Systematic Review Pilot Project: Final Report

February, 2008

Prepared by:
Institute for Natural Resources
210 Strand Ag Hall Oregon State University
Corvallis, Oregon 97331

Table of Contents

Executive Summary

This report documents an Oregon Department of Forestry pilot project conducted through the Institute for Natural Resources at Oregon State University on a science synthesis method known as *systematic review*- a rigorous, transparent literature review technique developed and now widely used in clinical medicine. A systematic review focuses narrowly on a single question and uses an explicit protocol for finding, screening, grading and integrating all primary research relevant to that question.

Systematic review is now being explored as a means to collate scientific evidence in natural resource conservation. But natural resource management and science differ significantly from clinical medicine, and much remains to be learned about adapting systematic review techniques for use in conservation research.

ODF commissioned this project to learn more about applying systematic review to technical natural resource questions. The project investigated the feasibility of using systematic review techniques to locate and synthesize technical information regarding the effectiveness of the salmonid habitat restoration practice of placing of large wood into streams. A key question was whether the systematic review process could be simplified and used to credibly assess scientific research concerning a topic that is relevant to ODF and their stakeholders.

This report summarizes the project **process** and key lessons learned from testing systematic review in the context of natural resource science. A companion document- *"Does wood placement in Pacific northwestern North American streams affect salmonid abundance, growth, survival or habitat complexity? A pilot test of systematic review techniques"* covers findings of the review itself.

Key findings

- The power of a systematic review lies in its requirement that reviewers assess studies through the lens of a tightly focused review question. A systematically and objectively predetermined body of evidence is assessed for its applicability, quality and overall strength in regard to this narrowly targeted question.

- Successfully recruiting and supporting qualified reviewers may be the most significant barriers to getting credible, defensible systematic reviews accomplished in the natural resource fields.

- Despite some challenges in adapting systematic review techniques to the available evidence base, a relatively robust review was produced. The primary benefits of a documented search strategy and review methods might lie more with transparency and objectivity than with repeatability.

- An expert reference librarian improved the review by more efficiently and effectively aligning the question and search strategy with available reference database resources. A reference librarian should be involved early in the systematic review process.

- Experimental designs, study contexts and outcome measures differed among included studies, making them harder to compare than is normally the case for reviews in clinical medicine. Study alignment with the review question also varied.

- Judging each study on its own merits was relatively straightforward. But disparity in study alignment with the review question left the reviewers with no clear way to *rank* studies strictly in terms of quality or rigor.

- Reviewers used a decision tree to generate a composite "relevance" rating for each study. Emphasis was placed on the research question addressed by each study, followed by the type of experimental design and statistical analyses used.

- Even limited statements regarding the applicability and quality (relevance) of included studies added value to the review. Study summary tables help document how decisions were made regarding the validity and reliability of study findings.

- The overall body of evidence to support wood placement was somewhat unclear, with significant information gaps. Evidence was stronger for direct effects on habitat components than for effects on salmon numbers or survival.

- Involving stakeholders in question development and post-review discussions appeared to add credibility to the review. The collaborative nature of the review was also cited as a strength.

- All of the high relevance publications were located by the systematic search and not by ad hoc methods. Systematic reviews may help reduce perceptions that scientific literature is being selectively or incompletely incorporated into natural resource management.

- A systematic review can provide a tightly packaged set of information specific to the review question in a form that is usable by policy makers. This in turn helps foster a stronger, more defensible basis for policy decisions.

- Systematic reviews may also identify evidence gaps that restrict the ability to reach strong, unequivocal conclusions. By clarifying information needs regarding policy-relevant science questions, systematic reviews have potential to help focus and prioritize research agendas.

- Systematic review is only beginning to be used in the natural resource and conservation sciences. Institutional awareness, professional recognition and capacity for such work remains limited.

Review process

The review team consisted of two expert reviewers, a reference librarian, two ODF staff members and an INR review coordinator. Members of two stakeholder groups also provided input. The review process consisted of

- question identification and refinement
- reviewer recruitment
- developing the review protocol and search strategy
- stakeholder involvement
- finding, filtering and evaluating the evidence
- collating the evidence and writing the review
- a "lessons learned" workshop
- final project report

Question identification

In clinical medicine, a systematic review question is tightly focused on a particular treatment rather than open-ended about a general topic, relevant to medical policy or practice but answerable in scientific terms, and value-free to the extent possible. The intent of this project was to address a reasonable analog to this type of question from the field of forest ecosystem management. Within these constraints, ODF identified the topic of large wood placements to aid salmonids. Review team collaboration with stakeholder review resulted in the finalized review question: *Does instream wood placement affect salmonid abundance, growth, survival or habitat complexity?*

Reviewer recruitment

A defensible systematic review hinges on qualified reviewers- ideally, academic scientists in the field under which the review question falls who do not have a vested interest in review outcomes. But the synthesis work required to produce a good systematic review garners little professional recognition compared to original research- a disincentive for natural resource scientists to participate. Two excellent reviewers served in this project. But overall, reception to the idea of participating in the review was lukewarm at best among potential reviewers contacted. Successfully recruiting and supporting qualified reviewers may prove to be significant barriers to conducting systematic reviews in natural resources.

Protocol and search strategy

A systematic review starts with a written protocol that specifies review methods, including literature search strategy details. During protocol development, the reviewers suggested recruiting a reference librarian from Hatfield Marine Science Center. The reference librarian refined and executed a precisely documented literature search based on her familiarity with reference database structure and content, and test searches. Involving a reference librarian strengthens a systematic review in many ways - a key lesson learned from this project.

Stakeholder involvement

Stakeholder involvement helps assure that the review question is relevant to policy and practice, and promotes stakeholder "buy-in" and use of review results. Stakeholders with some technical background and interest in the review question from an environmental group and a timber products company were invited to comment on the review question and protocol, and to participate in a post-review workshop. The stakeholders agreed that the question was relevant and related to science rather than values. Their interests focused on ensuring that studies were evaluated objectively, outcome metrics, gray literature, and documenting the larger ecological context and use history of study areas.

Finding and filtering the evidence

The systematic search of references databases produced 457 publications. Due to a lack of standardized stream restoration keywords and the need to favor inclusiveness, most of these publications were not relevant to the review. A “coarse filter” excluded publications that did not: 1) address salmonids, or 2) address active placement of large wood. This reduced the set to about 65. Limited to peer-reviewed journal articles reporting on studies conducted in the Pacific northwest only, the final review included 22 publications. Review of 11 additional papers from outside the PNW indicated that including the larger body of international literature would not have significantly altered review conclusions.

Evaluating and collating the evidence

Each reviewer reviewed and summarized 50% of included studies. Independent reviews of four studies by both reviewers showed high consistency. To allow comparison among studies and provide transparency into assessments about their relevance and quality, a summary table showing details about study parameters was prepared for each. The reviewers used a decision tree to judge relevance of each study, created summary tables and graphics to characterize the studies, and documented important points to serve as a basis for integrating the evidence.

Systematic review methods forced reviewers to assess the findings of each study through a focused lens. Putting study details and conclusions in summary tables helped clarify studies with flaws or unclear findings. The overall body of evidence to support wood placement was unclear, with significant information gaps. Study variables such as season, life stage, topography, and species differed. Many studies were designed to answer a somewhat different question than the review question asked of the literature.

Unequivocal ranking of study “quality”- based on overall rigor of study design and execution- proved challenging due to the variable nature of the evidence. Reviewers used a decision tree to generate a composite “relevance” rating for each study. Study quality was only one of several factors considered. Even more limited statements regarding the quality/relevance/suitability of included studies added value and rigor to the review.

Review document and “lessons learned” workshop

The review coordinator, reviewers, reference librarian, ODF technical staff and the timber industry stakeholder representative attended a half-day “lessons learned” workshop. Discussion topics included the review process and what had been learned during the project about the review topic itself, and the feasibility of applying systematic review techniques to natural resource questions. ODF project review questions were addressed. Responses to those questions are provided in this document.

There are challenges associated with applying systematic review in the natural resource and conservation fields- especially with recruiting qualified reviewers. But the need for “best available science” to use in natural resource and environmental remediation policymaking is greater than ever. Systematic review shows promise, both for identifying and packaging scientific evidence, and for helping set science agendas to address critical knowledge gaps.

1. Purpose of this document

This document reports on the process of a pilot project on a science synthesis method known as *systematic review*. The project was commissioned by the Oregon Department of Forestry and conducted through the Institute for Natural Resources at Oregon State University. The project investigated the feasibility of using systematic review techniques to find, screen, assess and synthesize technical information regarding the effectiveness of large wood placement for stream restoration to improve salmonid habitat.

2. Introduction

Among the primary duties of the Oregon Department of Forestry (ODF) are regulation and oversight of forest practices and management of state forest lands. This work involves identifying, assessing and collating technical information about forest resources to use for policy and management decisions. Forest management stakeholders consistently agree that best available science should guide state forest management and forest practice rulemaking. But conflicts over what is, and is not "good" science and selective use of studies with different conclusions by competing interest groups continue to pose major challenges.

These conflicts point to a need for methods of synthesizing technical information in a way that will be more readily accepted as objective and definitive. One promising tool for this is called *systematic review*- a rigorous, transparent technique for reviewing technical literature developed and now widely used in the field of clinical medicine to assess all relevant evidence regarding the efficacy of particular surgical procedures or medications. A systematic review differs from a traditional literature review in its narrow focus on a single question and use of an explicit protocol for finding, screening, grading and integrating all primary research relevant to that question.

As its use in clinical medicine continues to grow, systematic review is now being explored as a means to collate scientific evidence in other disciplines such as natural resource conservation (Fazey et al. 2004, Pullin and Knight 2001). But natural resource management and the science upon which it is based differ significantly from clinical medicine, and much remains to be learned about adapting systematic review techniques for use in assessing ecological research.

In light of this knowledge gap, ODF commissioned a pilot project to learn more about applying systematic review to technical natural resource questions. Systematic reviews in medicine tend to be exhaustive, time consuming and expensive. The resources and capacities that state agencies such as ODF can bring to bear for reviewing science usually pale in comparison. So a key question was whether a simplified systematic review process could be used to assess scientific research concerning a topic that is relevant to ODF and their stakeholders.

3. Background

In June 2004, former Oregon Governor John Kitzhaber presented testimony to the

Oregon Board of Forestry (BOF) on a number of forest policy issues, including the problem of "dueling science". Dr. Kitzhaber introduced the systematic review process as defined and used in clinical medicine to rigorously evaluate evidence on treatment efficacy. He suggested that systematic reviews could be adapted and brought to bear on developing a credible evidence base for natural resource policy making.

The BOF subsequently added exploration of the systematic review process to the ODF State Forests Program work plan. ODF then contracted with the Institute for Natural Resources (INR) at Oregon State University to prepare a report on systematic reviews. The goal was to develop a small scale, practical systematic review-like approach that could be tested and adapted for use by ODF programs to objectively review and characterize technical information for decision making.

That report- *"Applying Systematic Evidence Reviews in Oregon Forest Policy: Opportunities and Challenges"* (INR 2005)- was completed in late 2005, with key findings presented to the BOF in early 2006. The INR report suggested that a "pilot" systematic review could produce significant insights regarding whether the approach was indeed practical and feasible for ODF to use. With support from the BOF, ODF subsequently contracted with INR to conduct such a pilot test on science question relevant to forest management in Oregon.

One relevant topical area is scientific evidence regarding the effectiveness of salmon and steelhead habitat restoration strategies. Many landowners have engaged in stream restoration projects involving the placement of large wood. ODF chose a question related to the effectiveness of placing pieces of large wood in streams because the practice is widespread and it was thought that a question could be developed appropriate to the desired scale of the pilot project. Such a question was developed and a pilot systematic review on that question was conducted in 2007.

This document reports on the review **process,** and key findings regarding application of systematic review to a body of scientific evidence that informs one area of natural resource policy and practice. A companion document- *"Does wood placement in Pacific northwestern North American streams affect salmonid abundance, growth, survival or habitat complexity? A pilot test of systematic review techniques"* (Burnett, Giannico and Behan 2007) reports on findings of the systematic review itself.

Note on terminology: The terms "systematic evidence review", "SER" and "systematic review" appear in this document. The term "systematic evidence review" was used by former Governor Kitzhaber and is found throughout much of the literature on the topic in clinical medicine. It was also used and abbreviated as "SER" in the 2005 INR report referenced above. More recently "systematic evidence review" is being supplanted by "systematic review" because the latter term is less unwieldy. Consistent with current practice, "systematic review" was adopted for this report.

4. Project description

ODF contracted with INR to perform the following tasks:

- Form teams composed of ODF technical specialists and external technical participants to refine specific question(s) related to the management topics of interest. Questions will be formulated in a way that both address question of interest, and limits the project to a scope consistent with resources available to complete it. There will be some stakeholder discussion around the relevancy and neutrality of the questions developed.
- Develop and apply search criteria – including protocol on how "grey literature" (thesis, meeting abstracts etc) will be addressed.
- Organize search results.
- Identify Science Reviewer(s).
- Facilitate the review of the technical material by the Science Reviewer(s). Science Reviewers will assess the feasibility of applying some type of evidence quality hierarchy, and apply as deemed feasible.
- Facilitate and/or develop the narrative synthesis resulting from the technical review and application of the evidence quality hierarchies.
- Facilitate discussion among project participants, including stakeholder representatives, on the evaluation questions. Characterize and summarize discussion for use in the final report.
- Respond to the evaluation questions, and include in the final report any other "lessons learned" from the project.

5. Review process

The review team consisted of an INR review coordinator, two expert reviewers and two ODF staff members. Two stakeholder representatives also provided input. The review process consisted of

- question development
- reviewer recruitment
- developing the review protocol and search strategy
- stakeholder involvement
- finding, filtering and evaluating the evidence
- collating the evidence and writing the review
- a "lessons learned" workshop
- final project report.

These steps are described below.

5a. Question development

As used in clinical medicine, systematic reviews are designed to address questions regarding the efficacy of active medical interventions to improve human health. The question should be tightly focused on a particular treatment rather than open-ended about a general topic, relevant to medical policy or practice but answerable in scientific terms, and value-free to the extent possible. Within these constraints on the nature of the question, ODF identified the topic of large wood placements to aid salmonids as a reasonable analog from the field of forest ecosystem management.

The review coordinator, ODF staff and the expert reviewers met to refine the review question. A key consideration was keeping the scope of the project manageable- reviewers agreed to participate with the proviso that it would not require a large commitment of time, and ODF sought a question that was appropriate to the desired scale of the pilot project. Topics of discussion included the pros and cons of restricting the review to the Pacific Northwest to limit the project scale. Initially, the decision was made to include studies from anywhere in the world because salmonid species and their habitats are similar enough that research results would be relevant to the Pacific Northwest, even if the study was conducted in another country. After the literature search identified a much larger than expected number of potentially relevant studies, the review was again mostly limited to the Pacific Northwest, with a subset of studies from outside this region. The rationale for these decisions is discussed in more detail below.

The finalized review question was: *Does instream wood placement affect salmonid abundance, growth, survival or habitat complexity?*

The question was then vetted with stakeholders representing an environmental group and a timber products company, as discussed in more detail below.

5b. Recruitment of expert reviewers

A defensible systematic review hinges on availability of qualified personnel to do the actual review work- typically, scientists working in the field of study under which the review question falls. Successfully recruiting qualified reviewers with expertise in salmonid fisheries biology was the most significant challenge to completing this project. A diligent search was made and in the end two excellent reviewers were recruited from about 20 potential candidates. But among those contacted overall, reception to the idea of assisting with a systematic review was lukewarm.

In contrast to the medical professions, systematic review is mostly unknown in ecological and natural resource management sciences. An overview of systematic review in the medical professions and the ODF pilot project was provided to each potential reviewer. Many cited existing workloads, time constraints, and research and teaching commitments as reasons for not participating. But there is probably more to this general reticence.

The workplace for natural resource scientists in academia emphasizes project development, original research and publication of results in peer-reviewed journals. This is particularly true for professors seeking tenure. Systematic review, on the other hand, involves rigorous synthesis of existing research- a labor intensive, time consuming task for which there is little professional recognition or support in natural resource fields. In clinical medicine, systematic review work is widely known and regarded as important- almost on the level of primary research- “a study of studies”. Funding and an established network of professionals and tools are available to support reviews. In comparison, the natural resource and ecological sciences are not well funded and awareness of systematic review is limited.

In short, there are strong disincentives for natural resource scientists to participate in systematic review work, deeply rooted in university culture. The experience of this pilot project suggests that successfully recruiting and supporting qualified reviewers may be the most significant barriers to conducting systematic reviews in natural resources.

The review coordinator and reviewers discussed how to implement systematic review techniques, and how tasks would be shared. The overall project plan was for the review coordinator to oversee the literature search and collation phase, and assist with writing background and methods sections for the review. The expert reviewers would be responsible for reviewing and synthesizing the included studies, and study quality ranking to the degree this was deemed feasible.

It was emphasized that ODF was at least as interested in the systematic review *process* as the review product itself, and that a key interest of theirs was the feasibility of applying some type of quality ranking or assessment to studies included in the review. It was agreed that each reviewer would review a subset of the studies to check for level of consistency in their assessments, as is standard practice in clinical medicine reviews.

5c. Protocol and search strategy

A key tenet of systematic review is use of a protocol that details how the review will be conducted before any actual review work begins. A protocol was developed that provided background on the review topic and laid out review objectives and methods, including details about the search strategy, plans for study quality assessment and summaries, and the narrative synthesis. The protocol also listed potential comparators and metrics for study outcomes. The expert reviewers refined background information on the importance of large wood as a component of salmonid habitat, and activities that have significantly reduced the supply of large wood in many salmonid streams. The reviewers also helped refine the search terms.

At the suggestion of one of the expert reviewers, a reference librarian from Hatfield Marine Science Center was contacted and agreed to assist with the literature search. She was provided with the review protocol and search strategy, which she subsequently modified, based on professional expertise, familiarity with reference database structure and content, and test searches. The review protocol and revised search strategy are shown in Appendix A.

5d. Stakeholder involvement

Stakeholder involvement in question development is a hallmark of clinical-medicine systematic reviews. This helps assure that the question is relevant to policy and practice, and also promotes stakeholder "buy-in" and use of review results. ODF recruited stakeholders with some technical background and interest in the study question from an environmental group (Ecotrust) and a timber products company (Plum Creek) to participate. Stakeholders were invited to comment on the review question and protocol. The timber industry representative provided some edits and suggestions, most of which were incorporated into the protocol.

Discussion topics with stakeholders focused on systematic review as used in clinical medicine, the review topic and question, and review techniques as laid out in the protocol. The stakeholders agreed that the question was relevant and objective in nature, i.e. related to science rather than values. Most discussion centered on how included studies would be evaluated.

One stakeholder suggested that it might be better and/or easier to look at salmonid habitat preference rather than population change because it is hard to develop good population metrics. For example, there is not consensus on whether it is best to assess juveniles or adults. Studies vary in this regard, making comparison across studies problematic. The suggestion was also made to leave evaluation parameters in the protocol more flexible until more was known about the types of studies that would be included.

Some challenges associated with gray literature were discussed. A stakeholder asked- would review results be different if gray literature was not included? It was suggested that as the review progressed, reviewers should consider whether including gray literature was worth the time invested, i.e. how much 'better' or different would review results be with gray literature included? It was suggested that a cut-off point for including gray literature should be defined. In the end, gray literature was not included in the review due to time limitations.

A question was posed regarding how the reviewers would interpret study findings in the context of general watershed conditions. What is the ecological context of each study and to what degree did activities elsewhere in the drainage affect study results? Did the study look at these contextual issues? How would the review document them? These questions address some fundamental challenges in ecological research of disentangling causes and effects in complex systems, especially those with multiple or significant alterations by humans, and related difficulties associated with comparing studies in which baseline conditions differ even in the absence of human impacts. It was explained that one benefit of systematic reviews is the additional transparency provided by documenting study parameters and contextual information in summary tables for each study.

The nature of "objectivity" in scientific research was discussed in some detail. The stakeholders seemed to agree that objectivity is an ideal that is sometimes only partially met, but that ethics and the peer review process in science are helpful in limiting bias and helping ensure that results are portrayed objectively. It was again stressed that the primary reason for investigating systematic review was the potential for it to reduce controversy over perceived bias in the conduct and use of ecological science by providing greater insight and transparency into how individual studies are interpreted and synthesized for use in policymaking. Stakeholder representatives were informed that they would have the opportunity to comment on the completed review, and to participate in the project wrap-up workshop.

5e. Finding and filtering the evidence

The reference librarian estimated that searching references databases, refining search terms and packaging search results for delivery to the review team took approximately 40 hours. The literature search produced 457 publications.

Due to a lack of agreed upon standards for stream restoration keywords and terminology, and the need to balance inclusiveness with specificity in order to capture as many relevant publications as possible, numerous publications were identified in the initial search that were not relevant to the review. Also, a key project goal was to limit the review to a manageable scope. For these reasons, publications in the initial set were subjected to "filtering" criteria.

First, the review coordinator conducted a "coarse filter", excluding publications that did not: 1) address salmonids, or 2) address active placement of large wood, determined mostly by reading study abstracts but also the full text in some cases. This reduced the set to approximately 65 publications. Next, the review coordinator and ODF staff met and recommended inclusion of only peer-reviewed journal articles reporting on studies conducted in the Pacific northwest. The expert reviewers were then provided with PDF files of 44 publications, about 25% of which were from studies outside the Pacific northwest.

The reviewers winnowed the list of publications further, using expert judgment and a decision tree tool, as explained in Section 5, below. The final review included 22 publications from the Pacific northwest region only.

To help ensure that review conclusions were robust, an additional 11 publications from studies conducted outside the Pacific northwest but that otherwise met the filter requirements were reviewed to assess whether results from these studies differed significantly from those within the Pacific northwest region. The reviewers concluded that including these studies would not have significantly changed the review findings.

5f. Evaluating and collating the evidence

Four included studies were independently reviewed by both reviewers to check for consistency in their interpretations of study results. The two reviewers' interpretations and assessments of these studies were very consistent. Disagreement over interpretation of findings is not uncommon in science, but these two reviewers' standards for interpretation were closely aligned. This indicates that it is possible to achieve a high level of consistency in natural resource systematic reviews with two or more reviewers.

Each reviewer was responsible for reviewing and summarizing about 50% of the included studies. To allow for comparisons among the different studies and to provide transparency into the basis for assessments about their relevance and quality, a summary table showing details about study parameters was prepared for each. Aside from the consistency check, the reviewers completed most of this work independently but met periodically to compare notes and discuss papers that didn't appear to meet the previously described filtering criteria and check with one another to ensure these assessments were accurate.

The reviewers found it useful to write short summaries of each paper to document important points. Studies were challenging to compare because many variables (e.g. season, life stage, topography, species) differed among the studies. To help weight and integrate the included studies reviewers developed a decision tree to judge the relevance of each. The reviewers created detailed summary tables and graphics to characterize and compare the studies. This highly distilled set of information served as the basis for the narrative synthesis.

Over the courses of their careers scientists may assess hundreds of papers as part of the peer review process, or to place their own work within the context of existing research streams, or to marshal evidence in support of a particular academic theory. A systematic review requires reviewers to assess studies somewhat differently - through the lens specified by the review question. What is different is that a systematically predetermined body of evidence is assessed for its "relevance" (i.e., quality and applicability) and overall strength in regard to this very narrowly focused question.

The reviewers expressed some surprise at the number of studies that were not directly relevant in addressing the review question. Being forced to put study characteristics and conclusions in the summary tables clarified these issues. The overall body of evidence to support wood placement was somewhat unclear, with significant information gaps.

These findings illustrate the value of systematic reviews for assessing and presenting available information in an organized, transparent fashion, and the potential for using systematic reviews to focus and set science agendas. Experience gained through this project supports the notion that policymakers faced with mandates to use "best available science" would find systematic reviews valuable for illuminating information gaps that are impeding development of science-based policies, and for prioritizing research to bridge these gaps. It is worth noting that in medicine, many research organizations currently require that a systematic review have been completed before additional funds are granted to study a particular intervention.

5g. Review document and "lessons learned" workshop

The review coordinator provided draft introduction, background and methods sections for the review document to the reviewers, who edited this work, completed the methods section and added the narrative synthesis, conclusions and summary tables. This draft final review was provided to the ODF project team members and stakeholder representatives prior to a "lessons learned" workshop attended by the review coordinator, reviewers, reference librarian, ODF technical staff and the timber industry stakeholder representative. Discussion topics included the review process and what had been learned through the project about the review topic itself, and the feasibility of applying systematic review techniques to natural resource questions. Project review questions developed by ODF were addressed. Responses to those questions are provided in the next section of this document.

After the workshop, the reviewers addressed comments from other review team members and finalized the review, entitled *"Does wood placement in Pacific northwestern North American streams affect salmonid abundance, growth, survival or habitat complexity? A pilot test of systematic review techniques"* (Burnett, Giannico and Behan 2007). Systematic methods located about 90% of included studies and a defensible systematic review was produced. Reviewers characterized review conclusions as "robust but maybe not definitive". There are two primary reasons for this qualifying statement. First, decisions were made to restrict the review to peer-reviewed journal articles from the Pacific northwest in order to meet the goal of limiting the project to a reasonable scope. Second, the reviewers suggested that a *systematic* review may not necessarily be equivalent to an *exhaustive* review. In other words, the need to be systematic and transparent by adhering closely to the review protocol and search procedures may reduce the freedom to use ad hoc, informal literature search methods, including informal solicitations from peers, non-systematic expansion of search terms and other hard-to-track steps often utilized in traditional reviews.

This is an early stage of testing systematic review in natural resources. Given the lack of consistent keywords and chance that some studies were still missed, reviewers were not 100% comfortable with relying exclusively on systematic search procedures. A degree of creep into non-systematic methods occurred with inclusion of a few documents from reviewers' personal libraries. In general, this is counter to systematic review doctrine but in the natural resources context, limited use of informal search methods is probably inevitable and if well documented, need not compromise review integrity.

Overall, systematic review methods appeared to be effective at finding relevant literature in a transparent, objective fashion. Of 33 reviewed publications, approximately 80% were identified by the systematic search. All of the high relevance publications were identified by the systematic search and not by the ad hoc search. These outcomes suggest that systematic review methods can be effective in reducing selective, incomplete or "biased" use of scientific literature in natural resource management.

6. Pilot SER Discussion and Evaluation Questions

Did the development of specific review questions and a search protocol enhance the likelihood that the results of the literature search are repeatable?

Yes. Repeatability is enhanced over an ad hoc search, but the results have a "shelf life"- in part because reference databases change, and also because new literature is being published all the time. A literature search repeated within a very short time frame after the original search could be expected to produce similar results. The likelihood of this will decrease over time as new references are added and database structure evolves. The primary benefits of a documented search strategy might lie more with transparency than with repeatability.

OSU Libraries must continually review whether use of each database warrants the cost of maintaining a subscription to it. Some databases that were available for this review may not be available in the future, at least through OSU Libraries. Conversely, additional references are continually being digitized and added to electronic databases and new databases may become available.

Were the draft evidence quality hierarchies possible to apply?

Yes, to some degree. Parameters used to assess the rigor of an individual study (e.g. sample size, replications, controls, before/after data, appropriateness of statistics used) are relatively straightforward. As expected, some studies were well conducted while others were not. But quality *ranking* of multiple studies is different than quality *assessment* of individual studies. The research questions addressed by some included studies were closely aligned with the review question, while research questions in other studies were not. Study quality and study alignment with the review question were two separate parameters that reviewers had to consider, and they found a range of combinations of each among the included studies. Some combinations of these parameters were as follows:

- Study well designed and conducted and closely aligned with review question
- Study well designed and conducted but only tangentially related to the review question
- Study had significant flaws but was closely aligned with the review question
- Study had significant flaws and was only tangentially related to the review question

Disparity in study quality *and* alignment with the review topic left the reviewers with no clear way to rank studies strictly in terms of quality when the studies were viewed through the lens of the review question.

In clinical medicine, many studies are designed specifically to test the kind of questions posed by systematic reviews, i.e. does the treatment work, or does it not? Much of this research is structured around double blind, randomly controlled clinical trials and systematic reviews to assess and integrate them. In other words, there is often strong congruence between the way a review question is framed and the format of the research available to address it. There is also much stronger consensus among researchers on outcome measures. Systematic review is well established and widely used in medicine, so methods used in individual studies are typically chosen with conscious knowledge of how the study itself will be assessed and combined with other studies later.

This is much less true in ecology. The science is younger and theories less well developed. Many studies are designed with more open-ended questions. And most ecologists are not familiar with “systematic review”. Some studies reviewed were well planned and executed. Several studies were set up in ways that made it difficult to differentiate effects of wood placement from other interventions. Outcome measures, life stages and species studied all varied as well. Most studies were "one of a kind" in experimental design, location and a range of other parameters, and thus difficult to directly compare with one another.

In short, the nature of the evidence base in ecology challenges the notion that study quality can be ranked in a way that closely approximates such ranking in clinical medicine systematic reviews. Instead, reviewers used a decision tree/flow chart (Figure 1, below) to determine "relevance" to the review question. Quality parameters such as experimental design and study rigor were some of, but not the only factors reviewers used to determine "relevance". Emphasis was placed on the research question addressed by each study, followed by the type of experimental design and statistical analyses used.

An alternative approach to quality ranking was employed by the Center for Evidence Based Conservation in the U.K. They set the "bar" at a certain level and included all studies that met that criterion. Inclusion decisions were primarily based on whether or not the study had data that could be included in their meta-analysis.

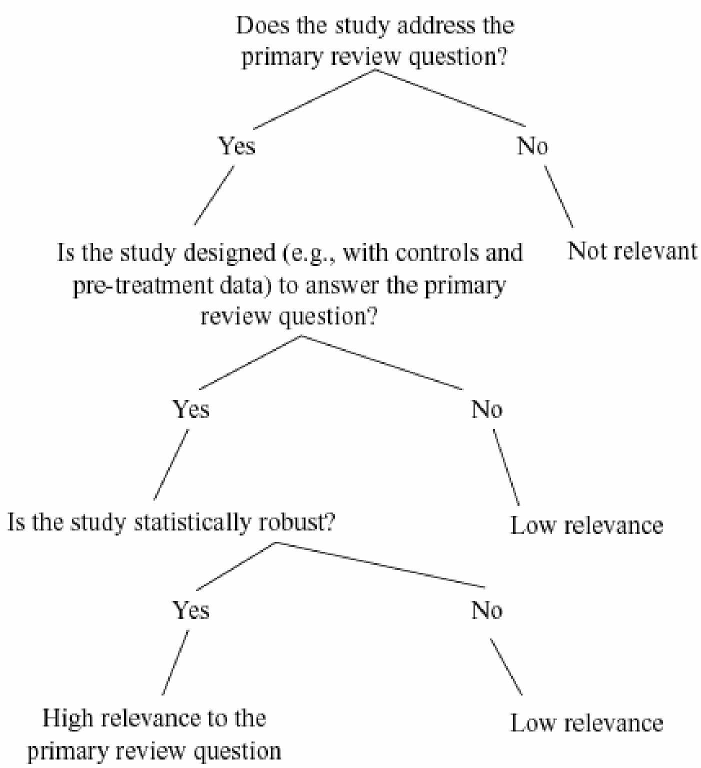

Figure 1 - Decision tree used to evaluate the relevance of publications to the primary review question.

Knowledge gained through effectiveness research and monitoring is widely cited as a key component of adaptive natural resource management. The paucity of such information is what spurred interest in adapting systematic review to conservation issues in the U.K. Wider use of systematic reviews could illuminate evidence gaps, improve consensus on study designs for assessing the effectiveness of environmental interventions and ultimately raise the level of congruence between study questions and the systematic review format for collating results. Greater attention to and funding for such work could increase the volume of evidence that lends itself to assessment and synthesis in a systematic review.

For now, the decision tree developed by the reviewers appears to winnow out the strongest pieces of evidence from a range of heterogeneous study types, and pulls together a body of evidence that is pertinent to a focused natural resource systematic review question.

Are there ways the hierarchy could be improved?
Depending on the nature of the evidence base being assessed, it may be possible to further refine the relevance flow chart. For some review topics, research questions addressed by included studies may prove to be aligned better with the review question than was the case in this project. It was also suggested that an explicit definition of what is meant by the term "peer-reviewed" might improve the transparency of a review. But challenges associated with quality ranking similar to those outlined above are likely for many natural resource questions.

What level of expertise was/is required to apply the hierarchies?
At a minimum, a good understanding of the scientific method and of study designs and statistical techniques used in the field of stream ecology (or whatever field the review question falls under) seem necessary to assess the research included in a systematic review in a defensible manner.

How was gray literature handled in the evidence quality hierarchy?
Gray literature was not included in the review, due to the larger than expected number of potentially relevant studies identified in the literature search phase, and the need to limit the project to a manageable scope. This decision was made in June 2007 at a meeting of the review coordinator and ODF staff.

How is gray literature best addressed in the search and evaluation process?
Gray literature was not included in the review, as explained above. During the stakeholder meeting, it was suggested that if a decision is made to review gray literature, some kind of "cut-off" could be established regarding what types to include. For example, USDA Forest Service General Technical Reports are generally viewed as "gray" literature but are subject to internal peer review at the USFS Research Stations where they are produced. Reports or papers which have not been subject to peer review of any type should probably be accorded less weight, or perhaps excluded from a review.

Gray literature is sometimes included in clinical medicine reviews in order to address the problem of publication bias- the tendency of statistically non-significant results to be rejected from peer-reviewed journals. The expert reviewers indicated that if they were asked to review gray literature, more time would have been required to examine statistics, study design and other parameters. This work is typically done during the peer-review process used by scientific journals. So including gray literature might add considerable time (and expense) to a review.

What advantage, if any, did the SER-like process used have over a traditional literature review?

In contrast to a traditional review that addresses a more general topic, a tightly focused review question provides a stronger, more defensible basis for decisions about which studies to include and which to exclude. A focused question makes it easier to develop a systematic, documented search strategy that can be repeated and/or expanded upon in the future. Asking a specific, focused question of the literature *a priori* also results in a tightly packaged set of information specific to that question, which may be more powerful and useful to managers than more general, less targeted information resulting from a traditional review. Systematic review methods also provide transparency into how studies were located and compiled.

Summary tables listing study parameters help document how decisions were made regarding the validity and reliability of study findings. There is still the potential for disagreement about such decision but how they were arrived at is clearer because the context of study findings is described in detail. It is easier to assess the degree to which a study's conclusions follow logically from its data when study parameters are documented using systematic review techniques. In contrast, most traditional reviews simply report study findings without formally assessing and reporting on their validity. When such reviews do attempt some critical assessment of study validity, this is usually limited to a short narrative rather than specifically listed details about how the study was carried out.

Involving stakeholders in question development and post-review discussions was intended to add credibility to the review. This helped assure that the review topic was relevant to natural resource policy and practice, and promoted greater stakeholder "buy-in" and use of review results. Such involvement may help foster goodwill between management agencies and stakeholders affected by decisions the agencies make.

Reviewers and stakeholders indicated that despite the challenges associated with quality ranking, even the more limited statements regarding the quality/relevance/suitability of included studies added considerable value to the review. The collaborative nature of the review was also cited as a strength.

Are there ways of making the process more cost effective and/or efficient?

Involving a reference librarian in question and protocol development may help save time by efficiently aligning the question and search strategy with available reference database resources and terminology. Use of library science students to conduct searches and collate results would be cost effective and provide valuable experience for the students. It was suggested that some type of common virtual workspace could be used to streamline the process by facilitating collaboration among review team members and reducing the need for scheduling face-to-face meetings. Examples include a "wiki", the Blackboard software used by OSU, and the free social networking service Ning (http://www.ning.com/).

Development and use of standardized templates for review protocols and study summary tables that could be tailored to specific review questions would be more efficient than starting from scratch each time, and would promote consistency in review documentation.

Before any decision to include gray literature in a natural resource review, the potential benefits should be carefully considered. The extra time required to carefully examine the methods, statistical analysis and results in such publications could add significantly to project costs.

What are some possible means of getting SER-like work done?
The reviewers indicated that they would have been much less willing to participate if there had not been a review coordinator to guide the process and assist with tasks other than the work of actually reviewing the studies. They felt it was important to use expert reviewers' time effectively by not asking them to do tasks that could be accomplished by technical assistants or grad students. To successfully recruit university faculty, it will be critical to limit their time commitment to just the actual review work. Without a review coordinator, such projects will likely be of interest only to private consultants.

The review coordinator could be an ODF staff person rather than a contractor such as the INR staff person who coordinated this project. ODF could recruit and contract directly with reviewers, work with them to develop the review question, and direct them regarding systematic review techniques the agency would like to see utilized.

Another potential strategy is for ODF to collaborate with other agencies to conduct reviews on questions of broad relevance. Yet another option is to acquaint ODF staff with systematic review techniques (perhaps through workshops) that they could use internally as they see fit. It was also suggested that systematic review is consistent with the type of science synthesis work conducted by the Independent Multidisciplinary Science Team (IMST) and that they could perhaps be encouraged to adopt the systematic review framework. The fact that IMST has staff and writers, a reference librarian and also a source of funding makes this option potentially more feasible.

In general, getting systematic reviews accomplished may hinge on promoting awareness of the process and its potential uses and benefits, and working to get systematic review work recognized as important by the Oregon University System and state agencies. One potential mechanism would be to develop a graduate-level class taught by a reference librarian and professor that integrates systematic review as a teaching mechanism about the scientific method and science assessment.

Under what circumstances would this process be most valuable?
Reviewers and the stakeholder representative at the "lessons learned" workshop suggested that circumstances or questions for which it might be most appropriate or worthwhile to use a systematic review include:

- A "burning", focused policy question that is answerable in scientific terms; a politically "hot" question over which people are arguing
- When there are serious or major threats or economic consequences to a management action that can be informed by better scientific knowledge
- When it can potentially inform and/or elevate conversation by reducing uncertainty about the science
- When it can address a "place-based" science policy question and compare to other places

Is there some initial screening that could be done to assess 1) the feasibility and 2) the costs/benefits of applying the SER approach?
Questions that approximate the "single species, single intervention" model of review questions in clinical medicine are more likely to be feasibly addressed by a systematic review than questions that diverge from this model. Workshop attendees discussed the importance of examining and documenting cost and benefit *outcomes* from a systematic review to assess their value and effectiveness. A thorough accounting may be difficult- it is likely that some significant benefits might not be tangible or obvious in the near term, i.e. illuminating knowledge gaps, reducing uncertainty and informing policy. Use of a checklist of items such as those listed for the previous question might also help identify the potential value of a systematic review. Contacting experts in the field under consideration would help illuminate the scope and nature of the evidence base that would be assessed in the review, and the feasibility of reviewing it.

7. Summary and next steps

This project demonstrated the feasibility of applying systematic review techniques to a natural resource management question. Despite challenges associated with recruiting reviewers and the diverse nature of the available evidence, the project did produce a robust systematic review on the question at hand.

Systematic review involves difficult, time-consuming synthesis work at the nexus of natural resource science and policy. Reviewers do not develop policy themselves, but rather work to "package" scientific knowledge on policy-relevant science questions. Identifying, recruiting and supporting qualified reviewers who also have an interest in such work is perhaps the biggest barrier to getting credible, defensible systematic reviews accomplished in the natural resource fields. Because systematic review is only beginning to be used in the conservation sciences, institutional awareness, appreciation and capacity for such work remains limited.

On the positive side, reviewers were encouraged that systematic reviews are possible for questions regarding active environmental interventions on behalf of specific species. They indicated that asking carefully considered, focused *a priori* questions of the scientific literature and using unbiased, transparent search and review techniques to address them could improve consensus on “best available science” and delivery of this knowledge to managers and policymakers. A key lesson learned was the benefit of collaborating with a reference librarian on the review protocol and literature search. Such collaboration should be a key facet of any future systematic review work.

A project overview was presented to a group of reference librarians in December, 2007. This led to an invitation to give a similar presentation to a group of Oregon Department of Transportation biologists in January, 2008. ODF staff identified a range of parties potentially interested in interagency collaboration on systematic reviews, including Oregon Department of Fish and Wildlife, Oregon Watershed Enhancement Board and Oregon Department of Agriculture. ODF’s preference is to have a coordinating entity (such as INR) take the lead in organizing such reviews. Potential topics and issues include salmon and watershed restoration, invasive species and pesticide use and management. The USDA Forest Service Pacific Northwest Research Station Focused Science Delivery Program has expressed interest in further investigation of systematic review.

The Institute for Natural Resources at OSU is interested in and well positioned to coordinate future systematic review work in natural resources. This project demonstrated that such reviews are possible, but also reinforced the fact that they are difficult and time consuming to do well. The INR will work to expand awareness of systematic review and findings from this project, and hopes to coordinate a “best available science” workshop, with systematic review a prominent discussion item. Key challenges for INR to coordinate future systematic review work will be adequate support and recruiting qualified reviewers.

In summary, there are considerable challenges associated with applying systematic review in the natural resource and conservation fields. But the need for synthesis of “best available science” for use in natural resource and environmental remediation policymaking is greater than ever. Systematic review shows considerable promise, both for identifying and packaging scientific evidence, and for helping set science agendas to address critical knowledge gaps. Much remains to be learned about the use of systematic review in these diverse and challenging arenas, but this project demonstrated that such work could produce many significant benefits.

References Cited

Institute for Natural Resources. 2005. Applying Systematic Evidence Reviews in Oregon Forest Policy: Opportunities and Challenges. Prepared under contract with the Oregon Department of Forestry. 103p.
http://egov.oregon.gov/ODF/RESOURCE_POLICY/docs/SER_Report_final.pdf

Burnett, K, G. Giannico & J. Behan. 2007. “Does wood placement in Pacific northwestern North American streams affect salmonid abundance, growth, survival or habitat complexity? A pilot test of systematic review techniques”

Fazey, I., J. G. Salisbury, D. B. Lindenmayer, D. Maindonald, & R. Douglas. 2004. Summarizing and disseminating conservation research: can we use methods applied in medicine? Environmental Conservation 31 (3), 190–198.

Pullin, A. & T. Knight. 2001. Effectiveness in conservation practice: Pointers from medicine and public health. Conservation Biology, 15, 50-54.

Appendix: Pilot Systematic Review Protocol and Revised Search Strategy

Does instream wood placement affect salmonid abundance, growth, survival or habitat complexity?

1. BACKGROUND

In Pacific northwestern coastal and western Cascades streams, large wood- trunks, larger branches and roots of trees that fall into stream channels- is a primary determinant of channel form, creating pools and small abrupt drops and influencing channel depth and width. Pools formed by large wood (LW) are important habitat and provide cover for many fish species, including salmonids (Bilby and Bisson 1998). Streams with more LW tend to have more and larger pools, as well as more variation in depth, substrate types and amount of cover compared to streams with less LW (Quinn 2005). Streams with more complex pool habitats tend to have more fish species, and greater numbers of each species (Reeves et al. 2002). LW also influences sediment transport- the greater the proportion of elevation loss in a stream due to waterfalls, the less efficient the stream is at transporting sediment (Bilby and Bisson 1998).

Because of its key role in salmonid habitat, LW is a commonly used measure of habitat quality. Undisturbed streams in coastal Pacific northwestern forests typically contain LW in great abundance. Past land use practices have substantially reduced LW in many of the region's salmonid-bearing streams and rivers. After Euro-American settlement, LW was often removed from streams to facilitate the practice of splash damming to transport logs from harvest sites downstream to sawmills. In the 1960's and 70's, federal and state programs were implemented to clear LW from stream channels. This was in part motivated to eliminate migration impediments for adult salmon caused by large instream accumulations of logging slash. Timber harvesting along streams has also reduced the amount of large wood available for recruitment into channels (Reeves et al. 2002).

Concern over declines and disappearance of several Pacific northwestern salmonid stocks (e.g., Nehlsen et al. 1991; National Research Council 1996) has resulted in major efforts to restore freshwater salmonid habitats. This includes active placement of LW in salmonid-bearing streams to recover stream processes and functions. Land managers, landowners and citizens who invest public and private funds in restoration have an interest in knowing when and where LW placement projects are most likely to be effective.

A Systematic Evidence Review (SER) will be conducted to locate and review evidence (e.g. peer reviewed and non-peer reviewed literature, and readily available monitoring or research reports) concerning the effects of large wood placement on salmonids and habitat complexity. The review will employ a comprehensive, documented literature search and specific criteria for assessing the quality and reliability of each study. Results for each study will be reported in a table. The table will be used to identify factors that might affect study conclusions as well as commonalities and differences among studies. The overall strength of reviewed evidence will be summarized and reported in a narrative synthesis. Gaps in research will be highlighted. The review should be useful to land and watershed managers, landowners and citizens with a stake in salmonid habitat management.

2. OBJECTIVE OF THE REVIEW

2.1 Primary question

Does instream wood placement affect salmonid abundance, growth, survival or habitat complexity?

Assessing the effectiveness of large wood placement may be aided if studies use some frame of reference for comparison. Possible comparators include:

....as compared to streams without wood placement?
....as compared to pre-treatment?
....as compared to similar reaches with ***low*** *wood loading?*
....as compared to similar reaches with ***high*** *wood loading?*

Possible metrics for measuring study outcomes. Outcomes for salmonids can apply to any life stage:

- frequency of pools
- depth or volume of pools
- cover from predation
- gravel retention
- over-winter salmonid habitat (off-channel habitat and pools)
- habitat selectivity and/or preference
- site fidelity/turnover rate
- salmonid growth
- salmonid survival
- salmonid biomass/area
- salmonid movement
- salmonid density
- salmonid foraging activity

2.2 Secondary question

To the degree possible, the review will evaluate differences among study site variables that may help explain differences among study outcomes. Such variables are termed *effects modifiers* (Stewart et al. 2006). Specifically, the review will attempt to address the following secondary question: What influence do variables such as land use history, local geology, stream gradient and valley confinement, proportion of cobbles in substrate, degree of existing modification, stream size, drainage size, water flow, canopy cover, fish species present and other potential effects modifiers have on the impact of large wood placements?

3. METHODS

3.1 Search strategy
Electronic databases to be searched, listed by database name and host/administrator:

- Aquatic Sciences & Fisheries Abstracts: Cambridge
- Environmental Sciences and Pollution Management: Cambridge
- Forest Science: CAB Direct*
- Treesearch: USDA Forest Service Research
- AGRICOLA: USDA/NAL
- Fish & Fisheries Worldwide: NISC
- StreamNet Library
- Dissertation Abstracts: FirstSearch
- WAVES Canada: Libraries of Fisheries and Oceans Canada
- Sport Fish Division Reports: AK Dept. of Fish & Game
- Web of Science: Science Citation Index

The following meta-search engines will be searched
- Dogpile
- Google Scholar
- Oregon State Library
- Washington State Library
- Streamnet Library Columbia Basin

Search terms:

EITHER stream, river channel, trout, salmon, char, Onchorynchus kisutch, Oncorhynchus keta, Oncorhynchus tshawytscha, Oncorhynchus gorbuscha, Oncorhynchus nerka, Oncorhynchus mykiss, Oncorhynchus clarki AND

1. wood placement or restoration
2. woody debris placement or restoration
3. restoration
4. habitat structures
5. habitat restoration
6. fish habitat improvement
7. stream channel improvement

Search terms may be added or dropped as the search progresses. In such instances, rationale and details will be documented. Publication searches will be undertaken on conservation and statutory organization websites (e.g. Oregon Dept. of Fish & Wildlife, Washington Dept. of Natural Resources).

A record of the first 100 word document or PDF hits from each source will be saved. Titles and abstracts will be assessed for relevance.

Additional foreign language searches will be conducted on Google to capture information from the following non-English speaking countries with significant managed salmonid fisheries: Denmark, Finland, France, Norway, Spain, Sweden Chile, Argentina, Japan, and Russia. Only those references with English language abstracts concerning native stocks of salmonids will be considered.

Bibliographies of recent, relevant articles- primary peer reviewed papers and book chapters recognized by experts as seminal or important- may be searched for further references. Recognized experts and practitioners may be contacted for further recommendations and relevant unpublished material or monitoring data.

3.2 Study inclusion criteria

- **Relevant subjects:** Rivers and streams containing trout and salmon populations.
- **Type of Intervention:** Only studies that investigate large wood placement or augmentation by humans will be included. Studies that investigate the ecological role of large wood in unaltered systems will not be included.
- **Types of Outcome:** Change in abundance, growth, survival, habitat preference, and/or habitat complexity of trout and salmon. However, studies will not be rejected on the basis of outcome and outcomes other than change in fish abundance and habitat preference will be catalogued.
- **Types of Study:** Type of study (e.g. retrospective, BACI) will not be used to define inclusion or exclusion criteria. All information regarding the primary outcome will be collated qualitatively in tables and accompanying narrative synthesis.

It is anticipated that some studies will be clearly relevant to the primary review question based on titles and abstracts. For other studies, relevance may be less clear. If titles and abstracts provide insufficient information to make a decision regarding study inclusion, reviewers will view the full text of articles in order to determine their relevance and make decisions regarding inclusion in the review.

Personnel conducting the initial searches will conservatively include all studies that meet inclusion criteria listed above and defer to science reviewers regarding final decisions about which studies to include and which to exclude. In other words, some studies may be initially be included but later excluded if, in the view of the science reviewers, they do not meet the criteria listed above. In such cases, reasons for excluding the study will be documented.

3.3 Study quality assessment

Quality assessment is a hallmark of systematic reviews. Reviewers will attempt to rank each piece of evidence based on relative quality, and give greater weight to those of higher quality.

Overall, evidence quality will be judged based on how well the research was conducted and minimized chances for inferential error. Ideally, each piece of evidence is assigned a numerical ranking for quality, based primarily on rigor of experimental design (Table 1). Studies that meet criteria in quality level 1 would be given greater weight than studies ranked 2, and so on.

Ranking the quality of studies with different sample sizes, locations, methods and variables may prove challenging. In practice, it may be necessary to use different or less rigid categories while applying the same general framework. For example, studies may be assigned to categories such as:

1. Study was well designed and conducted overall; evidence is relatively strong
2. Study had some flaws in design or conduct that reduce evidence strength
3. Study had major flaws which seriously compromise it's reliability

Criteria and categories for ranking evidence may be refined or amended during the course of the review. Rationale and circumstances for any such amendments will be documented.

At least two reviewers will independently assess a random subset of 25% of articles. Disagreement will be resolved by consensus, or following assessment by a third reviewer.

If there are instances where studies are included that were authored by one of the reviewers, the other reviewer will review that study.

Table 1: Hierarchy of different study designs to assess stream rehabilitation projects

Relative quality level	**Study design**	**Example Outcome**	**Relative Level of confidence**
1.	Replicated sampling, replicated controls, sampling before and after rehabilitation	'The increase in the frequency of pools in the treated reach was greater than any increase at either control reach'	Very high
2.	Unreplicated, controlled, sampling before and after rehabilitation	'The number of salmon increased after rehabilitation in the treated reach, but not in the control reach'	High
3.	Unreplicated, uncontrolled, sampling before and after rehabilitation; OR Unreplicated, controlled, sampling after rehabilitation	'There were more salmon after the work than before'; OR 'After rehabilitation there were more salmon in the control reach than in the treated reach'	Moderate
4.	Unreplicated, uncontrolled, sampling after rehabilitation	'There was a gradual increase in the number of salmon in the two years after the work'	Low
5.	Unreplicated, uncontrolled, anecdotal observation after rehabilitation	'I saw lots of salmon after we had done the work'	Very low

(Modified from a table in from Fazey et al. (2002), which was modified from Rutherfurd et al. (2000), *A Rehabilitation Manual for Australian Streams*, Vol 1, pp 164-73.)

3.4 Study summaries

Information about study characteristics, quality and results will be documented in tables with fields for:

- Study date
- Study location
- Sample size
- Stream characteristics (e.g. width, gradient, confinement)
- Variables measured
- Summary of experimental/study design
- Outcome(s) measured
- Findings
- Potential sources of bias or inferential error
- Effects modifiers
- Relative study quality level

Author/ PI and Date	Location, Study Duration	Variables/ Outcomes Measured	Methodology/ Exp. Design/Life stage assessed (if applicable)	Sample Size, Rep-lications	Analysis/ Statistics	Findings	Relative Study Quality Level	Potential Sources of Bias	Effects Modifiers

3.5 Narrative synthesis

To rate the strength of a body of evidence (a group of studies), reviewers must not only identify all relevant studies and evaluate the quality of each, but also assess consistency of results and heterogeneity of study designs to assess their comparability. This is more difficult than assessing the quality or strength of an individual study.

Meta-analysis is preferred for evidence synthesis in the medical profession, but may be inappropriate or impossible for many natural resource SERs. Opportunities for merging datasets will be explored and reported, but performing meta-analysis is not anticipated in this review.

A narrative synthesis is especially critical as the principal means of synthesizing evidence when meta-analysis is not conducted. Information from included studies will be collated qualitatively in table format. Narratives that summarize available evidence and evidence gaps will accompany the tables.

Tabulated study characteristics and results in the narrative synthesis allow similarities and differences between the studies to be compared and help document how reviewers arrived at an overall assessment. The narrative will document an organized qualitative evaluation of the strength of the body of evidence as a whole, and how it may have been impacted by study characteristics and quality.

Reasons for heterogeneity in study results may include stream size, local gradient and valley confinement, proportion of cobbles in substrate, land use history in the watershed, water quality, water flow, stream and canopy cover.

Criteria for assessing the strength of a body of scientific evidence:

Quality: Aggregate quality of a body of evidence is based on the internal validity of each included study.

Quantity: Magnitude of effect, numbers of studies, and sample size or statistical power.

Consistency: For any given topic, the extent to which similar findings are reported using similar and different study designs.

Coherence: Do the findings of a body of evidence make sense as a whole?

4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT

Some studies to be reviewed may have been authored by the reviewers themselves. This potential conflict of interest will be addressed as explained above. No other potential conflicts of interest to be declared. This systematic review is funded by the Oregon Department of Forestry.

References Cited

Bilby, R.E. and P.A. Bisson. 1998. Function and distribution of large woody debris in River ecology and management: lessons from the Pacific coastal ecoregion, Bilby, R.E. and P.A. Bisson (eds.) New York/Berlin/Heidleberg: Springer-Verlag. Pp. 324-341.

Fazey, I., & Salisbury, J. G. 2002. Evidence-based environmental management: What can medicine and public health tell us? Proceedings of a workshop, June 24, 2002. National Institute for the Environment, Australian National University, Canberra, Australia. http://eprints.anu.edu.au/archive/00002150/01/ebem_workshop_summary.pdf

National Research Council (NRC). 1996. Upstream: salmon and society in the Pacific northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Academy of Science, Washington, D.C.

Nehlsen, W., J. Lichatowich and J. Williams. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. Fisheries 16, 2, p. 4-21.

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon and trout. Seattle WA: University of Washington Press.

Reeves, G.H., K.M. Burnett and S.V. Gregory. 2002. Fish and aquatic ecosystems of the Oregon Coast Range in Forest and stream management in the Oregon Coast Range, Hobbs, S.D. et al. (eds.) Corvallis, OR: Oregon State University Press. Pp. 68-98.

Stewart, G.B., H.R. Bayliss, D. Showler, A.S. Pullin and W. Sutherland. 2006. Does the use of in-stream structures and woody debris increase the abundance of salmonids? Systematic Review No. 12, Center for Evidence Based Conservation, Birmingham, UK.

Systematic Evidence Review REVISED SEARCH STRATEGY

Question: Does instream wood placement affect salmonid growth, survival or habitat complexity?

Search Protocol

Revision 4/10/07

3. METHODS

3.1 Search strategy

Theses electronic databases, listed by database name and host/administrator, were searched. ASFA and Fish & Fisheries cover international information, searching was not limited to US generated material or English language.

- Aquatic Sciences & Fisheries Abstracts: Cambridge
- Environmental Sciences and Pollution Management: Cambridge
- Forest Science: CAB Direct
- Treesearch: USDA Forest Service Research
- AGRICOLA: Ebsco
- Fish & Fisheries Worldwide: NISC
- Wildlife & Ecology Studies Worldwide: NISC
- Dissertation Abstracts: FirstSearch
- Web of Science: Science Citation Index

The following meta-search engine was searched.

- Google Scholar

The following library collections were searched:

- Oregon State Library (OCLC)
- Washington State Library (OCLC)
- Oregon State University Library (OCLC)
- University of Washington Library (OCLC)
- Washington State Library (OCLC)
- Streamnet Library Columbia Basin (OCLC)
- Sport Fish Division Reports: AK Dept. of Fish & Game (OCLC)
- WAVES Canada: Libraries of Fisheries and Oceans Canada

The following search strategy was used combining, when possible, these three sets of keywords:

Set 1: Species - These search terms were combined with OR. None were truncated as preliminary searches truncating 'salmon' returned too many irrelevant results.

- Oncorhynchus kisutch
- Coho salmon
- Oncorhynchus keta
- Chum salmon
- Oncorhynchus tshawytscha
- Chinook salmon
- Oncorhynchus gorbuscha
- Pink salmon
- Oncorhynchus nerka
- Sockeye salmon
- Oncorhynchus mykiss
- Salmo gairdneri
- Rainbow trout
- Oncorhynchus clarki
- Cutthroat trout
- Salmo salar
- Atlantic salmon
- Salmo trutta
- Brown trout
- Hucho taimen
- Salmon
- Trout
- Char

Set 2: Environment – These broad search terms in conjunction with the treatment terms narrowed the search appropriately. These three terms were combined with OR.

- Stream
- River
- Channel

Set 3: Treatment - These terms were searched as phrases and combined with OR. Originally, broader treatment terms were used such as 'stream restoration', 'habitat restoration' and 'stream channel improvement.' This original strategy skewed the relevancy ranking of the results giving items with the most keywords from the search strategy the highest ranking. Consequently, more relevant items with only a few critical keywords could have been overlooked, especially if results had been limited to the first 100 or 200 hits. The terms listed below, while returning a smaller number of items, seemed to be more appropriate for the issue

- Wood placement

- Wood restoration
- Woody debris placement
- Woody debris restoration
- Large wood
- Logs
- Woody debris
- LWD

Three of the resources searched posed challenges for the chosen search strategy as the systems have intrinsic limitations.

- TreeSearch has a very limited search term capability and is a relatively small dataset. So, a simplified search strategy was used after some experimentation.

  Salmon **AND** "large wood" **or** "woody debris" **or** "habitat restoration" **or** "stream channel" = 9

- GoogleScholar limits search terms to 42 and is not transparent on phrase searching. So, a more general search strategy was used resulting in close to 4,000 hits. As GoogleScholar improves its advanced search engine, this problem of irrelevant and duplicated results may diminish.

  (Phrases = "wood-restoration" or "large-wood" or "woody-debris" or wood placement **OR** (All words = logs or LWD)) **AND (**At least one word = salmon OR trout OR char)

- WAVES does not allow Boolean combining of multiple sets.

All items found in each source were imported except for GoogleScholar where the first 100 of 3,820 results were reviewed for inclusion. Those with indeterminate information (e.g. incomplete citation) were discarded. After compiling the results in a ProCite database, duplicates were removed as well as meeting abstracts.

Additional searching of pertinent conservation and statutory organization websites including the Oregon Department of Fish & Wildlife and the Washington Department Fish & Wildlife was considered, but discarded as neither had comprehensive publication lists. Pertinent publications by both agencies were retrieved with searches of regional library catalogues as Oregon State University and University of Washington are depositories for their respective state government publications. Both also collect nondepository items generated by the agencies as available. Some agency publications were retrieved via GoogleScholar.

In addition to the databases and catalogues searched, selected bibliographies of recent, relevant papers and book chapters recognized by experts as seminal or important were reviewed for further references. This helped identify additional references as well as reinforcing the validity of the initial search results.

> Bayley, Peter. 2002. A review of studies on responses of salmon and trout to habitat change, with potential for application in the Pacific Northwest: A report to the Washington State Independent Science Panel.
>
> Lassettre, Neil S. 1999. Annotated Bibliography on the Ecology, Management, and Physical Effects of Large Woody Debris (LWD) in Stream Ecosystems. Department of Landscape Architecture and Environmental Planning University of California, Berkeley. http://www.cnr.berkeley.edu/forestry/curr_proj/woodydebris/woodbiblio02.html#113
>
> Roni, P.; Hanson, K.; Beechie, T.; Pess, G.; Pollock, M ; Bartley, D.M. 2005 Habitat rehabilitation for inland fisheries. Global review of effectiveness and guidance for rehabilitation of freshwater ecosystems. FAO Fisheries Technical Paper, No, 484, Rome, FAO. 116 pp. [Reviewed Section 2.5: Instream Habitat Structures. Pp. 37-49]

The set used for initial review included 457 references.