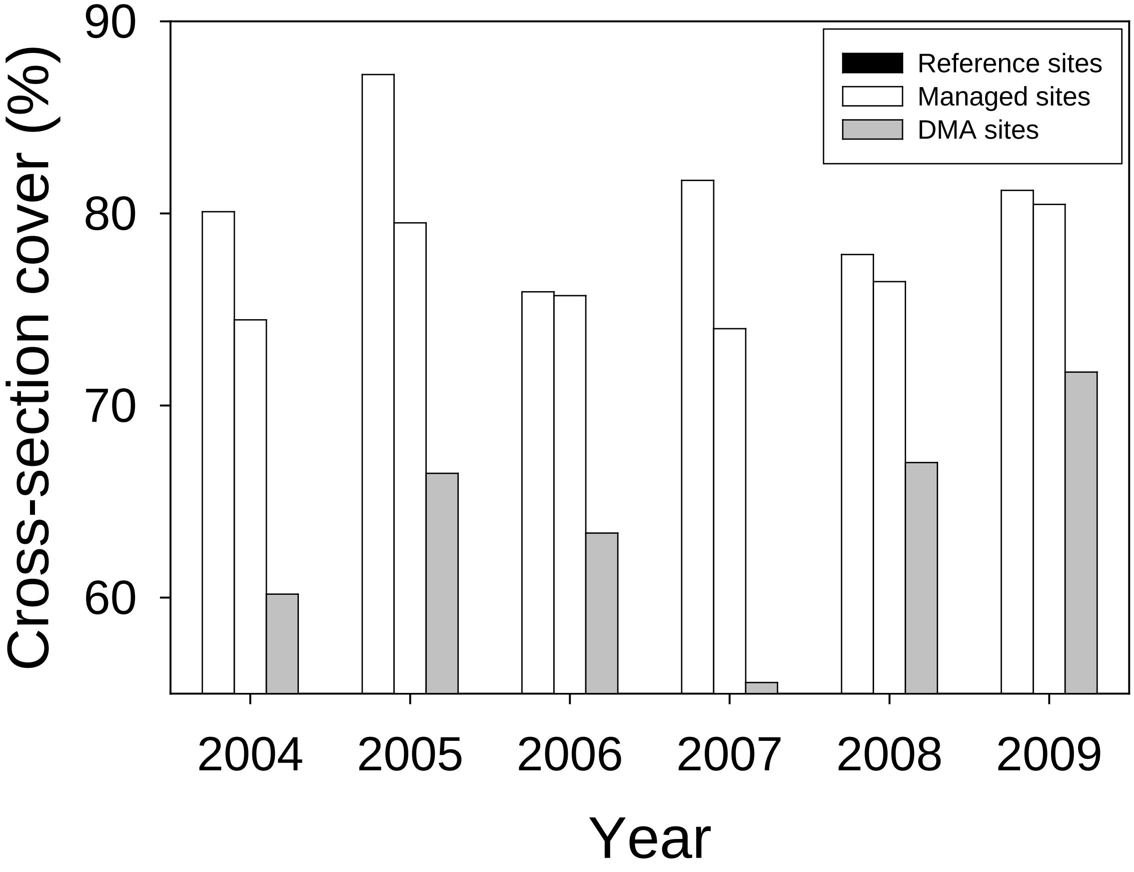

Figure 16. Average estimates of vegetative cover at cross sections for reference (black), managed (hollow), and DMA sites (grey) from 2004 – 2009.

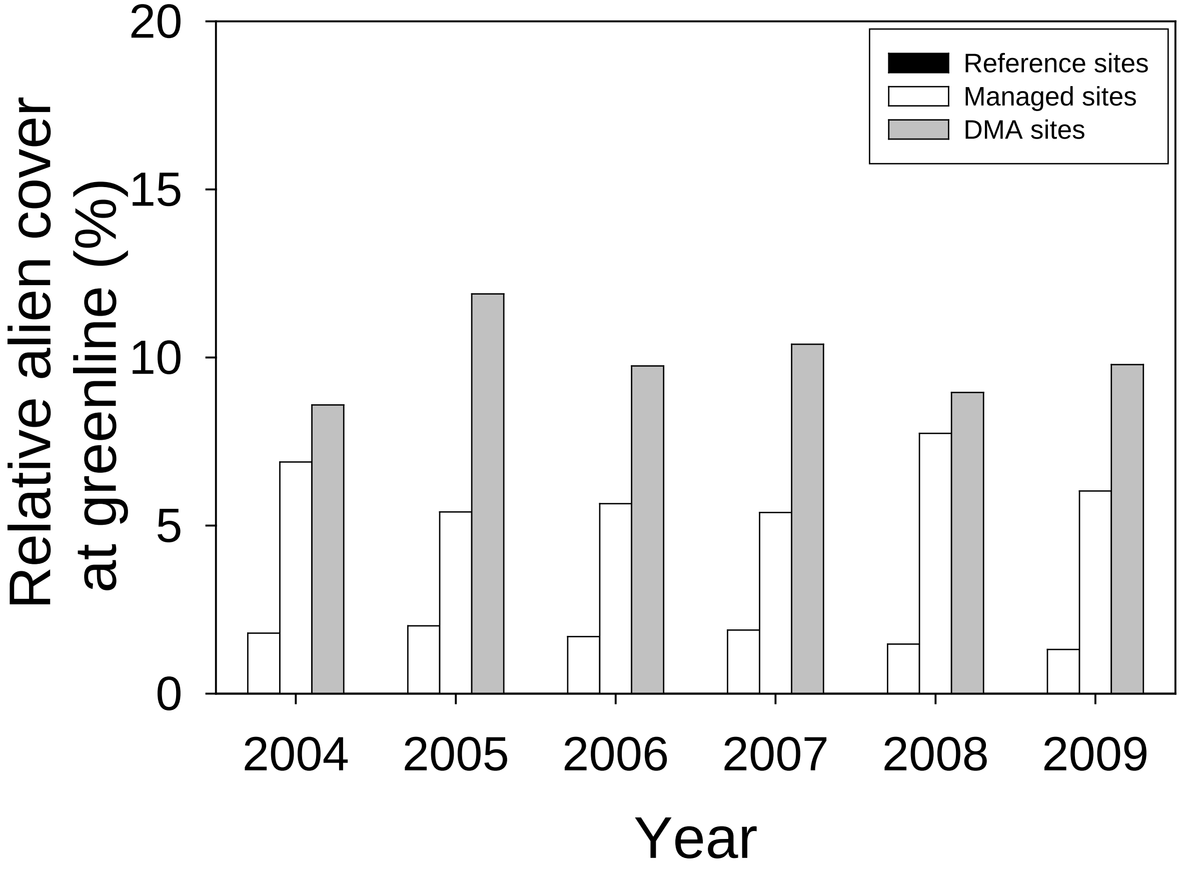

Figure 17. Average estimates of relative alien cover at the greenline for reference (black), managed (hollow), and DMA sites (grey) from 2004 – 2009.

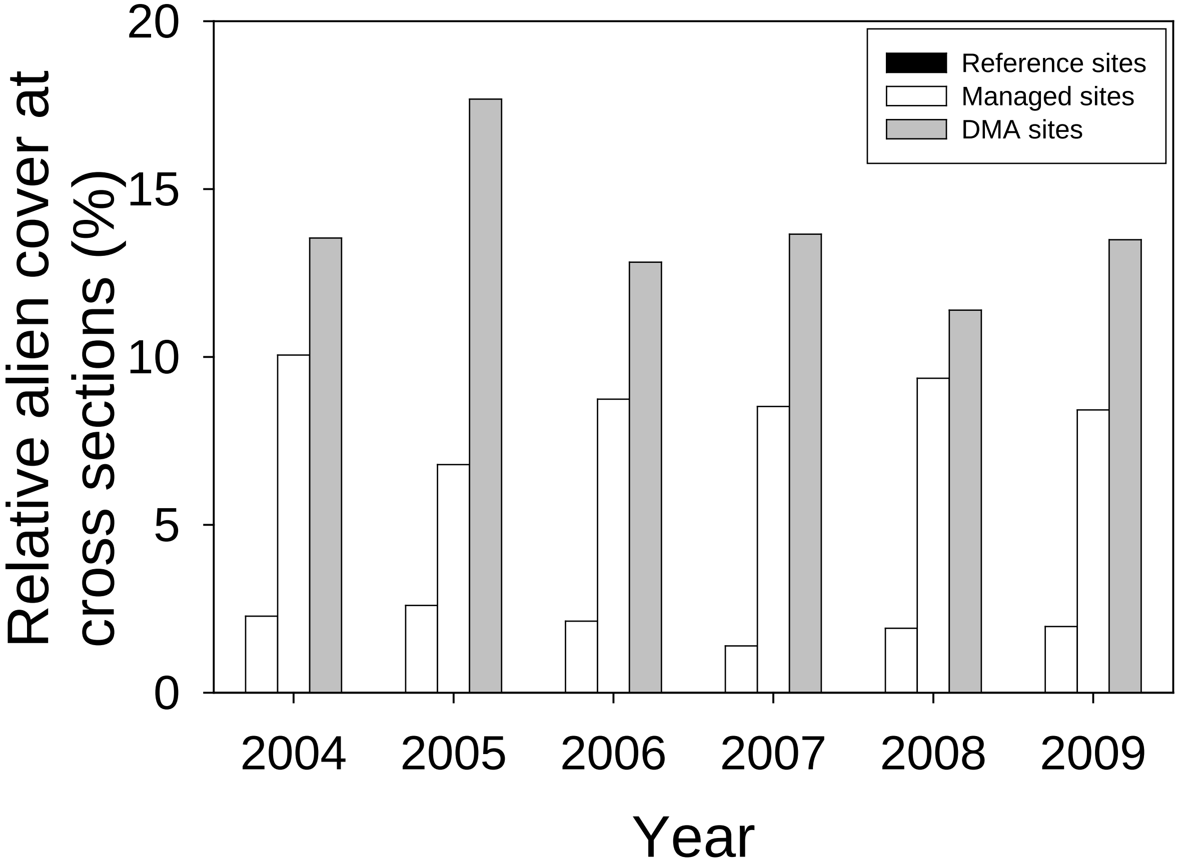

Figure 18. Average estimates of relative alien cover at cross-sections (XS) for reference (black), managed (hollow), and DMA sites (grey) from 2004 – 2009.

ONGOING AND RECENT EFFORTS

Title: *A review of bull trout habitat associations and exploratory analyses of patterns across the Interior Columbia River Basin*

Collaborators: Al-Chokhachy, R., (USFS PIBO Effectiveness Monitoring Project), B. Roper (USFS Fish and Aquatic Ecology Unit), T. Bowerman, (Utah State University), and P. Budy (Utah Cooperative Fish and Wildlife Research Unit).

Overview: Understanding bull trout (*Salvelinus confluentus*) habitat relationships remains an important component for identifying future restoration, management, and recovery efforts. Here, we synthesized past efforts through a comprehensive synthesis of peer-reviewed articles evaluating bull trout habitat relationships, and used field data within a classification tree analysis (CTA) to improve our understanding of the consistency of bull trout habitat use patterns. We performed CTAs using reach-level habitat data collected from stream networks currently occupied and unoccupied by bull trout where hierarchical filters (i.e., area and temperature) were met, and areas within the current distribution of bull trout where temperature criteria were exceeded. Results from the literature review demonstrated consistent results at the microhabitat and channel-unit scales and indicated the importance of slow-velocity, deeper habitats, and together with observed diel shifts, highlighted the importance of complex habitat, regardless of scale or season. At the reach scale, however, our results indicated substantially less consistency in bull trout habitat relationships. Including maximum stream temperature into the CTA did not result in changes to the overall structure of the CTA; results from the CTA indicated bull trout were found in sites with larger substrate, deeper pools, and more cover, but the specific criteria differed along a gradient of stream depth. Our results indicated important gaps in our knowledge regarding the role of substrate size in juvenile bull trout habitat use, patterns of habitat use in downstream sites, which may act as critical overwintering habitat or migratory corridors, and the need to incorporate sampling efficiencies in future bull trout habitat evaluations.

Citation: Al-Chokhachy, R., B.B. Roper, T. Bowerman, and P. Budy. 2010. A review of bull trout habitat associations and exploratory analyses of patterns across the Interior Columbia River Basin. North American Journal of Fisheries Management 30:464-480.

Title: *A comparison of the performance and compatibility of protocols used by seven monitoring groups to measure stream habitat in the Pacific Northwest*

Collaborators: Roper, B.B., (USFS Fish and Aquatic Ecology Unit), J.M. Buffington, USFS RMRS), S. Bennett (Utah State University), S.H. Lanigan and C. Moyer (USFS, Aquatic and Riparian Effectiveness Monitoring Program), E. Archer

(USFS PIBO Effectiveness Monitoring Project), S. Downie (California Department of Fish and Game), J. Faustini (Oregon State University), T. Hillman (BioAnalysts), S. Hubler (Oregon Department of Environmental Quality), K. Jones (Oregon Department of Fish and Wildlife), C. Jordan, (NOAA Fisheries), P.R. Kaufmann (US EPA), G. Merritt (Washington Department of Ecology), and A. Pleus (Northwest Indian Fisheries Commission).

Overview: In order to comply with legal mandates and/or meet local management objectives, many federal, state and tribal organizations have monitoring groups that assess stream habitat at different jurisdictional scales. This myriad of aquatic monitoring groups has difficulty sharing data across groups and scaling up stream habitat assessments to regional or national levels because of differences in group goals and data collection methods. To assess performance and the potential for data sharing amongst monitoring groups, we compared measurements made by 7 monitoring groups in 12 stream reaches in northeastern Oregon. We evaluated (1) consistency of measurements within a monitoring group, (2) ability to detect environmental heterogeneity, and (3) compatibility of measurements amongst monitoring groups, and their relation to values determined from more intensive sampling. Overall, we found that some stream attributes were consistently measured both within and among groups and there was a moderate correlation ($r^2 > 0.50$) between monitoring groups and the intensive measurements for at least 50% of the channel attributes for all but one monitoring group. However, none of the monitoring groups were able to achieve high precision for all measured stream attributes, and few of the measured attributes had potential for being shared among all groups. Given the high cost of stream habitat monitoring, we suggest that additional effort be focused on developing approaches that increase precision and compatibility of measured stream attributes so that their utility can extend beyond the monitoring group that collects the data. Ultimately, local monitoring programs should consider incorporating regional and national objectives so that data can be scaled up and limited monitoring dollars can be maximized across spatial scales.

Citation: Roper, B.B., and 14 coauthors. *(In press)*. A comparison of the performance and compatibility of protocols used by seven monitoring groups to measure stream habitat in the Pacific Northwest**.** North American Journal of Fisheries Management.

Title: *Evaluating the status and trends of physical stream habitat in headwater streams within the Interior Columbia River and Upper Missouri River Basins using an index approach*

Collaborators: Al-Chokhachy, R. and E. Archer (USFS PIBO Effectiveness Monitoring Project) and B.B. Roper (USFS Fish and Aquatic Ecology Unit).

Overview: Identifying the overall status of freshwater streams is an important step in evaluating land management effects and prioritizing restoration activities. To address these needs, we developed an index of physical habitat condition for headwater streams based on physical stream habitat data (2003-2007) and evaluated the status of the condition of 217 reference and 934 managed streams in the Interior Columbia River and Upper Missouri River Basins. We used data collected from reference sites to generate this index, which consisted of 8 commonly-collected metrics used in stream habitat monitoring. We incorporated landscape and climatic covariates into multiple linear regression analyses to control for inherent differences in physical habitat attributes among sites, and scored the overall condition of reaches with index scores ranging from 0 to 100. Our results indicated the condition of physical habitat in reference reaches (47.1, SE = 1.4) was significantly higher than for managed reaches (mean = 30.4, SE = 0.7), with a greater frequency of managed reaches with low habitat condition and a lower frequency of managed reaches with high habitat condition than observed in reference reaches. Analyses evaluating the relationship between management activities and the condition of physical habitat in streams indicated a significant negative relationship with lower index scores in stream reaches within catchments containing higher densities of roads. When roads and livestock grazing occurred within catchments, we found the presence of grazing had an additional, significant negative effect on the relationship between road density and the condition of physical habitat of streams. Our results suggested a multimetric index approach, when natural variability and geoclimatic differences among reaches are accounted for, can provide managers with an easily-interpretable tool to monitor the status of the overall condition of physical habitat.

Citation: Al-Chokhachy, R., B.B. Roper, and E. Archer. (*In press).* Evaluating the status and trends of physical stream habitat in headwater streams within the Interior Columbia River and Upper Missouri River Basins using an index approach. Transactions of the American Fisheries Society.

Title: *Different approaches to habitat surveys can impact fisheries management and conservation decisions*

Collaborators: Al-Chokhachy, R. (USFS PIBO Effectiveness Monitoring Project) and B.B. Roper (USFS Fish and Aquatic Ecology Unit).

Overview: We illustrate how the variability in data collected within and among habitat sampling protocols can profoundly affect the interpretation of habitat quality, quantity, and the development of habitat-to-fish population metrics. We input data collected from two standardized survey techniques as well as data collected using one standardized technique with multiple crews, into empirically based relationships and found the variability in estimates of habitat data resulted in 1-50% differences in predictions of Chinook salmon (*Oncorhynchus tshawytscha*) egg-to-fry survival rates. Estimates of percent pool habitat collected via different protocols resulted in up to a 3.5-fold difference in juvenile trout abundance. We also found substantial differences in the geomorphic relationships between large woody debris (LWD) and the frequency of pools using data collected by different protocols. Within protocols, we illustrate how the precision of estimates of LWD and pool frequency can substantially affect data-crosswalk opportunities between habitat data collected via different protocols. The effects of the variability in habitat assessments illustrated here highlights the importance of standardized, well-documented protocols, adequate training of field crews collecting habitat data, and the need to evaluate potential bias and error.

Citation: Al-Chokhachy, R., and B.B. Roper. (*In press). Different approaches to habitat surveys can impact fisheries management and conservation decisions*. Fisheries.

Title*: Quantifying temporal variability in stream habitat data: implications for restoration and monitoring*

Collaborators: Al-Chokhachy, R. and E. Archer (USFS PIBO Effectiveness Monitoring Project) and B.B. Roper (USFS Fish and Aquatic Ecology Unit).

Overview: Quantifying natural and anthropogenic-induced levels of temporal variability is essential for robust trend analyses and for evaluating the effectiveness of restoration activities or changed management actions. Here, we used data collected as part of the Pacfish/Infish Biological Effectiveness Monitoring Project to evaluate the extent of temporal variability in instream habitat collected at the reach scale. We integrate habitat data collected yearly (2001 to 2009) at 50 sites experiencing a range of management activities into our analyses to better understand the consistency of temporal variability in watersheds with inherently different landscape characteristics and disturbance regimes. We initially decompose variance estimates to remove site-to-site variability, sampling error, and year effects and use the remaining variance as a measure of site-specific temporal variability. We then relate this temporal variability to landscape, management, and climate attributes at multiple scales to better understand which characteristics result in more or less variability in habitat attributes at specific sites. Our results suggest temporal variability differs significantly across individual sites and attributes within sites, indicating our ability to detect significant changes as a result of management changes and/or restoration efforts are context dependent. The spatial scale of landscape attributes (e.g., stream buffer vs. catchment) related to temporal variability also varied across individual attributes. Our efforts highlight the importance of considering site-specific measures of temporal variability as they relate to specific restoration and management goals.

Title*:* *Broad-scale genetic and compositional monitoring of fish populations: a proof of concept in the interior Columbia River and upper Missouri River basins*

Collaborators: Young, M.K., K. McKelvey and M. Schwartz, (USFS Rocky Mountain Research Station); S. Narum, Columbia River Inter-Tribal Fish Commission, Hagerman Genetics Lab, and B. Roper (USFS Fish and Aquatic Ecology Unit).

Overview: Monitoring fish populations is essential to gauge the success of conservation efforts and the status and trends of individual species, but obtaining abundance estimates is time-consuming and problematic because of spatial and temporal variation in abundance. Also, relations between fish populations and their surrogates, such as habitat characteristics, are often obscure. As an alternative, genetic assessment and monitoring offers promise as an indicator of population status and trends by providing information on effective population size, genetic diversity, connectivity among populations, and the prevalence of hybridization with non-native species. We have undertaken intensive sampling of native and nonnative fishes and amphibians with lotic life histories on a subset of streams currently monitored by the Pacfish/Infish Biological Opinion Monitoring Program. These streams represent a spatially comprehensive, random sample of subbasins in the interior Columbia River Basin. We are developing a new set of genetic markers—single nucleotide polymorphisms—derived from nondestructively collected tissue samples that should be more cost-effective to process than those previously used. If fully realized, sampling of over 1500 streams in Montana, Idaho, eastern Oregon, and eastern Washington on federal lands should permit broad-scale evaluations of the status and distribution of much of the aquatic vertebrate fauna and enable detection of responses to climate change. Although many aspects of this project are in developmental stages, preliminary sampling at over 400 sites on 150 Montana streams indicates that brook trout are more widely distributed than previously recognized, the taxonomic diversity of sculpins is underappreciated, and that westslope cutthroat trout occupy headwater sites in most of their historical range except in the Kootenai and Missouri River basins.

Title: *Temporal and spatial variation in ecological assessments of riparian plant communities*

Collaborators: Laine, C., and K. Kettering (Utah State University), B.B. Roper (USFS Fish and Aquatic Ecology Unit), and E. Archer (USFS PIBO Effectiveness Monitoring Project).

Overview: Riparian habitats on public lands are key areas of concern in the western United States because of their importance to wildlife, recreation, and biodiversity. Making educated choices about appropriate land management strategies requires monitoring and assessing ecological attributes, such as vegetation, over time in response to various management activities. However, plant communities have natural temporal and spatial variation due to abiotic and biotic factors, and this may be further pronounced in riparian plant communities because of a naturally dynamic environment. Greenline plots are used in riparian vegetation assessments to capture information about the vegetation that grows directly adjacent to the stream. Since the greenline plot is an area with high water availability and has a relatively quick recovery period to disturbance, it is a good location for determining the impact of management activities on riparian areas; although, this location may vary throughout the season. A variety of metrics are used when assessing riparian plant communities, including total cover of live vegetation, species richness, the ratio of native to exotic diversity, species composition and wetland indicator rating. However, some of these metrics may be influenced by temporal or spatial variation, an important consideration for management decisions regarding riparian plant communities. One predominant management activity on western public lands is cattle grazing, and the assessments of riparian plant communities under grazing pressure may be more variable than in areas that are not grazed. For my research, I will be exploring how temporal and spatial variation in riparian plant communities affects the results of ecological assessments in creeks within the Salmon National Forest and BLM lands in Idaho. Temporal variation will be measured by conducting surveys every two-three weeks from June-October at the same sites and recording the vegetation within greenline plots. Spatial variation will be measured by comparing fixed, permanent plots to plots that dynamically change throughout the season as the greenline location changes. Last I will compare how assessments of riparian sites with cattle grazing compare to adjacent riparian exclosures. My research will aid land managers in understanding how temporal and spatial variation in riparian plant communities affects the results of ecological assessments, which will allow them to properly design their research to determine whether land management activities are effective.

Title: *Modeling the distribution and abundance of an invasive riparian plant species: testing model assumptions and predicting impact*

Collaborators: Menuz, D., and K. Kettering (Utah State University), B.B. Roper (USFS Fish and Aquatic Ecology Unit), and E. Archer (USFS PIBO Effectiveness Monitoring Project).

Overview: Invasive plant species cause substantial economic and ecological harm throughout the world. Riparian areas are particularly sensitive to invasion; they are subject to high levels of anthropogenic and natural disturbance that create dispersal opportunities and open habitat for the establishment of new species. Riparian vegetation plays an important role in determining characteristics of adjacent streams; therefore, changing the composition of riparian plant communities via biological invasion can have detrimental effects on sensitive aquatic ecosystems. Modeling can be an important tool for combating invasive species. Species distribution and abundance models can help land managers identify climatic and land use factors that promote the establishment and success of invasive species. Species distribution models can also be used to predict areas that are susceptible to invasion in order to prioritize sites for early detection and eradication programs. Species abundance models can predict areas most likely to be severely impacted by invasive species where control efforts should be focused. For model results to be valid, it is important to test the validity of model assumptions. The model assumption that the modeled species is at equilibrium with its environment may frequently be violated by invasive species because they have had less time to disperse to all suitable habitat within their introduced range. In this study, I am going use data from riparian areas in the Columbia River Basin to compare model fit for distribution and abundance models of the aggressive invasive riparian species reed canary grass (*Phalaris arundinacea*) and the functionally similar native riparian species, bluejoint (*Calamagrostis canadensis)*. The novel approach of comparing model fit between an invasive and native species will suggest the extent to which we can apply these models to invasive plant species. Furthermore, I am going to evaluate two methods for improving model fit for non-equilibrium species- the incorporation of dispersal parameters into models and the use of presence-only rather than presence-absence distribution models. This research will suggest the best-practice model to use with invasive species and determine the extent to which these methods equalize model fit for the native and invasive species. Finally, to provide information that land managers can use, I will determine what climatic and land use factors promote the distribution and abundance of reed canary grass and extrapolate model information to create a predictive map of areas susceptible to reed canary grass invasion in the Columbia River Basin.

Presentations at professional meetings (2009)

Al-Chokhachy, R., B. Roper, T. Bowerman, and P. Budy. 2009. Exploring bull trout habitat relationships: where do we need to go from here? Oregon Chapter American Fisheries Society, Annual Meeting.

Al-Chokhachy, R., B. Roper, and E. Archer. 2009. Quantifying the effects of management, climate, landscape characteristics, and disturbance on the temporal variability of stream habitat. Western Division of the American Fisheries Society, Annual Meeting.

Al-Chokhachy, R., B. Roper, E. Archer, and P. Ebertowski. 2009. Using occupancy modeling to monitor changes in the distribution of non-native riparian vegetation species. Western Division of the American Fisheries Society, Annual Meeting.

Al-Chokhachy, R., and B. Roper. 2009. How different approaches and observers can impact fisheries management and conservation. Western Division of the American Fisheries Society, Annual Meeting.

Al-Chokhachy, R., B. Roper, and E. Archer. 2009. Temporal variability and trends in instream habitat: implications for monitoring. Pacific Salmonid Recovery Conference. Seattle, WA.

PREVIOUS PIBO ACCOMPLISHMENTS (peer-reviewed manuscripts)

Archer, E.K., B.B. Roper, R.C. Henderson, J.L. Kershner, and S.C. Mellison. 2004. Testing common stream sampling methods: how useful are these techniques for broad-scale, long-term monitoring? Gen. Tech. Rep. RMRS-GTR-122. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

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Kershner, J. L., E.K. Archer, M.C. Coles-Ritchie, E.R. Cowley, R.C. Henderson, R. C., K. Kratz, C.M. Quimby, D.L. Turner, D.L. Ulmer, and M.R. Vinson. 2004a. Guide to effective monitoring of aquatic and riparian resources. Gen. Tech. Rep. RMRS-GTR-121. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 57 p.

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SUMMARIZED DATA

Summarized data collected by the PIBO EM program are available for download in the "2009 PIBO EM Report files" folder on our ftp site. The data are presented in five Excel files:

1. **PIBO_StreamHabitat_2009data.xls:** All integrator and DMA reaches sampled are included (fewer attributes are measured / reported for DMAs).
2. **PIBO_RiparianVeg_2009data.xls:** All integrator and DMA reaches sampled are included.
3. **PIBO_Weed_2009data.xls:** All integrator and DMA reaches sampled are included.
4. **PIBO_Temperature_2009data.xls:** All reaches with temperature data are reported.
5. **PIBO_Macroinvertebrate_2009data.xls:** All reaches with macroinvertebrate data are reported. Data from 2009 is not presented because these samples have not been classified at this time.

- Each file has 2 worksheets: 1) data table; and 2) associated metadata.
- If you have a question about an attribute, please read the metadata.
- Each metadata document is comprised of 5 columns:
    - Category: Classifies attributes into groups. Forest is an example of a "location" attribute; stream name is an example of an "identification" attribute.
    - Short name: Column headers for each attribute in the data tables.
    - Long name: The unabbreviated title of each attribute.
    - Description: A brief explanation of each attribute and how the values were generated.
    - Units/format: States how the values for each attribute are presented (%, # of days, m, etc.).
- For greater explanation of how data is collected, review the sampling protocols available on our website.
- Each table includes the same 21 descriptor columns, followed by the data.

We have made every effort to provide all available data collected from 2001 to present, however every reach may not be represented in all tables.

The data presented in these tables describe the current status or baseline condition for each attribute measured. Rigorous statistical analyses of these data are not presented in this report, but are included in additional PIBO EM publications.

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