PIBO Effectiveness Monitoring Program
for Streams and Riparian Areas
USDA Forest Service
2012 Annual Summary Report
PREPARED BY THE PACFISH INFISH Biological Opinion
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Evaluating Status Using Habitat Index Score ................................................................. 20

RESULTS ........................................................................................................................... 21

Stream Habitat: Trends Over Time: Integrator Sites (Figures 3-10; Table 2) ........... 21

Macroinvertebrate Condition at Integrator Sites (Figure 11) ................................. 27

Example: Evaluating Status Using Habitat Index Scores ...................................... 28

Lochsa (Figures 12a-12g) .............................................................................................. 28

South Fork Clearwater (Figures 19-25) ...................................................................... 36

PREVIOUS PIBO ACCOMPLISHMENTS (publications, before 2010) ................. 44

SUMMARIZED DATA ..................................................................................................... 45

REFERENCES ..................................................................................................................... 47
ACKNOWLEDGEMENTS

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As always, we thank personnel from the BLM/USU National Aquatic Monitoring Center for identifying and reporting the invertebrate samples.

Finally, thanks to our recent graduate students Lindsey Goss and Ryan Lokteff for their dedication and hard work in support of the PIBO EM program. Finally, we thank all of the PIBO EM seasonal employees that have collected data during all of our field seasons.
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 PIBO EM’s primary objective. 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 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.

In this report, we provide an overview of the research and monitoring efforts that have recently been conducted by PIBO personnel and collaborators. We also provide an update of our ongoing evaluation of stream and riparian condition at the study sites. To evaluate habitat condition, we used a habitat index score to compare changes in key habitat attributes and an index of macroinvertebrate health over time from 2001 to 2012. These and previous efforts are an integral part of this project, with 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. Publications and links to summarized data can be found by accessing the Fish and Aquatic Ecology Unit Webpage.

1 http://www.fs.fed.us/biology/fishecology/emp/index.html
INTRODUCTION

This report is a review of the PACFISH INFISH Biological Opinion Effectiveness Monitoring (PIBO EM) annual 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 the Fish and Aquatic Ecology Unit Webpage\(^2\). 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). A complete list of PIBO publications is also available on our website:

http://www.fs.fed.us/biology/fishecology/emp/index.html

The information provided in this report is intended to assist National Forest and BLM office land managers in their monitoring efforts. All analyses were conducted 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 in the context of their Region or Forest. This report however, is not intended to be a complete interpretation of the results and it is recognized that further analyses need to be conducted. The PIBO EM makes no attempt to evaluate the implications of the data presented herein. Please contact any of the personnel listed on the PIBO 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) has placed increasing scrutiny on the effects of forest and rangeland management activities on spawning and rearing habitat and prompted interest in the condition of habitat throughout these species' ranges. 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 upper CRB.

Several documents currently provide guidance for protecting anadromous fish habitat in the Columbia River Basin. Each National Forest within the range of steelhead trout in

\(^2\) http://www.fs.fed.us/biology/fishecology/emp/index.html
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), and United States Fish and Wildlife Service (USFWS). As part of the Section 7 consultation process with the Bureau of Land Management (BLM) and United States Forest Service (USFS), 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 of 1998. Goals derived from the biological opinions for this plan included: 1) developing a coordinated effort with a defensible sampling 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 within steelhead and bull trout ranges as a result of land management within the CRB (Kershner et al. 2004a). We defined the effectiveness monitoring component of this program with three specific 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. The sampling effort, which has continued to 2012, has allowed for a long-term assessment of stream and riparian habitats throughout the study region.

Recent PIBO Publications, 2010 and later

(* Past publications can be found at end of this report)


METHODS: Data Collection

Study Area

The original study area included portions of Eastern Oregon, Eastern Washington, Idaho, and Western Montana (Figure 1-CRB portion). In 2006 the PIBO EM rotating panel study design was applied to National Forests within the upper Missouri River basin (MRB) in Montana (Figure 1- MRB portion). This includes the Lewis and Clark, Gallatin, and Custer along with eastern portions of the Helena and Beaverhead-Deerlodge National Forests. The study area is bordered by the Cascade Mountains on the west, Canada to the north, the continental divide to 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 occurs predominantly as snow from October to May (Quigley and Arbelbide 1997). Some precipitation falls as rain during the spring, summer, and fall months, but makes up a minority of the annual water balance. Temperatures within the study area are highly variable with short, cool summers in mountainous areas and longer, extended growing seasons in montane valleys and at 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 and 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 forest (Douglas fir, ponderosa pine, grand fir, white fir) and cold forest communities (mountain hemlock, spruce-fir, aspen, white bark pine, lodgepole pine, alpine larch). Range vegetation communities 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) (Franklin and
Livestock grazing has occurred since the late 19th century at varying intensities. Current range integrity ratings are low-moderate throughout most of the study area (Quigley and Arbelbide 1997).

Sample Site Selection and Description

Integrator Sites

Beginning in 2001, PIBO EM implemented a 5-year, rotating panel design described in the PIBO Monitoring Plan (Kershner et al. 2004a). We used the 3,547 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 ≈20 sub-watersheds. Groups were then randomly assigned to a panel year, numbered one through five 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 of the sample area, are sampled within each panel year. Within most groups, 7 out of the 20 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 have a history of minimal timber harvest, 2) they have not been grazed by livestock within the last 30 years, 3) watershed road densities are less than 0.5km / km², 4) riparian road densities are less than 0.25km / km², and 5) no historic dredge or hard rock mining has occurred in 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 were 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, and no current beaver activity. Integrators are at least 20 bankfull channel widths in length (160m minimum length) as measured along the thalweg. From 2001 through 2002, the minimum reach length was 80 m. When
these “short” reaches were resampled 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.

**Sentinel Sites**

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. Sentinel sites are also considered Integrator sites. Data collected at sentinel sites will be used to examine annual variability and rate of change of each measured attribute (objective 2a).

**Grazing Designated Monitoring Area Sites**

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 initially measured a subset of the stream characteristics sampled at integrator sites. These included all vegetation and streambank parameters, gradient, sinuosity and bankfull width. Channel cross-section and pool data were collected at DMA sites starting in 2007, and all attributes were collected for DMA sites starting in 2011.

**Contract Sites**

Given the availability of funding, we also sample contract sites on lands owned by the USFS, the BLM, and the National Park Service. These sites are not part of our rotating panel design and are not considered Integrator reaches.
Figure 1. PIBO EM study area with all sample reaches and number of visits to each location from 2001-2012. This map does not include points for additional sampling projects.
Figure 2. DMA reaches with all sample sites and number of visits to each location from 2001-2012. This map does not include points for additional sampling projects.
Table 1. Summary of all PIBO EM sites sampled within the jurisdiction of each Forest Service Region and BLM State Office since 2001, including contract sites. The number of sites sampled in 2011 is shown in parentheses.

<table>
<thead>
<tr>
<th>Region</th>
<th>Integrator Reference</th>
<th>Integrator Managed</th>
<th>DMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idaho BLM</td>
<td>0</td>
<td>51 (10)</td>
<td>55 (13)</td>
</tr>
<tr>
<td>Montana BLM</td>
<td>0</td>
<td>3 (0)</td>
<td>0</td>
</tr>
<tr>
<td>Oregon-Washington BLM</td>
<td>0</td>
<td>35 (4)</td>
<td>54 (12)</td>
</tr>
<tr>
<td>National Park Service</td>
<td>0</td>
<td>26 (14)</td>
<td>0</td>
</tr>
<tr>
<td>Region 1</td>
<td>176 (39)</td>
<td>685 (144)</td>
<td>50 (11)</td>
</tr>
<tr>
<td>Region 4</td>
<td>72 (8)</td>
<td>360 (71)</td>
<td>150 (42)</td>
</tr>
<tr>
<td>Region 6</td>
<td>24 (7)</td>
<td>321 (43)</td>
<td>175 (20)</td>
</tr>
</tbody>
</table>

Data Collection

We collect a combination of 11 riparian vegetation, 6 stream temperature, 10 macroinvertebrate, and 18 in-stream variables for each integrator site (Kauffman et al. 1983, Platts et al. 1983, Myers and Swanson 1991 and 1992, Karr and Chu 1997, Winward 2000. Information on how these variables were collected is described within our protocols and can be found at the Fish and Aquatic Ecology Unit Webpage. A summary of some of data collection methods is below. In this report, we focus on assessing trends in habitat condition using in-stream variables and macro-invertebrates.

Data Collection-Riparian Habitat

PIBO field crews sample plant composition at both the stream’s first line of vegetation (greenline) and across the riparian area (cross-sections). Numerous cross-section and greenline sample plots are used at each reach to identify species and estimate vascular plant cover.

Results related to riparian habitat condition are currently available through 2011 and can be found in our 2011 Annual Report and in our 2011 “weeds” report entitled “The PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Program and Invasive Species Detection: A retrospective summery 2003-2011 (Archer et al. 2012). These reports are available on our website and by request.

In our “weeds” report, we summarize the proportion of reaches invaded by invasive species within each management classification (reference, managed, and designated monitoring areas). We also map invasive species richness across the study area, including maps for individual problem species. We conclude that riparian condition and
vegetation communities within the Columbia River Basins have been altered by biological plant invasions and that these invasions.

**Data Collection-Temperature**

PIBO-EMP collects temperature data from July through 15th through August 31st at each integrator site. We summarize temperature attributes, including average temperature, maximum temperature, 7-day maximum temperature, number of days above 12 °C, number of days above 18 °C, and number of days above 22 °C. These data are available upon request.

**Data Collection-Macroinvertebrates**

We sample macroinvertebrates using the protocol recommended by the Center for Monitoring and Assessment of Freshwater Ecosystems, Utah State University (Hawkins et al. 2003). Two Surber net samples are 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 eight samples are combined for each reach for a total sample area of 0.744 m².

Samples are analyzed and summarized by the BLM/USU National Aquatic Monitoring Center using ten metrics (Karr and Chu 1997). One summary attribute termed RIVPACS score, or O/E, was developed by the Center for Monitoring and Assessment of Freshwater Ecosystems in cooperation with the National Aquatic Monitoring Center. We frequently use this attribute to assess habitat condition using macroinvertebrates. This attribute is 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).

**Data Collection: Stream Habitat:**

% Fines (< 5 mm)

The percent surface fines (6 mm) was measured at a subset of pool-tails in each reach using the 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 also measure percent surface fines less than 2 mm. 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.

\( D_{50} (\text{mm}) \)

The \( D_{50} \), or median grain size, was determined using a modified Wolman pebble count method (Wolman 1954). Throughout the course of the project, different methods have been used to collect particles at different spatial locations in the channel. Starting in 2004, particles were collected at channel transects and not just in riffles, and this method has continued through 2012.

**Percent Pools (%)**

The percent of reach comprised of pools was obtained by dividing the length of the reach containing primary pools by the total length of the reach. Primary pools are defined as concave depressions in the streambed bound by a head and tail crest where the thalweg runs through the pool. Primary pools must occupy at least half of the wetted channel with a maximum depth of at least 1.5 times the pool-tail crest depth and 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.

**Residual Pool Depth (cm)**

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. Residual depths were calculated as the difference between the maximum depth and the pool-tail crest depth.

**Bank Angle (degrees) and Percent Undercut 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°. An estimate of bank angle and percent undercut banks at each reach was based on the average values collected at transects throughout the reach.

**LWD Frequency (pieces/km)**

Large woody debris frequency was estimated as the number of pieces per km of stream. All large wood pieces were counted if they were equal to or greater than 1 m in length and 0.1 m in diameter and extended into the bankfull channel. The results were summarized as counts and volumes of large wood per km.
Bank Stability (%)

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.

Methods: Analyses

Stream Habitat: Trends Over Time at Integrator Site

We used mixed models to evaluate the trend of change in each habitat condition measure over time for both managed and reference sites across the PIBO dataset. This statistical approach controls for inherent differences in climate and landscape characteristics between sites. We considered a trend to be occurring if the model which includes a trend (e.g., Year effect included in the model) had the lowest model performance, meaning lowest AIC (Burnham and Anderson 2002). We considered the trend to be different for managed and reference sites if the model which contained an interaction between the year effect and management had better performance than the model which does not include the interaction. We report the desired direction of change that would indicate habitat is improving (Kershner et al. 2004) as well as the direction of the observed change based on coefficients (“+” for positive, “-” for negative, and ”0“ for no significant change). Because the protocol for measuring was not the same prior to year 2004, we only analyzed trend in $D_{50}$ using data collected from 2004-2012.

Macroinvertebrate Condition Over Time at Integrator Sites

We also used mixed models to evaluate the slope (0,+,-) of change in the RIVPACs
(O/E) score over time at Integrator sites. The RIVPACS score is a measure of how many macroinvertebrates are present at a site compared to how many are expected given climactic and landscape factors. A score greater than 0.8 is usually considered to be indicative of good condition.

Stream Habitat: Trends Over Time at DMA Sites

Because mixed models require large sample sizes to run, we could not use mixed models to evaluate changes in habitat condition measures at DMA sites. We evaluate changes at DMA’s using a Wilcoxin Sign Test, which uses the direction and magnitude of change to determine significance. We report the mean of the habitat condition the first and last time each site was sampled, the % difference in the mean, the number of changes in each direction (negative, positive, and none), and the p-value. A p-value less than 0.10 indicates that the change was significant.

Evaluating Status Using Habitat Index Score

To determine whether habitat conditions are being maintained or improved throughout the study area, we analyze patterns over time, or “trends”. However, to determine how habitat conditions at managed sites compare to conditions at reference sites, we analyze current conditions or “status”. We can evaluate status for particular portions of the study area (e.g.) National Forests or watersheds. During 2012, we refined methods for evaluating status of habitat condition using the habitat index score (Al Chokhachy et al. 2010).

The habitat index approach evaluates measures of habitat condition that have been shown to be most responsive to management activities and that show low sampling variation based on repeat-sampling within a year. These measures residual pool depth, pool percent, percent fines, $D_{50}$, bank angle, and wood frequency. Linear regression techniques are used to develop an equation to predict each aspect of habitat condition at reference sites from climate, landscape, and geomorphic covariates. By controlling for these factors, we remove variation that is not related to management. We then compare the value predicted to that actually measured at each managed and reference site. If the predicted value is the same as expected, the site scores a 5. Otherwise, the site scores a value from 0-10 depending on how it compares to what is expected at reference sites. For instance, an increase in residual pool depth is generally considered to be an improvement in habitat condition. If the actual value of residual pool depth is similar to the maximum observed at reference sites, than the site scores a 10. If the actual value is lower than predicted at any reference site, the score is a 0. If it is exactly
what would be expected at a reference site, it scores a 5. Therefore, the score depends on what is expected at reference sites. In the case of residual pool depth, a 0 means that the site had much lower residual pool depth than observed at any reference site, and 10 meaning it has a residual pool depth equal to or higher than any reference site. A final index is developed by adding the individual index scores (each ranging from 0-10) and then rescaling to 100, with 100 being the highest possible score.

To determine how status of a forest of watershed differs from reference conditions, we compare the average index score within a forest or watershed to that of reference sites in that same area, or in the surrounding eco-region. If the score is opposite of what we expect based on reference conditions, we determine that that specific habitat condition is potentially impaired due to management. We determine whether conditions are significantly different using 10% confidence intervals. The benefit of this approach is that it considers the overall distribution of scores to determine status. One or several sites may be different from reference conditions by chance, but if the average of all sites in an area are different from reference conditions than it is more likely that this is due to management.

During 2012, we evaluated status for a number of national forests and watersheds throughout the study area, including the Nez Perce National Forest and John Day subbasin. In this report, we provide examples of status evaluation that we completed for the Lochsa and South Fork Clearwater subbasins. We used box plots to compare index scores at managed sites in each sub subbasin to those at reference sites in the subbasin, reference sites in the Nez Perce National Forest, and reference sites in the entire PIBO EM study area. We also used histograms to compare the distribution of scores at managed sites sampled by PIBO EM. We used the most recent sampling event from each site in order to evaluate current status. We also evaluated trends within each subbasin using the Wilcoxin Sign Test. Similar valuations for National Forests and watersheds are available upon request by contacting our office.

RESULTS

Stream Habitat: Trends Over Time: Integrator Sites (Figures 3-10; Table 2)

If stream habitat condition is improving, we would expect a positive trend in residual pool depth, pool percent, percent undercut banks, bank stability, wood frequency, and $D_{50}$. We would expect a negative trend in bank angle and % Fines. For further information on why these trends are expected, refer to Kershner et al. 2004b.

At reference sites, we observed a positive trend for residual pool depth, wood frequency, bank stability, percent fines, and percent undercut banks. We observed a
negative trend for pool percent, \( D_{50} \) and bank angle (Table 2).

For managed sites, we observed a positive trend in residual pool depth, wood frequency, percent undercut, bank stability, and bank angle. We observed a negative trend in pool percent, and \( D_{50} \). There is some evidence that \( D_{50} \) is declining faster at reference sites than at managed sites based on the magnitude of the trend and managed and reference sites. However, this difference in trend could not be detected statistically. There is no significant trend in percent fines at managed sites (Table 2).

These results are similar to reported trends in the 2011 report. However, whereas we were previously not able to detect a significant increasing trend for residual pool depth at managed sites, we can now detect this trend. We can also now detect a negative trend in pool percent at managed sites as well as reference sites, a negative trend in \( D_{50} \) at both managed and reference sites, and positive trends in large wood frequency at both managed and reference sites. Figures 3-10 found below show the trends in both reference and managed sites for each attribute while Table 2 summarizes the results of this trend analysis.

Although some aspects of habitat condition at managed sites were different than we would expect if conditions were improving (pool percent, \( D_{50} \), and bank angle), the fact that similar trends were observed at reference sites indicates that these changes may not be management-related. For instance, they may be related to changes in climate, fire regime or other broad scale perturbations over time.
Figure 3. Changes in mean residual pool depth over time for each management type.

Figure 4. Changes in mean pool percent over time for each management type.
Figure 5. Changes in mean bank angle over time for each management type.

Figure 6. Changes in mean $D_{50}$ over time for each management type.
Figure 7. Changes in mean percent fines over time for each management type.

Figure 8. Changes in mean wood frequency over time for each management type.
Figure 9. Changes in mean percent undercut over time at managed and reference sites.

Figure 10. Changes in mean bank stability over time at managed and reference sites.
Table 2. Desired and actual trends for managed and reference integrator sites in PIBO study area. A 0 indicates no statistically significant trend.

<table>
<thead>
<tr>
<th></th>
<th>Desired Trend</th>
<th>Managed Trend</th>
<th>Reference Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual Pool</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Depth</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pool Percent</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wood Frequency</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bank Angle</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>D₅₀</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>% Fines &lt; 6 mm</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Bank Stability</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Percent Undercut</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Macroinvertebrate Condition at Integrator Sites (Figure 11)

Our results indicated that the RIVPACS score, a score of macroinvertebrate health, is increasing at managed and reference sites. This report and the 2011 report demonstrates a larger difference in RIVPACS scores for managed and reference sites than was reported in the 2009 annual report. The RIVPACS scores in this report are based on expected values collected at a greater number of sites compared to the prior annual report and can be considered to better represent the health of macroinvertebrates compared to expected conditions.

Figure 11. Changes in RIVPACS macroinvertebrate score (O/E) for each management type.
At DMA sites, we documented that bank stability and wood frequency exhibited significant positive changes; this would indicate improvements in habitat condition at many of the sites. Pool percent exhibited a significant negative change. All other habitat attributes exhibited no significant change between the first time each DMA site was sampled and the last time each site was sampled. Prior to 2010, only integrator sites were sampled for wood frequency and D_{50}; therefore, we have a low sample size for these attributes. DMA sites are now sampled for these surrogates of habitat condition, which will allow us to better evaluate them at DMA's in the future.

Table 3. Direction and significance of change in habitat condition at DMA sites. The significant changes included an increase in bank stability, an increase in large wood frequency, and a decrease in pool percent, all of which are indicative of potential improvements in habitat condition. A p-value < 0.10 indicates significant change.

<table>
<thead>
<tr>
<th>habitat condition</th>
<th>desired direction</th>
<th>mean-1st time sampled</th>
<th>mean-2nd time sampled</th>
<th>difference</th>
<th>no. negative change</th>
<th>no. positive change</th>
<th>no. no change</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Stability</td>
<td>+</td>
<td>93.26</td>
<td>96.03</td>
<td>3</td>
<td>97</td>
<td>131</td>
<td>51</td>
<td>0.001</td>
</tr>
<tr>
<td>% Undercut Banks</td>
<td>+</td>
<td>23.13</td>
<td>24.29</td>
<td>5.1</td>
<td>120</td>
<td>143</td>
<td>16</td>
<td>0.167</td>
</tr>
<tr>
<td>Bank Angle</td>
<td>-</td>
<td>118.02</td>
<td>117.99</td>
<td>0</td>
<td>131</td>
<td>140</td>
<td>8</td>
<td>0.839</td>
</tr>
<tr>
<td>Large Wood Frequency</td>
<td>+</td>
<td>56.84</td>
<td>72.43</td>
<td>27.4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0.068</td>
</tr>
<tr>
<td>D50 (m)</td>
<td>+</td>
<td>0.02</td>
<td>0.03</td>
<td>18.9</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0.18</td>
</tr>
<tr>
<td>Residual Pool Depth</td>
<td>+</td>
<td>0.25</td>
<td>0.26</td>
<td>4.3</td>
<td>23</td>
<td>29</td>
<td>5</td>
<td>0.293</td>
</tr>
<tr>
<td>Pool Percent</td>
<td>+</td>
<td>41.24</td>
<td>32.17</td>
<td>-22</td>
<td>43</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Example: Evaluating Status Using Habitat Index Scores

**Lochsa (Figures 12a-12g)**

Our findings indicate that habitat complexity in the Lochsa is similar between managed sites and reference sites in the local study area and across the entire Interior Columbia River Basin (Figures 12-18). One exception was for pool percent where the distribution of the managed sites was skewed better than at reference watersheds. In particular, the managed sites in the Lochsa subbasin scored much higher for pool percent than the reference sites in the Lochsa subbasin, the Nez Perce/Clearwater study area, and all of PIBO. The % Fines and D_{50} indices exhibited much larger variation for reference sites in the Lochsa subbasin compared to managed sites in the Lochsa subbasin.
Overall, results indicate that individual aspects of habitat condition in the Lochsa subbasin are either staying the same or getting better based on results of a Wilcoxon Sign test (Table 4). We documented significant increases in large wood frequency, significant decreases in bank angle, and significant increases in % undercut banks. We observed no significant change in pool fines < 6mm, pool percent, D$_{50}$, or bank stability.

![Boxplot](image)

Figure 12a. Boxplots illustrating that residual pool depth index was similar in managed and reference sites.

![Density plot](image)

Figure12b. Histogram illustrating that the distribution of managed sites was similar to reference sites for residual pool depth index.
Figure 13a. Boxplots illustrating that pool percent index was higher at managed sites than at comparable reference sites.

Figure 13b. Histogram illustrating that the distribution of pool percent index scores was similar or skewed to the right compared to reference conditions.
Figure 14a. The $D_{50}$ index was similar to that of reference sites in the study area and in all of PIBO.

Figure 14b. Histogram illustrating that the distribution of $D_{50}$ index was similar between managed and reference sites, although some managed sites had a low $D_{50}$ index score.
Figure 15a. The index score for pool fines was similar between managed and reference sites, but reference sites exhibited a wider range of values for pool fines.

Figure 15b. The percent fines index varied widely across managed sites as illustrated by a histogram, but generally had a similar distribution to reference sites.
Figure 16a. The wood frequency index at managed sites had a similar distribution to that estimated at reference sites.

Figure 16b. A histogram further indicated that the distribution of wood frequency index scores at managed sites was similar to that at reference sites.
Figure 17a. We found no significant difference between the average bank angle at managed and reference sites in the local area (i.e. National Forest) or in the entire study area. However, reference sites in the subbasin exhibited a wider range of bank angles than at managed sites.

Figure 17b. A histogram showed that the distribution of bank angle index varied widely but was similar to that at managed sites.
Figure 18a. The final index also showed high overlap in scores measured between managed and reference sites.

Figure 18b. The distribution of scores also indicates high overlap between managed and reference sites, with most sites scoring near 50, which is similar to average reference conditions.
Table 4. Change in habitat condition for managed sites in the Lochsa subbasin.

<table>
<thead>
<tr>
<th>Type</th>
<th>mean 1st sampling</th>
<th>mean 2nd sampling</th>
<th>percent difference</th>
<th>desired direction</th>
<th>no. negative change</th>
<th>no. positive change</th>
<th>no. no change</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Stability</td>
<td>95.26</td>
<td>96.2</td>
<td>1</td>
<td>+</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>0.594</td>
</tr>
<tr>
<td>Percent Undercut</td>
<td>30.81</td>
<td>43.72</td>
<td>41.9</td>
<td>+</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>0.008</td>
</tr>
<tr>
<td>Bank Angle</td>
<td>108.5</td>
<td>99.33</td>
<td>-8.4</td>
<td>-</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0.021</td>
</tr>
<tr>
<td>Large Wood Frequency (pieces/km)</td>
<td>269.1</td>
<td>337.86</td>
<td>25.5</td>
<td>+</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>D50 (m)</td>
<td>0.06</td>
<td>0.07</td>
<td>15.5</td>
<td>+</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>0.721</td>
</tr>
<tr>
<td>Percent Fines</td>
<td>22.31</td>
<td>19.39</td>
<td>-13.1</td>
<td>-</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>0.272</td>
</tr>
<tr>
<td>Residual Pool Depth (m)</td>
<td>0.42</td>
<td>0.37</td>
<td>-12.1</td>
<td>+</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>0.169</td>
</tr>
<tr>
<td>Pool Percent</td>
<td>44.64</td>
<td>42.4</td>
<td>-5</td>
<td>+</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>0.374</td>
</tr>
</tbody>
</table>

**South Fork Clearwater (Figures 19-25)**
We found that both sediment and channel morphology (percent pool, residual pool depth, \(D_{50}\), percent fines) at managed sites were different than what would be expected across all PIBO reference sites. We found wood counts to be comparable to reference sites in all of PIBO and in the local area. We also found bank angle to be comparable to reference sites in the local area and in all of PIBO. Overall we saw a substantial shift in the distribution of index scores compared to reference conditions (Figures 19-25). These results do not confirm that the shift is related to management but suggest that further investigation is needed to determine what factors are causing patterns to be different than reference conditions.

Despite these lower than expected values for habitat condition, we documented all aspects of habitat condition have either remained constant or have improved between the first time the site was sampled by PIBO and the last time (Table 5). For instance, we documented that pool tail fines has decreased at a significant number of sites and that residual pool depth has increased at a significant number of sites. We also observed significant increases in median streambed substrate size (\(D_{50}\)) and percent of the stream with undercut banks. We observed no significant change in large wood frequency, bank angle, pool percent, or bank stability. These results indicate that, despite the lower overall habitat complexity at South Fork Clearwater River sites, the status of habitat complexity has been improving over time. These improved conditions
likely represent a combination of active and passive restoration on public lands within the basin.

Figure 19a. Results show that residual pool depth index at managed sites in the South Fork Clearwater is typically lower than at reference sites.

Figure 19b. A histogram further illustrates that many managed sites scored lower for residual pool depth index than at reference sites sampled by PIBO EM.
Figure 20a. Results show that pool percent index at managed sites in the South Fork Clearwater is typically lower than at reference sites.

Figure 20b. A histogram further illustrates that many managed sites scored lower for pool percent index than at reference sites sampled by PIBO-EM.
Figure 21a. Results show that $D_{50}$ index at managed sites in the South Fork Clearwater was similar to at reference sites.

Figure 21b. A histogram further illustrates that many managed sites scored similar for $D_{50}$ index compared to reference sites sampled by PIBO-EM.
Figure 22a. Results show that % fines index at managed sites in the South Fork Clearwater was similar to at reference sites.

Figure 22b. A histogram further illustrates that the distribution of % fines index at managed sites was similar to that at reference sites sampled by PIBO-EMP.
Figure 23a. Results show that wood frequency index at managed sites in the South Fork Clearwater was similar to at reference sites.

Figure 23b. A histogram further illustrates that the distribution of wood frequency index at managed sites was similar to reference sites sampled by PIBO-EM.
Figure 24a. Results show that the bank angle index score at managed sites in the South Fork Clearwater was lower than at reference sites in the South Fork Clearwater subbasin but similar to other reference sites in the National Forest and reference sites sampled by PIBO EM.

Figure 24b. A histogram further illustrates that many managed sites had similar bank angle index scores to reference sites sampled by PIBO EM.
Figure 25a. Results show that the final index score at managed sites in the South Fork Clearwater is typically lower than at reference sites.

Figure 25b. Histogram results also show that final index at managed sites in the South Fork Clearwater is typically lower than at reference sites.
Table 5. Change in habitat condition for managed sites in the South Fork Clearwater subbasin.

<table>
<thead>
<tr>
<th>type</th>
<th>mean 1st sampling</th>
<th>mean 2nd sampling</th>
<th>percent difference</th>
<th>desired direction</th>
<th>no. negative change</th>
<th>no. positive change</th>
<th>no. no change</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Stability</td>
<td>98.82</td>
<td>99.22</td>
<td>0.4</td>
<td>+</td>
<td>4</td>
<td>7</td>
<td>10</td>
<td>0.503</td>
</tr>
<tr>
<td>Percent Undercut</td>
<td>32.24</td>
<td>38.03</td>
<td>18</td>
<td>+</td>
<td>8</td>
<td>13</td>
<td>0</td>
<td>0.085</td>
</tr>
<tr>
<td>Bank Angle</td>
<td>108.14</td>
<td>106</td>
<td>-2</td>
<td>-</td>
<td>11</td>
<td>9</td>
<td>1</td>
<td>0.55</td>
</tr>
<tr>
<td>Large Wood Frequency (pieces/km)</td>
<td>255.68</td>
<td>290.32</td>
<td>13.5</td>
<td>+</td>
<td>8</td>
<td>12</td>
<td>0</td>
<td>0.279</td>
</tr>
<tr>
<td>D50 (m)</td>
<td>0.04</td>
<td>0.05</td>
<td>13.6</td>
<td>+</td>
<td>5</td>
<td>16</td>
<td>0</td>
<td>0.017</td>
</tr>
<tr>
<td>Percent Fines</td>
<td>23.95</td>
<td>18.37</td>
<td>-23.3</td>
<td>-</td>
<td>12</td>
<td>8</td>
<td>0</td>
<td>0.067</td>
</tr>
<tr>
<td>Residual Pool Depth (m)</td>
<td>0.34</td>
<td>0.39</td>
<td>13.8</td>
<td>+</td>
<td>4</td>
<td>15</td>
<td>2</td>
<td>0.007</td>
</tr>
<tr>
<td>Pool Percent</td>
<td>46.14</td>
<td>42.85</td>
<td>-7.1</td>
<td>+</td>
<td>10</td>
<td>11</td>
<td>0</td>
<td>0.59</td>
</tr>
</tbody>
</table>

**PREVIOUS PIBO ACCOMPLISHMENTS (publications, before 2010)**


**SUMMARIZED DATA**

Summarized data collected by the PIBO EM program are available for download using instructions provided on our PIBO Webpage or by contacting our office. The following
data are available.

1. **Stream Habitat**: All integrator and DMA reaches sampled are included (fewer attributes are measured / reported for DMAs).

2. **Riparian Vegetation**: All integrator and DMA reaches sampled are included.

3. **Weeds**: All integrator and DMA reaches sampled are included.

4. **Stream Temperatures**: All reaches with temperature data are reported.

5. **Macroinvertebrates**: All reaches with macroinvertebrate data are reported. Data from 2012 are not presented because these samples have not been classified at this time.

- Each data type 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 webpage.

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.
REFERENCES


