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Metrics Review

Review of Project Reporting Metrics for the Columbia River Basin Fish and Wildlife Program

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ISRP Metrics Review

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Introduction

In a March 19, 2008 memo, the Northwest Power and Conservation Council (Council) asked the Independent Scientific Review Panel (ISRP) to conduct a review of metrics that are used for reporting actions on fish and wildlife projects. In past project reviews and reports, the ISRP has identified the need for improved reporting (see ISRP 2007-1[1]). In fact, the ISRP has had difficulty assessing the biological and physical results of prior year expenditures because the information was not readily available across most projects. The Council's stated purpose of this effort is to develop reporting metrics that can be specified for the projects before contracting, so there is no uncertainty about the monitoring information required.

To aid in the review and to provide the ISRP a sample of what the Council was looking for in metrics, the Council staff compiled metrics contained in various reports, including some by the ISRP and Independent Scientific Advisory Board (ISAB). Many of these metrics were from Bonneville Power Administration's Pisces project tracking database.[2] Metrics were provided under the following categories: artificial production and supplementation projects, aquatic habitat restoration projects, and wildlife monitoring. The Council asked the ISRP to provide a prioritized list of metrics for each of the different types of projects. The Council envisioned that reporting of these metrics by project sponsors should allow the ISRP to more effectively evaluate all project results, as specified in the amendment to the Power Act. The Council stated that the ranking should ensure that the most important metrics have the highest priority of being funded.

In addition, the Council asked the ISRP to answer the following questions:

1. Does the attached list of metrics for various categories represent the current thinking of the ISRP, and if not, which should be added, deleted, or modified?

2. Based on the results of question 1, what is the priority of acquiring and reporting these metrics for various categories?

3. Can the ISRP distinguish between implementation metrics to be required of all projects (depending on project type), and effectiveness metrics, which would apply to a narrower set of more intensively monitored projects?

With respect to Questions 1 and 2, the ISRP felt the list of metrics provided to us would provide valuable information for reporting project results. Some of the metrics in the Pisces tracking database are general in nature. Because of this we have added text in the tables presented below that gives detailed descriptions of what should be measured and

[1] ISRP 2006 Retrospective Report (March 1, 2007): www.nwcouncil.org/library/isrp/isrp2007-1.htm
[2] See BPA's Report Center: www.efw.bpa.gov/IntegratedFWP/reportcenter.aspx

why the measurements are important. We were, however, reluctant to delete any metric because we were unable to envision situations where we could state with absolute confidence that the information in the metric would not be of some value. We have added and embellished some metrics in the tables below to give project sponsors a better understanding of the type of monitoring information that would be useful. Nevertheless, we do not rank the metrics in priority order because each project will be somewhat unique and a blanket prioritization of metrics, even by project type, seemed inappropriate. If obtained and interpreted properly, each of the metrics in the tables will contribute to our understanding of the success of the Fish and Wildlife Program. The ISRP sees metrics development as an evolving effort, and the ISRP welcomes an ongoing dialogue to fine-tune the metrics in response to feedback on their use.

With respect to Question 3, the ISRP continues to believe that for habitat restoration projects some level of effectiveness monitoring should be carried out. We feel that *habitat* effectiveness metrics for these types of projects should not necessarily be confined to intensively monitored watersheds (IMWs), and in fact many such metrics are relatively inexpensive and easy to obtain. However, we recognize that *biological* effectiveness metrics for habitat projects are more expensive to measure and are more appropriate for intensively monitored watershed situations.

The ISRP emphasizes that data collection can be conducted by other M&E projects or programs, but results should be reported by individual project managers responsible for implementation of particular tasks relevant to the project of interest. While we provide a suite of metrics, not all are required for every project in a particular category. The metrics selected for monitoring should be designed and justified to track progress in meeting a specific project's objectives.

We also briefly discuss the relationship between implementation and effectiveness monitoring metrics to High Level Indicators (HLIs) that are being developed to serve as subbasin and program effectiveness measures for reporting to the Governors and Congress.

Finally, the ISRP has long believed that many restoration projects have not adequately reported their results and lessons learned, and this is particularly true for some projects that have spanned a decade or more. Monitoring and evaluation procedures deserve to be more than an afterthought in project plans. The metrics suggested below for reporting results should be considered at the outset of any new project and considered for inclusion in ongoing projects where monitoring and evaluation are deficient. Where several priority metrics are listed for a particular project type, we do not believe it is necessary to measure all of them for any given project. However, the Fish and Wildlife Program as a whole will benefit from improvement in the collection and analysis of effectiveness metrics.

Priority Reporting for Hatchery Projects

The ISAB (ISAB 2000-4[3]) identified that metrics were needed to evaluate three aspects of artificial production: 1) the performance of the fish in the hatchery, 2) the performance of the fish in the natural environment, and 3) the effect of the released hatchery fish on the wild fish they were meant to supplement as well as other species in the natural environment. The implementation metrics in the following table reflect the ISAB recommendations on hatchery monitoring applied to the category of project task used in the BPA Pisces database that were identified in the Council staff example metrics.

For this metrics review, the ISRP reviewed ISAB 2000-4 and concluded that the suggestions for hatchery information reporting do represent the current thinking of the ISRP. In application to the Pisces task categories, the ISRP identifies a series of metrics that should be collected and the rationale for the metric. In most instances the ISRP believes these are essential elements for tracking the implementation of artificial production tasks, so they are given a high priority. Some of the metrics in the following table are straightforward reporting of what happened in a hatchery – clearly implementation monitoring and reporting. Other metrics are derived values (SARS, harvest, first year marine survival) that involve estimates of hatchery performance following release. These may be interpreted as either implementation or effectiveness monitoring data. As an example, the number of green eggs collected and fertilized and the number of eyed eggs from a particular spawning are essential implementation metrics. The proportion of green eggs that survive to be eyed eggs is an effectiveness metric, easily calculated from the implementation metrics, and should be reported by all projects involved in the task of spawning and incubating eggs. In the table below, some of the metrics under the "implementation metric" heading, therefore, may also be effectiveness metrics.

Pisces task categories are not the only way to organize the reporting. Another would be by program and stock. This is the organization approach used by the ISAB (ISAB 2000-4), the Council APRE Basin Level Report (Council 2004-17[4]), and the more recent Hatchery Scientific Review Group (HSRG) review. To establish a complete understanding of the outcome of an activity that involves more than one project, it will be essential to establish data reporting, analysis, and presentation that crosses the interface of these projects. As an example, in the Umatilla River, fish are captured and counted, hauled, and then spawned, fry reared, and released, by as many as four projects. For an adequate understanding and interpretation of the effectiveness of a program, the movement of fish as returning adults, spawned parents, incubating, reared, and released progeny, must be trackable.

[3] ISAB Recommendations for the Design of Hatchery Monitoring Programs and the Organization of Data Systems (October 3, 2000): www.nwcouncil.org/library/isab/isab2000-4.htm
[4] www.nwcouncil.org/library/2004/2004-17.htm

Priority Implementation Monitoring Metrics

These are adapted from Bonneville's Pisces project tracking database. For the implementation metric "identify purpose of production program" project sponsors should identify whether the program is supplementation, harvest augmentation, including put and take fisheries, and/or research, and identify whether the program is integrated or segregated.

Type of Artificial Production Work Element	**Implementation Metric**	**Rationale**
Trap and Haul	# of fish trapped (by species, size, date, marks, disposition of data) # of fish hauled (by species, size, date, marks) Identify whether trapping and hauling is upstream adults or downstream smolts	Direct measure of action. Simple counts of fish are inadequate. Information needs to be collected on each species that is trapped, and subdivided into age and size classes, marks, etc to be most useful for evaluation.
Acclimate Juvenile Fish	Identify purpose of production program	Self Identified categories enable evaluation by program type.
	# smolts released from the program, the dates of release, dates acclimation began, length of acclimation period. Explanation of how the # of smolts was estimated. Size of fish at beginning of acclimation, size at the end of acclimation.	Direct measure of restoration action. Easy to determine. Method of estimating numbers may be important in evaluation interpretation.
	Disease outbreaks	Direct measure of restoration action. Easy to measure.
	Mortality during acclimation	Direct measure of restoration action. Easy to determine.
Incubate Eggs	Identify purpose of production program	Direct measure of restoration action. Easy to determine.
	Identify species, egg size, stage of development when incubation began, incubation temperature, incubation period (days and temperature units), incubation dates	Direct measure of restoration action. Easy to determine.
	# green eggs, # eyed eggs, # ponded fry, identify method of enumeration	Direct measure of restoration action. Relatively easy to determine.
Rear Fish	Identify purpose of production program	Direct measure of restoration action. Easy to determine.
	Description of rearing unit (raceway, circular pond, etc)	Direct measure of restoration action. Easy to determine.
	Description of water source, volume, and essential water quality parameters (temperature, dissolved oxygen, pH)	Direct measure of restoration action. Easy to determine.
	• # of alevins ponded; • # of fry ponded; • #of presmolts ponded; • # of smolts ponded; • # of adults ponded For each include species/stock; size; dates in/dates out; rearing density; method of enumeration; # of fish out; size of fish out; feed conversation rates; loss to disease; description of disease outbreaks.	Direct measure of restoration action. Easy to determine.

Type of Artificial Production Work Element	**Implementation Metric**	**Rationale**
	# of fish released; species, size, age, condition, tag information, release location, release conditions (volitional versus direct, acclimation, etc) , proportion of triploid individual in the population if the program releases sterile fish	Direct measure of restoration action. Easy to determine.
Spawn Fish	Identify purpose of production program	Direct measure of restoration action. Relatively easy to determine.
	For each type of parent - female, male, and jack - measure number of parents, size of parents; age of parents; sampling statistics for estimation of size and age distribution; source of parents (hatchery versus wild – how that is determined, i.e. unambiguous marks or estimated from sampling); and identify whether parents returned to spawning site or were translocated.	Direct measure of restoration action. Easy to determine.
	Mating design	Direct measure of restoration action. Easy to determine.
	Number of eggs per female (mean and variance by female size/age); Size of eggs per female (mean and variance by female size/age); Explanation of sampling statistics	Direct measure of restoration action. Easy to determine.
	Spawning dates	Direct measure of restoration action. Easy to determine.
	Proportion of eggs fertilized (percent eyed eggs) Days and temperature units to eye-up Method of estimating proportion of eyed eggs	Direct measure of restoration action. Easy to determine.
	Days and temperature units to hatch	Direct measure of restoration action. Easy to determine.
	Proportion surviving to swim-up	Direct measure of restoration action. Easy to determine.
	Days and temperature units to swim-up Method of estimating proportion surviving to swim-up	Direct measure of restoration action. Easy to determine.
	Incubation method and conditions	Direct measure of restoration action. Easy to determine.
	Method of triploid induction	Direct measure of restoration action. Easy to determine.
Trap/Collect/Hold/ Transport Fish - Hatchery	Identify purpose of production program	Direct measure of restoration action. Easy to determine.
	# of hatchery eggs transferred; source and stock history information	Direct measure of restoration action. Easy to determine.
	# of eggs collected from streams; method of egg collection; number of redds sampled for eggs; stream information; sampling dates; transportation method	Direct measure of restoration action. Easy to determine.
	# of natural and hatchery juveniles transferred; method of transfer; identifying marks and tags; age and size of fish (presmolt, smolt); dates of transfer	Direct measure of restoration action. Easy to determine.

Type of Artificial Production Work Element	Implementation Metric	Rationale
	# of natural and hatchery adults trapped – species, sex, age, size, method of enumerating age and size; location of trap; dates trap operated; fish caught by date; disposition of fish	Direct measure of restoration action. Easy to determine.
Mark/Tag Animals	Identify purpose of production program	Direct measure of restoration action. Easy to determine.
	Species tagged	Direct measure of restoration action. Easy to determine.
	Size tagged	Direct measure of restoration action. Easy to determine.
	Tag type (PIT, CWT); and codes	Direct measure of restoration action. Easy to determine.
	Purpose of tagging	Direct measure of restoration action. Easy to determine.
	Total numbers of fish in release group	Direct measure of restoration action. Easy to determine.
	Numbers tagged in release group	Direct measure of restoration action. Easy to determine.
	Citations for tag recovery program	Direct measure of restoration action. Easy to determine.
	Reported tag recoveries – location, date, any fish size and age information	Direct measure of restoration action. Easy to determine.
	Survival estimates, population size estimates, harvest estimates, etc derived from the reported tag recoveries	Interpretation parameter estimations will serve as performance measures for effectiveness of several program components – harvest contributions, hydrosystem survival, transportation efficacy, ocean survival etc.
Produce Hatchery Fish	This work element includes the fish culture activities associated with a "typical" hatchery O&M contract: obtaining broodstock, spawning broodstock, incubating fertilized eggs, rearing juveniles, acclimating the juveniles offsite prior to release, and releasing the juveniles into a stream or lake, either onsite or from a separate acclimation facility. See above for the metrics associated with those work elements.	

Effectiveness Monitoring of Supplementation Projects[5]

Type of Supplementation Action	Implementation Metric	Monitoring Priority
Performance of the natural and hatchery fish in the natural environment	All the appropriate implementation metrics on hatchery rearing in the above table.	High
Performance of the natural and hatchery fish in the natural environment	Estimates of the number and proportion of natural and hatchery fish spawning in a particular population, by sex, and age	High – essential implementation and effectiveness monitoring data.
	Estimates of pre-spawning mortality	High to Moderate – provides important explanatory information. When combined with temperature data could be very relevant to climate change.
	Distribution of spawning population – partitioned into natural and hatchery parents where possible	High to Moderate – provides important explanatory information.
	Estimates of juvenile production by the mixed population	Moderate – establishes important understanding of habitat carrying capacity.
	Estimates of smolt production by the mixed population	Moderate – establishes important understanding of habitat carrying capacity.
	DNA based parentage analysis of progeny	High – Apply in select sites to provide understanding of mating patterns and relative reproductive success of different parent types for demographic and long-term fitness evaluations. Use in select sites for effectiveness evaluation.

[5] At the time of the preparation of this report an Ad Hoc Supplementation Work Group (AHSWG) sponsored by NOAA-Fisheries, CRITFC, and Council are completing an experimental design to evaluation the demographic benefit and long-term fitness consequences of supplementation. That report should be completed by July/August 2008. The essential features of that experimental design have been submitted as an amendment to the 2000 Fish and Wildlife Program. Once the draft AHSWG report is reviewed by the ISAB and finalized, the AHSWG report and design should be given consideration in developing supplementation effectiveness monitoring metrics for specific projects.

Effectiveness Monitoring of Harvest and Other Mitigation Hatchery Production Projects

In general, everything measured after fish are released contribute to effectiveness monitoring. Some of the metrics below are also presented above associated with Pisces work elements.

Type of Harvest/Mitigation Action	Implementation Metric	Monitoring Priority
Release juveniles	Survival, timing, and behavior during out-migration (this may apply as a metric for other categories of projects as well – for example hydrosystem and transportation).	Moderate – Information is needed on representative sampling of programs.
Adult Return	Passage efficiency, timing, and survival up river upon return from the ocean.	Moderate – Information is needed on representative sampling of programs.
	Genetic changes in allelic diversity and structure in both the hatchery and natural populations i.e. how is the artificial production program influencing the existing genetic structure of the natural population.	Moderate – Information is needed on representative sampling of programs.
	Stray rates into both local and non-local streams	High – Information is needed in locations where natural populations are a high priority.
	Life-history (e.g. age of maturation) and sex biases from propagation	Moderate – Information is needed on representative sampling of programs.
Harvest	Contributions to harvest	High – Information is needed on specific programs for Pacific Salmon Treaty and U.S. vs Oregon and other harvest management obligations.

Priority Reporting for Aquatic Habitat Projects

The Council and BPA are seeking to develop a list of metrics for habitat implementation monitoring (Was the project implemented as planned?) and effectiveness monitoring (Is the project achieving desired habitat and population benefits?). The ISRP examined the list of candidate habitat metrics from the Pisces project tracking database as well as some additional candidate metrics that can be used for monitoring project implementation and effectiveness. For each type of habitat improvement project in the Pisces tracking system, we list the recommended metric and a rationale for using that particular metric. The ISRP recognizes that the measures of implementation and effectiveness success differ for most project categories; i.e., there is no one-size-fits-all metric that will be useful for all, or even the majority of, habitat restoration efforts. Rather, most of the metrics (especially the implementation metrics) consist of reasonable measurements that can be accommodated in most project budgets. Even biological effectiveness monitoring metrics can be as simple as, for example, a chronological sequence of photographs documenting the recovery of streamside vegetation after a riparian fencing project.

Three habitat metrics tables are presented below. Although there is overlap between the items in the tables (particularly for the two implementation monitoring tables) and the distinction between them may be confusing, each table addresses a somewhat different aspect of habitat monitoring. The first table, **Implementation Monitoring Metrics,** lists all of the metrics currently used by project sponsors and BPA to quantify habitat improvement actions. These are all implementation monitoring measures from BPA's Pisces project tracking database. The ISRP was asked to assign priorities to these for use by project sponsors. We believe that these metrics, if applicable to a restoration project of interest, have a high or moderate-to-high priority and represent information that is likely to be useful for project tracking.

The second table, **Priority Metrics for Implementation Monitoring by Habitat Project Type,** has been adapted from previous ISRP reports and is meant to provide project sponsors with guidance when choosing implementation monitoring metrics appropriate to their project. This differs somewhat from the first table in that it reflects the ISRP's belief that project sponsors should have a reasonable choice in what they measure to document project implementation.

The third table, **Effectiveness Monitoring Metrics**, addresses the issue of selecting appropriate measures of habitat restoration effectiveness. The table also reflects the ISRP opinion that project managers should have some flexibility in what they choose to measure to document project effectiveness, and therefore more than one option is usually presented. In this table we distinguish between habitat effectiveness monitoring, which entails measuring the habitat changes that occur after the project is implemented, and biological effectiveness monitoring, which involves measuring the effects of the project on target species.

The ISRP emphasizes, as we did in our 2007 Retrospective Report,[6] that every habitat project merits some type of effectiveness monitoring plan in order to improve learning from our restoration experiences. That is, a habitat project should not be considered finished immediately following the completion of its implementation, but rather after some time (usually 1-3 years) has passed and the effects of the project on the target habitat or focal populations can be assessed. We realize that biological effectiveness monitoring is time-consuming and costly (and often best done within the context of an IMW-type study); therefore, we emphasize habitat improvement metrics for most effectiveness monitoring situations. We suggest that biological effectiveness monitoring for most project categories should be carefully coordinated with other agencies and stakeholders in the watershed of interest, and costs shared appropriately.

We acknowledge the need for high level indicators (HLIs) of habitat condition over large geographic scales such as watersheds and subbasins. HLIs are needed to track how well the Fish and Wildlife Program is working to restore habitat over the entire Columbia

[6] ISRP Retrospective Report 2007 (April 11, 2008): www.nwcouncil.org/library/isrp/isrp2008-4.htm

River Basin, and to provide metrics for reporting to Congress. The ISRP agrees that integrated, high level indicators of habitat condition would be very helpful; however, the metrics summarized below are focused on tracking project-level success and by themselves will be of limited use apart from summing up the implementation of different categories of habitat restoration (e.g., number of miles of fenced riparian areas). High level indicators of restoration effectiveness will involve large-scale measures of vegetation, land use, flow, and hydrologic connectivity, as well as multi-species indices of population health. This level of indicator goes beyond the aggregate effect of project level results. Examples of HLIs for the Columbia River can be found in some of the Interior Columbia Basin Ecosystem Management Project databases (www.icbemp.gov) developed by the federal land management agencies during the 1990s. The ISRP feels the issue of high level indicators is of sufficient importance that it deserves a special assignment from the Council, and could possibly include the ISAB as well. The metrics discussed below are limited to project-scale measures, except for some of the biological metrics, which are best assessed at watershed scales.

The following matrices summarize our recommendations for habitat implementation and effectiveness M&E. Some items pertain equally to fish and wildlife habitat projects.

Priority Implementation Monitoring Metrics

These types of habitat improvements (work elements) and metrics are from Bonneville's Pisces project tracking database.

Type of Habitat Improvement	**Implementation Metric**	**Rationale**
Develop Terrestrial Habitat Features	# of features	Direct measure of restoration action. Simple counts of habitat features such as nest boxes are easy to determine.
Install Fence	# of miles of fence	Direct measure of restoration action. Easy to determine.
Plant Native Vegetation	# of acres of planted; # of riparian miles treated	Direct measure of restoration action. Easy to determine. Can include counts of different tree species. Aerial photography can sometimes be used to track implementation success.
Weed Control	# of acres treated	Direct measure of restoration action. Easy to determine. Weed control agent(s) should be identified. Aerial photography can sometimes be used to track implementation success.
Practice No-till and Conservation Tillage Systems	# of acres treated	Direct measure of restoration action. Easy to determine.
Upland Erosion and Sedimentation Control	# of acres treated	Direct measure of restoration action. Easy to determine.
Increase Instream Habitat Complexity	# of stream miles treated; # of structures installed	Direct measure of restoration action. Easy to determine.
Realign, Connect, and/or Create Channel	# of stream miles before treatment; # of stream miles treated, including off-channels, after realignment; # of acres of new aquatic habitat created (if applicable)	Direct measure of restoration action. Relatively easy to determine.

Type of Habitat Improvement	Implementation Metric	Rationale
Decommission Road	# of road miles decommissioned	Direct measure of restoration action. Easy to determine.
Improve/Relocate Road	# of road miles improved, upgraded, or relocated. List of measures implemented in the project (e.g., side cast removal, culvert replacement, installation of cross drains)	Direct measure of restoration action. Easy to determine.
Remove invasive vegetation	# of acres treated	Direct measure of restoration action. Easy to determine. Control agent(s) should be identified.
Create, Restore, and/or Enhance Wetland	# of acres treated	Direct measure of restoration action. Easy to determine. The type of wetland should be specified (e.g., pond, marsh, etc.).
Install Fish Passage Structure	Estimated # of miles of habitat accessed	Direct measure of restoration action. May be somewhat difficult to determine unless there is a known blockage upstream that defines the upper limit of fish distribution. For the purposes of implementation monitoring, the amount of stream habitat potentially made accessible by the blockage removal could be estimated using maps.
Install Well and/or Pipeline	Amount of unprotected water flow returned to the stream by conservation in cubic feet per second as per the conservation agreement. The estimated # of miles of primary stream reach improvement is an effectiveness metric.	Direct measure of restoration action; however, quantifying the amount of water actually returned to a stream requires gauging, which may be beyond the technical capability of some land owners. Estimated return flows specified in the water agreement based on pump capacity and duration of well operation may be the only practical way to quantify implementation benefits. Actual measurement of instream flow enhancement constitutes effectiveness monitoring.
Remove/Install Diversion	Amount of water flow left in the stream in cubic feet per second as per the conservation agreement	Direct measure of restoration action. Determined by the water right foregone. Actual measurement of instream flow enhancement constitutes effectiveness monitoring.
Lease Land	# of acres of new lease; # of riparian miles protected	Direct measure of restoration action. Easy to determine.
Trap and Haul	# of fish, including species	Direct measure of restoration action. Relatively easy to determine.
Install Fish Screen	Quantity of water protected by screening, as determined by what is stated in the water right or calculated based on flow rate; Screen installed as per plans; thorough photo documentation of installed screen	Direct measure of restoration action. Easy to determine.
Remove/Modify Dam	Estimated # of miles of habitat accessed	Direct measure of restoration action. Somewhat difficult to determine unless there is a known blockage upstream from the dam that defines the upper limit of fish distribution.
Install Sprinkler	Amount of unprotected water flow returned to the stream by conservation in cubic feet per second as per the conservation agreement	Direct measure of restoration action; however, quantifying the amount of water actually returned to a stream requires gauging, which may be beyond the technical capability of some land owners. Estimated return flows specified in the water agreement based on pump capacity and duration of well operation may be the only practical way to quantify implementation benefits. Actual measurement of instream flow enhancement constitutes effectiveness monitoring.

Type of Habitat Improvement	Implementation Metric	Rationale
Restore Access to Floodplain	Estimated # of acres of potential floodplain habitat reconnected to river; # of new floodplain access points	Direct measure of restoration action; however, estimating the area inundated during floods will depend on flood magnitude. It may be easier to estimate the area that can be flooded after floodplain access is restored using 50-year flood projections.
Acquire Water Instream	Amount of water secured; flow of water returned to the stream as prescribed in the water acquisition as a percentage of the mean annual flow.	Direct measure of restoration action; however, quantifying the amount of water actually returned to a stream requires gauging, which may be beyond the technical capability of some land owners. Estimated return flows specified in the water agreement may be the only practical way to quantify implementation benefits. Actual measurement of instream flow enhancement constitutes effectiveness monitoring.
Remove Mine Tailings	# of acres treated; tons of tailings removed	Direct measure of restoration action. Relatively easy to determine. Quantifying the weight of tailings removed may require assumptions about weight-volume relationships.

Priority Metrics for Implementation Monitoring by Habitat Project Type

Project Type	Implementation Monitoring Priority Recommendations (at least one metric should be determined for each project)
Riparian fencing; riparian vegetation management	1. Measurements of miles of fence installed, acres of weeds or invasive plants treated, or acres planted with native vegetation. 2. Photo-documentation at pre-determined photo points to provide a basis for changes in the condition of the fence or riparian zone over time.
Erosion control	1. Measurements of the number of acres treated and the types of control measures employed. 2. Photo-documentation at pre-determined photo points of the erosion control treatments applied to a site. The photos should provide a representative sampling of the entire area treated and the range of conditions to which treatments were applied.
Stream habitat improvement; channel realignment; floodplain reconnection	1. Number of rearing habitat structures installed. 2. Length of stream receiving habitat treatments or channel bioengineering. 3. Number of floodplain access points; potential acres of floodplain reconnected with channel. 4. Estimated area of spawning habitat created or rehabilitated. 5. Photo-documentation of the stream or floodplain before and after treatment.
Water conservation (including water right acquisition); no-till or conservation tillage; improved irrigation systems (wells, pipelines, drip	1. Acres of land affected by the improved irrigation system. 2. Reduction in agricultural water withdrawals from streams or rivers – measured in cfs (cubic feet per second). 3. Amount of water conserved by installing well(s) – requires measurement of water yield from well in cfs.

Project Type	Implementation Monitoring Priority Recommendations (at least one metric should be determined for each project)
irrigation, reduced water consumption sprinklers)	4. Amount of water released to instream flow from water rights acquisition (while this is usually a theoretical figure, actual before and after stream discharge measurements are helpful). 5. Acres of land in no-till or conservation tillage practices.
Road improvement, relocation, or decommissioning	1. Miles of road decommissioned. 2. Miles of road relocated away from a riparian zone, floodplain, or unstable slope. 3. Number of road improvements implemented, e.g., # of water bars, ditch relief culverts, improved road crowns, and other sediment control measures. 4. Number of direct entry sediment points (ditches or culverts discharging directly to a stream channel) eliminated.
Fish passage improvement; road crossing replacement; dam removal; trap and haul	1. Photo-documentation of the site before and after treatment. 2. Documentation of steps taken to ensure that site is passable (include description of passability at different flows and by different species/life history stages). 3. In the case of trap and haul projects, the actual number and species of fish captured and relocated above a barrier.
Terrestrial habitat improvement; land leases	1. Number of acres treated or leased. 2. Number of habitat features installed or improved. 3. Photo-documentation of habitat features improved.

Effectiveness Monitoring Metrics

Project Type	Habitat Effectiveness Monitoring Recommendations (it is desirable that at least one metric should be determined for each project)	Biological Effectiveness Monitoring Recommendations (biological effectiveness monitoring should be coordinated according to the applicable subbasin plan or IMW study design)
Riparian fencing; riparian vegetation management	1. Measurements of changes in ground cover over time (several years, if possible). This can be carried out by standard vegetation survey methods such as transects or regularly spaced vegetation plots. Sampling locations should include the outer riparian zone as well as the streambank. Photopoints can be used if standard vegetation survey methods are not feasible. 2. Quantitative measurements of changes in riparian canopy density over time. This can be accomplished with canopy densiometers, fisheye photography coupled with computer analysis, or an array of light sensing	1. Surveys of plant mortality due to browse pressure. This includes monitoring to determine livestock grazing as well as browsing by wildlife (ungulates, rodents, and beaver). The surveys should examine plant mortality rates and, where possible, identify the causes of mortality. These causes might be due to browsing. But lack of water, disease, or other causes also might be important, depending on site conditions.

Project Type	Habitat Effectiveness Monitoring Recommendations (it is desirable that at least one metric should be determined for each project)	Biological Effectiveness Monitoring Recommendations (biological effectiveness monitoring should be coordinated according to the applicable subbasin plan or IMW study design)
	devices (e.g., PAR sensors). Whatever the method, measurements should be taken throughout the project area and be replicated over time periods sufficient to capture trends. It is assumed most of the monitoring will occur in summer when shade is most important to aquatic ecosystems. Temperature measurements should accompany shade measurements.	
Erosion control	1. Measurements of changes in ground cover over time (several years, if possible). This can be carried out by standard vegetation survey methods such as transects or regularly spaced vegetation plots. Photo documentation can be used if funding is insufficient for actual vegetation surveys. 2. Upstream-downstream and before-after comparisons of stream sedimentation at the project area. Turbidity measurements are much easier to analyze, but sufficient samples must be obtained to capture the range of turbidity variation, so automated samplers may be needed. Deposited sediment is much harder to sample and analyze (e.g., freeze coring), but surrogate measures (e.g., embeddedness) may reveal trends if large changes occur. 3. Measurements of surface erosion over time using sediment collection trenches, erosion pins, or some other erosion study method. This is a difficult undertaking because it is often hard to sample enough sites to be fully representative of the project area, so it is unlikely to be carried out in most cases. It is, however, the most direct method of determining surface erosion.	1. Stream macroinvertebrates have sometimes been used to assess habitat degradation, and there are sediment-specific macroinvertebrate metrics (e.g., extent of gill fouling on mayflies), but great care must be used to partition the effects of a sediment control project from other factors that may influence sediment quantity in the stream channel. Some of the more commonly-used macroinvertebrate metrics include RIVPACs and IBI.
Stream habitat improvement; channel realignment; floodplain reconnection	1. Inventory of stream habitat composition, preferably using a Before-After-Control-Impact (BACI) design. Above and/or below stream reaches may serve as control sites if they possess similar gradients and other geomorphic features in common with the treated reach. To establish the longevity of instream structures inventories should be repeated over several years or until a major channel-forming flood occurs.	1. Surveys of fish use of rehabilitated habitat in the project area, using techniques as quantitative as funding permits (this will range from electrofishing to snorkel counts, depending on conditions). Similar surveys should be carried out at control sites, using a BACI design where possible. 2. Depending on the location and extent of the stream habitat improvement project,

Project Type	Habitat Effectiveness Monitoring Recommendations (it is desirable that at least one metric should be determined for each project)	Biological Effectiveness Monitoring Recommendations (biological effectiveness monitoring should be coordinated according to the applicable subbasin plan or IMW study design)
	2. Where the goal is to increase channel sinuosity by realigning the channel, monitoring should track sinuosity over time to verify that desired changes have occurred and the stream has not reverted back to its former alignment. This can be done remotely (e.g., air photos). Where the goal is to reconnect the stream with its floodplain, measure the area of floodplain inundated at different flood stages and the time period flooded.	it might be possible to monitor the number of migrating adults and smolts, which can potentially provide a very powerful way of measuring productivity change. However, great care must be taken to ensure that adult spawning and smolt production occurred within the project reach, not somewhere else. In most cases, this can't be done unless the restoration treatment is applied to the entire available stream network. The alternative is to place permanent fish traps at the upstream and downstream boundary of the treated reach, but this often imposes maintenance problems and traps may occasionally fail. Generally speaking, it would be very difficult to assess the effect of a project implemented at the reach scale on smolt production or the abundance of returning adults. These metrics are influenced by factors not related to the project (especially for adults) and the interannual variation is typically so large that detecting any response would take many years of data collection. It is very important to understand how these metrics do respond to habitat restoration. However, this type of assessment requires an IMW type approach to have any realistic chance of success.
Water conservation (including water right acquisition); no-till or conservation tillage; improved irrigation systems (wells, pipelines, drip irrigation, reduced water consumption sprinklers)	1. Effectiveness monitoring should focus on two aspects of water conservation – the quantity of water added to instream flows as a result of the conservation action, and both the quality and quantity of water returned to the stream, if this is part of the project. Water quantity should be measured as directly as possible (instream discharge and, where applicable, careful measurements of return water volume) and related to the natural hydrograph of the drainage system, e.g., does the project increase summer low flows? The quality of agricultural return water should be monitored, including sediment, temperature, and agriculturally-related chemical concentrations (particularly nutrients, hormones, herbicides, and pesticides).	1. Fish condition and abundance within and downstream from the reach receiving the additional water can be monitored and compared to control (usually upstream) sites. Fish abundance should be monitored using techniques as quantitative as possible. Fish condition – a ratio of weight to length for specific species and age classes – can provide a surrogate measure of trophic conditions in the stream. 2. Water or tissue samples of fish downstream from agricultural return water sites can be monitored for chemicals that might interfere with survival, growth, or reproduction.
Road improvement, relocation, or decommissioning	1. Upstream-downstream and before-after comparisons of stream sedimentation at the project area. Turbidity measurements are much	1. Stream macroinvertebrates have sometimes been used to assess habitat degradation, and there are sediment-specific macroinvertebrate metrics (e.g.,

Project Type	Habitat Effectiveness Monitoring Recommendations (it is desirable that at least one metric should be determined for each project)	Biological Effectiveness Monitoring Recommendations (biological effectiveness monitoring should be coordinated according to the applicable subbasin plan or IMW study design)
	easier to analyze, but sufficient samples must be obtained to capture the range of turbidity variation, so automated samplers are often needed. Deposited sediment is much harder to sample and analyze (e.g., freeze coring), but surrogate measures (e.g., embeddedness) may reveal trends if large changes occur. 2. Because many road relocation projects aim to get roads out of riparian zones, post-treatment effectiveness monitoring should include surveys of riparian vegetation condition, re-establishment of secondary channels that were cut off by the old road, and reconnection of the stream with off-channel wetlands and other floodplain features that were formerly isolated. Such surveys need not be repeated in multiple years as long as the riparian zone remains intact.	extent of gill fouling on mayflies), but great care must be used to partition the effects of a sediment control project from other factors that may influence sediment quantity in the stream channel. Some of the more commonly-used macroinvertebrate metrics include RIVPACs and IBI. 2. Measurement of egg-fry survival rates may be appropriate in cases where improvement of spawning gravel quality is a project objective,
Fish passage improvement; road crossing replacement; dam removal; trap and haul	None	1. Actual surveys of fish use of the newly accessible section of stream. At a minimum, two or more foot surveys, or other appropriate survey method, of the reach upstream from the former barrier (one early in the spawning season; one late) to determine how far up in the watershed adults migrate. This should be repeated for several years to capture a range of flow conditions and adult abundances. 2. Where feasible, determine smolt production from the newly available habitat. This will facilitate a much better understanding of the productivity of the upper watershed and the long-term benefits of the barrier removal project (dividing smolts going out by brood-year adults coming in gives a crude but valuable ratio of smolt production per adult). This should only be attempted where accurate estimates of adults and smolts are possible.
Terrestrial habitat improvement; land leases	1. Effectiveness monitoring should include measures of the rate at which a site is returning to a desired condition. Quite often the focus will be on restoring a particular type of plant community, so survey techniques appropriate to plant assemblage succession should be used, such as	1. If the goal is to restore habitat for various wildlife species, direct census techniques (e.g., winter bird counts, pitfall traps for rodents, etc.) should be used.

Project Type	Habitat Effectiveness Monitoring Recommendations (it is desirable that at least one metric should be determined for each project)	Biological Effectiveness Monitoring Recommendations (biological effectiveness monitoring should be coordinated according to the applicable subbasin plan or IMW study design)
	permanent vegetation plots. 2. Remote sensing can be used to track changes in canopy cover, forest composition, and other potentially useful measures of landscape change. Although these techniques can be expensive (e.g., LiDAR), the cost can often be spread among several projects if they are in close proximity.	

Priority Reporting for Wildlife Projects

Most habitat enhancement actions for wildlife are covered in the categories below. Likewise, many of the routine M&E activities would fall into these categories in the sense that they should be supporting populations or particular resources required by populations of focal species.

Acquisition and reporting for wildlife has evolved based on the assumption that habitat is an acceptable surrogate for wildlife populations. This assumption underlies approaches using Habitat Evaluation Procedures (HEP), Habitat Units (HU), and Habitat Suitability Indices (HSI) as metrics for assigning credits to wildlife projects. While these procedures may have represented the state of the science underlying wildlife management when formulated decades ago, they are now seldom used by wildlife habitat researchers. Implementation of the Endangered Species Act has spurred evaluation of the "habitat as surrogate" concept and found it lacking, both biologically and legally. Given that BPA has committed to HEP and HUs for crediting against habitat losses, there are better strategies following acquisition and development of wildlife habitat projects to directly evaluate wildlife responses and determine if the Wildlife Program is meeting its biological objectives. The ISRP has stated that HEPs, HSIs, and HUs can provide a baseline crediting function as part of implementation tracking, but their use after that is questionable. Thus, these terms are not used below.

Priority Implementation Monitoring Metrics

Type of Wildlife Action (work element)	Implementation Metric	Rationale
Land acquisition	Type of acquisition (Fee Title, New Easement, Renewed Easement, Exchange, Lease, Mix)	Needed for current/future planning and budgeting
	Focal species/guilds to benefit	Basis for effectiveness monitoring and planning

Type of Wildlife Action (work element)	Implementation Metric	Rationale
	Area of current and anticipated habitat available for species of interest following project and anticipated use	Basis for effectiveness monitoring and planning
	Effective date of acquisition(PISCES reporting is Optional)	Needed for current/future planning
	End date of easement or lease (PISCES reporting is Optional)	Needed for current/future planning
	# of riparian miles protected to 0.01	Basis for effectiveness monitoring
	# of riparian acres protected to 0.1	Basis for effectiveness monitoring
	Start latitude of protected stream reach entered in decimal degrees to 0.000001 or GPS coordinates (PISCES reporting is Optional)	Integrate project with other spatial habitat and population data Planning
	End latitude of protected stream reach entered in decimal degrees to 0.000001, or GPS coordinates (PISCES reporting is Optional)	Integrate project with other spatial habitat and population data Planning
	Start longitude of protected stream reach entered in decimal degrees to 0.000001, or GPS coordinates (PISCES reporting is Optional)	Integrate project with other spatial habitat and population data Planning
	End longitude of protected stream reach entered in decimal degrees to 0.000001, or GPS coordinates (PISCES reporting is Optional)	Integrate project with other spatial habitat and population data Planning
	# of upland acres protected to 0.1	Basis for effectiveness monitoring
	# of wetland acres protected to 0.1	Basis for effectiveness monitoring
Produce Environmental Compliance Documentation	As required by Federal or State codes for stream channel alteration, species relocation, genetic modification, controlled burning or herbicide use.	Insure legal clearances and implementation Entry into relevant databases
Develop/modify water source	Focal species/guilds to benefit	As a basis for future monitoring
	Area of current and anticipated habitat available for species of interest following project and anticipated benefit to species (e.g. nesting, feeding)	As a basis for future monitoring
	All location data as above	For future monitoring and planning
	Water rights status	Protect resources and enter right into record Planning
Modify vegetation	Intent, acreage and location information as above	Basis for effectiveness monitoring Planning
Operate and Maintain Passage /Structure	Intent, location and acreage information as above	Basis for effectiveness monitoring Planning

Type of Wildlife Action (work element)	Implementation Metric	Rationale
Introduce new species, individuals of a species present or new genetic element within species (plant or animal)	Intent, location and acreage information as above. Number and source of individuals. Marking system. Population size (and/or pop. genetic characteristics) before and anticipated after project	Basis for effectiveness monitoring Planning
Remove individuals or populations	Intent, location and acreage information as above. Number, source and fate of individuals removed. Marking system (if used) Population size (and/or pop. genetic characteristics) before and anticipated after project	Basis for effectiveness monitoring Planning

Effectiveness Monitoring Metrics

There are two important situations to note regarding effectiveness monitoring of actions to benefit wildlife. First is the lag time before population level changes are usually apparent. Second, specific actions may only affect part of the habitat involved in a life stage or through the lifecycle of the target species, especially if the project is small in scope.

The time lag is one reason why indirect metrics or interim results such as number of acres of habitat restored are usually monitored instead of actual focal species population response. However, as a broader array of species is considered now than in the past, this may be less often the case. Populations of invertebrates, small mammals, and other species with short lifecycles may be easier to monitor than larger, longer lived game species. Time is still troublesome when most projects have a short lifespan during which even the most effective projects may yet to have had measurable effects on a population. An example would be controlling noxious weeds that compete with native vegetation needed for optimal nutritional support of early lactating herbivores. First, the weed must be successfully controlled, which can take several years, during which time desirable plants in the community may begin to respond. Several more good growing years may be needed until the plant community reaches the desired condition and could begin to impact herbivore condition. This sequence could easily take 10 years if all goes well. Bonneville has been able to offer longer funding periods than most sponsors. It is reasonable to fund monitoring beyond the action phase of a large or novel wildlife project. An alternative is to monitor “necessary but not sufficient” change – such as shifts in the plant community in the interim. Ideally, large scale population monitoring as discussed below would complement this level of monitoring. At some point, there should be a strong test of the hypothesis underlying the action. In the example above, it could be pre- and post-project fluid and tissue sampling of early lactating animals on the site or a comparable site from another study.

The spatial element is complex because a project may only impact part of the habitat used by a population within a life stage. All the other habitat and life stages also affect and probably distort the impacts of an individual project. One reasonable means to address this is monitoring the focal species within the habitat and life stage when the action is proposed to impact that species, for example, monitoring neotropical migrant bird nesting success in newly re-vegetated riparian zones. This would isolate the effects of the specific project from influences outside the project area. Where a population level response is expected across a wide area it makes more sense to participate in larger scale monitoring efforts. When a project plans to rely upon a larger scale effort, it is reasonable to expect that effort be underway and planned to continue until the project impact is anticipated. Evidence that such collaboration has been negotiated should be part of the project agreement. It should be clear that the scale and methods used in the larger effort will yield results that can be related to the proposed actions. Furthermore, the use of a similar reference area that is unaltered provides a means for measuring changes, especially in focal species' responses associated with habitat enhancement, whatever the time scale. The use of reference areas, when available, seems underappreciated in wildlife habitat monitoring.

Wildlife Effectiveness Monitoring Metrics Table. All the metrics in this table are high priority.

Type of Action	Metric
Land acquisition	Effect on focal species population(s), health, reproductive success, distribution, diet quality or whichever criteria are best determined to assess fitness of the focal species in this situation. Change in acreage of target habitat available.
Develop/modify water source	Effect on focal species population(s), health, distribution, diet quality or whichever criteria are best determined to assess fitness of the focal species in this situation. Amount and quality of water provided.
Modify vegetation	Change in vegetation community: seral stage, composition, structure and other relevant criteria. Number of acres effected and distance to other habitat elements required by focal species when using the land affected. Effect on focal species population(s), health, distribution, diet quality or whichever criteria are best determined to assess fitness of the focal species in this situation.
Operate and maintain passage/structure	Effect on focal species population(s), survival, genetic diversity, health, reproductive success, distribution, diet quality or whichever criteria are best determined to assess fitness of the focal species in this situation. Change in acreage of target habitat available during the period when structure would be used.
Introduce new species, individuals of a species present, or new genetic element within species (plant or animal)	Effect on focal species population(s), health, reproductive success, distribution, diet quality or selection, behavior, genetic diversity or whichever criteria are best determined to assess fitness of the focal species in this situation.
Remove individuals or populations	Effect on focal species population(s), health, reproductive success, distribution, diet quality or selection, behavior, or genetic diversity, whichever criteria are best determined to assess fitness of the focal species in this situation.