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# Abstract

The abstract should consist of one paragraph (up to 500 words) that concisely states why and (generally) how the study was done, as well as what the results were and what they mean. They should also include any lessons learned. The abstract should not simply outline the contents or present the methods in detail. Citations should not be presented in abstracts, and acronyms should be used sparingly. Detailed statistical results should be reserved for the main text. Because abstracts tend to be more widely read than complete papers, authors should make them concise, clear, and applied.

# Introduction

Ecological restoration projects have been initiated world-wide with the goal of recovering damaged or degraded ecological systems, increasing the resilience of biodiversity, and providing ecosystem services ([Wortley et al. 2013](#_ENREF_33)). Assessment of such projects is essential for improving their implementation and justifying their costs, but comprehensive monitoring and evaluation have rarely been incorporated into projects ([Suding 2011](#_ENREF_31)). The need for assessment of restoration activities conducted under the Albeni Falls Plan led to development of a monitoring plan for terrestrial ecosystems (AFIWG 2001). Monitoring under this plan was conducted by Eastern Washington University (EWU) for the Kalispel Tribe between 2002 and 2006 and then terminated because funding was stopped. A series of discussions amongst the members of the Upper Columbia United Tribes (UCUT), EWU, and BPA resulted in the development of a regional wildlife monitoring and evaluation program to assess ecological change on lands managed by the five member Tribes. Monitoring and evaluation are now recognized as essential components in the conduct of ecological restoration for projects and programs in the Columbia Basin by the ISAB ([2011](#_ENREF_20)). This is an important step forward, but requires that monitoring and evaluation be done appropriately ([Hallett 2013](#_ENREF_13)).

The approach adopted by the UCUT for ecological restoration on mitigation and tribal lands under their management is one of defining a reference condition and assessing the trajectory of degraded lands toward that condition. Once defined, the reference model describes the desired future condition ([Aronson et al. 1995](#_ENREF_2), [Clewell and Aronson 2007](#_ENREF_5)). The reference ecosystem provides a model for planning, implementing, and evaluating a restoration project ([Ruiz-Jaen and Aide 2005](#_ENREF_27)). The reference characterizes the desired physical environment, biological composition and structure, and flows of materials and organisms across the boundaries of the ecosystem to be restored. For the UCUT Wildlife Monitoring and Assessment Program (UWMEP), we characterized a minimum of three representative areas for each of eight habitat types to determine spatial variation. These areas were resampled for 3 yr to assess temporal variation. Our choice of reference model was pragmatic: examine the best examples of representative habitats that were available to us.

Objectives of ecological restoration include attainment of one or more ecological attributes ([Society for Ecological Restoration International Science & Policy Working Group 2004](#_ENREF_29)), but commonly also address social and cultural needs ([Hallett et al. 2013](#_ENREF_17)). Primary objectives of ecological restoration on damaged Tribal lands include return of native species composition and structure. For this reason, the monitoring program developed in partnership between UCUT and EWU has focused on evaluating species composition and structure for vegetation and terrestrial vertebrates. The monitoring program is open-ended and if appropriate and funding becomes available, other ecosystem components or processes can be added. UWMEP was developed to determine the effectiveness of management activities in returning damaged or degraded lands toward reference conditions. There program has a research component because of the need to evaluate our sampling approaches and methods for examining ecological change (Hallett and O’Connell 2013). A guide to our analytical approaches is being prepared for the next 3-year review in 2016. Because of the geographical extent of our monitoring and the expected lifespan of > 25 years, the UWMEP database will be useful for examining status and trends for some species.

Initial work to expand the Albeni Falls monitoring approach to a broader geographic region with a greater number of habitat types was conducted in 2008. Full sampling of new reference sites for four additional habitat types began in 2009 and sampling of mitigation lands was conducted between 2011 and 2014. Because ecological restoration activities are taking place across a broad geographical area and the sampling window is short, logistics dictated that we develop a 5-6 year sampling regime to include mitigation lands of all five Tribes. We will complete our first full sampling rotation in 2015.

In this report, we summarize the monitoring data collected through 2014. Then we consider aspects of the composition of the vegetation that can help guide management activities.

# Methods

## Monitoring locations

The Albeni Falls Work Group (2001) used a stratified-random sampling design to determine the location of points for monitoring. The protocol mapped a geo-referenced grid (200-m spacing) onto each mitigation property using GIS. Grid points were sequentially numbered and represented potential monitoring sample points on mitigation areas that could then be randomly selected by use of a random numbers generator. The 200-m spacing is equal to the preferred sample point separation for breeding bird point-count stations ([Huff et al. 2000](#_ENREF_4)), and yields one potential sample point for every 4 ha of habitat. Closer grid-point spacing would decrease the probability that data from adjacent sample points are independent and increase the risk of double counting birds when using point-count sampling techniques. Sites managed by the Kalispel Tribe were selected with this technique beginning in 2004. Although the minimum distance between sampling points was retained for all ownerships, we used some logistics criteria (e.g., distance to nearest road) to increase the number of sites that could be sampled.

A total of 25 reference sites have been established (Table 1). Completion of sampling on grassland-steppe is scheduled for 2015.

Figure 1. Locations of reference and permanent points on lands managed by the five Upper Columbia United Tribes. Reference sites were located on lands managed by BLM and Turnbull NWR.

Figure 2. Locations of permanent points sampled in 2014 on lands managed by the Kalispel Tribe. New sampling sites were located at Indian Creek (WA) and Big Meadows (ID).

Table 1. Reference sites sampled for eight habitat types. None of these sites were sampled in 2014.

Table 2. Habitats and number of sampling sites for mitigation units managed by the Kalispel Tribe. Complete sampling could not be conducted on the Big Meadows property north of Priest River because of agricultural activity.

## Vegetation sampling

Composition and structure of the vegetation are typically the first things to be addressed in terrestrial ecological restoration projects. In some cases, soil amendments or other changes to the physical environment might be necessary before this can proceed. Vegetation provides the template for inclusion and maintenance of wildlife species by directly providing requisites such as food, cover, perches, and nests, and indirectly through its effects on ecosystem functioning and microclimate. The goal of vegetation sampling was to collect comparative information on herbaceous vegetation, shrubs, and trees on both reference and mitigation points. Our methods for vegetation sampling have not yet been published at MonitoringMethods.org, but should be available there later in 2015. We summarize them here.

Frequency and percent cover of ground vegetation and substrate features were measured. Unless precluded by plant condition (e.g., seedling), all plants were identified to species. Ground vegetation and substrate were measured using a 20 x 50-cm plot placed at the center of each site point and on alternating sides of a 32-m transect radiating in each of the cardinal directions from the sampling point for a total of 33 plots. Species of herbaceous vegetation and substrate features (e.g., rock, litter) were recorded and assigned to 1 of 6 cover categories (Daubenmire 1959). The height (to nearest cm) of the tallest vegetation rooted in the plot was measured at three points along the midline of the plot frame. In tall marsh vegetation, the plot frame used is 3-sided (open on 1 of the 50-cm sides) to be able to slide the plot into the vegetation rather than placing over the vegetation. Instead of cover class, the number of stems of cattails and bulrushes were recorded. Plants were identified to species and their status as native, nonnative, and invasive were determined from the USDA database ([plants.usda.gov](http://plants.usda.gov/)).

Shrubs were measured along the same 32-m transects used for cover measurements. A 2-m belt was used and species and size (length x width x height) of each shrub were recorded. Number of trees by species and diameter at breast height (DBH) size class were recorded within 16 × 16-m plots centered on each reference or mitigation point in 6 size classes. Number of standing dead trees (i.e., snags) was recorded by size class and stage of decay.

## Vertebrate sampling

Full details of sampling procedures for larval amphibians, birds, and small mammals are available at MonitoringMethods.org ([Hallett and O'Connell 2013c](#_ENREF_3), [b](#_ENREF_2), [a](#_ENREF_1)).

Scientific collecting permits were approved by the Idaho Department of Fish and Game. Required annual reports were provided to both agencies in February 2015. Environmental compliance requirements of the Bonneville Power Administration were met. Approval by the Eastern Washington University Institutional Animal Care and Use Committee was renewed.

## Data analysis

Data summaries are available online and include metrics including species diversity and species richness (Appendix). In 2014, we began replacing SQL queries with R code (citation). We plan to implement additional analytical tools over the next 1-2 years to increase utility for managers. In this report, we used R to summarize sampling effort across years.

To better understand plant community composition, we examined data from 2002-2006 and 2009-2013 for plant species identified during cover sampling on 68 permanent (mitigation) sites and 25 reference sites. Because we were interested in general patterns of species composition, we included all sampling locations to look at the presence of nonnative species. We constructed frequency plots to examine the prevalence of non-native species and the proportion of noxious species. Using R (Version 3), we calculated a dissimilarity matrix using Chao-Jaccard values (Chao et al. 2005) based on the relative abundance of each plant species at each site. Non-metric multidimensional scaling (NMDS) was used to examine relationships among sampling sites with this matrix. We used a permutation test to perform an analysis of variance on the partitioned dissimilarity matrix (adonis in the vegan package for R).

# Results

## Sampling effort

The first full rotation for sampling of mitigation sites will be completed in 2015.

Table 3. Number of records obtained and number of species identified for each species group through 2014.

Field work was conducted from June through September 2014. Relative to previous years, we had very large sample sizes for amphibians and small mammals (Table 2). Full analysis of these data will be provided in our next annual report. Data summaries are now available online (see next section).

Add Table 2

## Plant species composition

We observed a total of 313 species from 53 plant families (n = 15,993 individual observations). Over 50% of all species were in eight families listed in decreasing order of abundance: Poaceae, Asteraceae, Cyperaceae, Fabaceae, Plantaginaceae, Ranunculaceae, Polygonaceae, and Rosaceae. Nonnative plants were represented by 85 species in 23 families with 5 families represented only by nonnative taxa (Fig. 3). Eighteen species in 7 families were classified as invasive.

Figure 3. Numbers of nonnative and invasive species in each family.

The incidence of nonnative plants in the species pool varied from 0 to 100% across all sampling units. The only sites without any nonnative plants were emergent wetlands dominated by cattails (*Typha latifolia*). Nonnative plant species comprised >25% of flora for most sites (Fig. 4). Over 50% of sites (n = 47) had >50% nonnative species. The proportion of nonnative species varied with habitat and geographical location (Fig. 5).

Figure 4. Distribution of sites relative to the contribution of nonnative plant species to the species pool.

Figure 5. Proportions of native and nonnative species for each habitat type and ownership.

# Discussion/Conclusion

Nonnative plants were observed on almost all reference and mitigation sites and for all habitat types. Very few sites had a species composition with <20% nonnative species and most had >50% (Fig. 4). Although infrequent in our dataset, some sites were entirely dominated by nonnative species such as *Phalaris arundinacea* (reed canarygrass). We did not anticipate such high proportions of nonnative species in the flora, and they reflect high levels of disturbance and degradation of many landscapes. Although there are many causes of degradation, intense grazing, overharvesting, and abandonment of agricultural fields were the dominant forces for most sites in our study.

Land degradation has significant consequences in terms of (1) loss of biodiversity; (2) reduction or loss of ecosystem services necessary for human health, food and water security, and culture; and (3) the strong relationship between poverty and degree of land degradation (Wortley et al. 2013). Our comparisons of mitigation sites undergoing ecological restoration with reference sites suggests that our strategies for restoration may have to be tailored to particular sites to a greater extent than currently practiced. The typically high variation in plant composition on mitigation sites means that the trajectories of these sites toward the reference condition are likely to differ. Because no single prescription for ecological restoration is likely to be successful at all locations for a given habitat, we believe that it is essential to monitor the changes following restoration activities to determine how the initial conditions (i.e., plant composition) determine the outcome. In some cases, small scale experiments might be preferred prior to initiating restoration.

A good discussion provides broad syntheses and stresses the relevance of the findings, including the benefit to fish and wildlife. Authors should indicate the importance of their work and how it relates to current knowledge. If issues during implementation of your work significantly impacted results, discuss those here. Please also highlight lessons learned from your project that could inform future RM&E work on a local and regional scale. Informed speculation is acceptable as long as it is clearly identified as such. Authors should avoid merely restating their results and/or (re)summarizing the literature. *For research and action effectiveness projects, please be sure to state whether hypotheses were accepted or rejected and whether your results addressed any critical uncertainties.*

# Adaptive Management & Lessons Learned

*In order to emphasize the application of results to management actions, adaptive management and lessons learned have been distinguished as a separate section from the Discussion/Conclusion section.*

Please explain how your results could be used by fish or wildlife managers to inform [program strategies](http://www.cbfish.org/ProgramStrategy.mvc/ProgramStrategiesIndex), including habitat restoration, predation, or hatchery and hydrosystem operations. Describe how your results could be applied at the watershed, subbasin, and Columbia Basin scale. Finally, please discuss how your results will be shared with other resource managers.

# Acknowledgements

Ray Entz, Matt Berger (Kalispel Tribe), provided support for work conducted on the lands under their management. Kristi Kimmet managed the field work and data entry. Adam Gebauer, Dylan Timmins, and Kim Quayle conducted much of the field work. Scott Price conducted the bird surveys. Funding was provided by the Bonneville Power Administration.

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Author(s) last name or Organization(s), Title, Publication Date, Publisher, Volume/Edition, Page #.

# Appendices

## A.1: Data sets or products:

All of the data collected between 2002 and 2014 are available in summarized form on the Geospatial Database Viewer created by the Kalispel Natural Resources Department (<http://gis.knrd.org/knrdgisviewer/>). The data viewer provides filters for restricting data to, for example, specific mitigation units or years, and displays the locations of sampling points. Data can be exported in summary form or raw data tables can be requested online.

Data tables are refreshed after field data have been examined and updated. This is usually several months after field work has been completed because of the time required to ensure correct species identification of plants and small mammals. The most recent implementation of the Geospatial Database Viewer now incorporates new data within 1 week from the time it is uploaded to our SQL database.

We have been working with the data consultants in charge of managing the Geospatial Database Viewer to increase the analytical tools available online. This year, the first of several stages was completed by incorporating the database extensions using the R programming language. As development proceeds, more informative summary tables, as well as additional tools for analysis and graphical display, will become available.