Supplementary material

Note that the characteristics of references with comparators included in meta-analysis are provided in the review and that details of data extraction are provided in the appendix.

Important note: Redefinition of subgroups was suggested by reviewers for Ecological Applications. The analyses reported in Ecological Applications refer to artificial instream devices and intentionally placed woody debris. The meta-analyses reported here attempt to separate natural woody debris from intentionally placed woody debris but this distinction is somewhat arbitrary. Consequently conclusions regarding woody debris in this review must be considered with caution pending further work.

Characteristics of references included in the review but excluded from meta-analysis.

REVIEWS

Reference	Topic	Summary Conclusions
Allouche (2002)	The role of instream cover for riverine fishes.	This review looks at the role of instream cover and its effects on the distribution of fish, especially the importance at a habitat unit scale. States the three main reasons for the importance of instream cover are protection, shelter and isolation from competition.
Armstrong (2003)	Habitat requirements of Atlantic salmon and brown trout in rivers and streams	Review looks at factors affecting the distribution and abundance of salmon and trout. Suggests that habitat structures have greatest affect when populations are near carrying capacity, and as such concludes that it is important to understand population bottlenecks in order to determine whether habitat manipulation is appropriate. Author presently finds predictive models of the effects of most habitat modifications hard to derive.
Bash & Ryan (2002)	Monitoring of stream restoration	Found that monitoring does not always occur, and that the type and quality of data

	projects.	collected varies widely for the projects that do monitor.
Bayley (2002)	The responses of salmon and trout to habitat changes.	A review of studies on fish responses of salmon and trout to habitat change through both restoration and environmental factors. The review was undertaken after a thorough journal literature search. Author reports that many studies were of a short time scale and used poor statistical analysis, and that confounding means that studies are often not able to clearly indicate which factor is responsible for changes.
Cowx & Welcomme (1998)	Rehabilitation of rivers for fish	Report looks at the methods and projects undertaken for rehabilitation of rivers.
Cowx et al (2003)	The Bullhead (*Cottus gobio*)	Looks at the ecology, distribution and habitat preferences of the Bullhead, *Cottus gobio*, part of the Conserving Natura 2000 Rivers Series.
Finlayson et al. (2005)	Trout restoration in national forests.	Discusses the projects and work done so far which attempt to restore trout populations, and looking at this evidence debate whether they are being successful or otherwise.
Glen (2002)	Recovery of Salmon and Trout following habitat enhancement works	Reviews case studies of habitat enhancement, including removal of obstruction to migration, with both economic and ecological factors included. Findings suggest that habitat enhancement projects do work, and this can be seen within a short timescale, with removal of migration barriers giving the greatest results. Also finds other habitat enhancement projects are successful but acknowledges the need for monitoring over a longer timescale.
Hamilton (1989).	Response of Juvenile Steelhead to Instream Deflectors in a High Gradient Stream	Found that there was little impact on fish populations from the installation of deflectors, which was attributed to the high gradient of the study reaches. Literature was found to reflect these findings- the most successful studies had been carried out in lower gradient streams.
Hendry et al. (2003)	Habitat management for rehabilitation of salmonids	Looks at the main areas to be taken into account in salmonid habitat management. Paper states that land-use regulation is required due to the high levels of degradation that have occurred, and that root causes of problems should be addressed in mitigation and enhancement works.
Holmes (1998).	A review of river rehabilitation in the UK, 1990-1996	Reports a lack of consistency in recording or reporting of habitat rehabilitation schemes. Found that the most commonly used methods were often the cheapest, such as restoration of riparian growth, or those river restoration projects targeted at a particular key species (often bird or mammal).
Keeley et al (1996)	Estimating production benefits of habitat improvement initiatives.	Summarised the findings of 30 studies that included control and intervention sites in order to calculate the potential production benefits of stream restoration initiatives on

		salmonids. Suggests off-channel habitat may increase numbers, and increases in spawning substrates should lead to great increases in numbers.
Kauffman & Krueger (1984)	The effects of riparian grazing	Looks at general effects of riparian grazing, includes studies regarding fish. Concludes that riparian grazing affects salmonid fish populations as a result of changes to water temperature and reduction of organic matter, and states that riparian management is an important part of fisheries management.
Kauffman et al (1997)	Restoration of riparian and stream habitat	Suggests that a holistic approach concerning both riparian and stream restoration needs to be used, and that often restoration efforts don't attempt to stop the processes causing degradation of the land.
Kauffman et al. (1993)	Fish habitat improvement projects and management recommendations	Reviewed habitat restoration projects over a number of sites. Report looks at the restricting factors that need to be taken into account and the implementation of these projects.
Kondolf, G. M., J. C. Vick, et al. (1996)	Salmon spawning habitat rehabilitation in the Merced, Tuolumne, and Stanislaus Rivers, California: An evaluation of project planning and performance	Found that projects did not always take into account features that modified the intended workings of modifications, such as upstream dams on riffle sequences. Also found that some of the projects actually increased suitable habitat for salmonid predators, negating positive outcomes of the improvement features.
McGrath, C. C. (2003)	Whitewater parks	Study looked at the effects of Whitewater parks on fish populations. Whitewater Parks commonly contain engineered versions of riffles and pools and therefore should provide a good habitat for fish, especially as shelter should protect them from recreational use of the habitat. Conclusions derived from comparisons with data from non-park locations as research in that area extremely limited.
McPhail and Baxter (1996).	A review of Bull Trout (Salvelinus confluentus) life history and habitat use in relation to compensation and improvement opportunities	This review looks at the biology and habitat use of fish at the different stages of their life cycle, and some of the habitat issues of concern
Opperman et al (2006)	Large woody debris in streams	This guidance document discusses the role of LWD in stream and river habitats in relation to salmonids, and states the importance of both living and dead woody debris in the ecosystem.
Pusey and Arthington (2003).	Importance of the riparian zone to the conservation and management of freshwater fish: a review.	Although with an Australian bias, this review describes the role and interactions between stream and riparian zones, and concludes that attention to riparian zones are of key importance when planning restoration work.

Roni et al (2002)	The effects of habitat improvement studies.	A review of habitat improvement studies. Concludes that little is known about the effectiveness of in-stream habitat improvements.
Roni et al (2005).	Habitat rehabilitation for freshwater ecosystems.	This review discusses the effectiveness of habitat improvement projects and translates the findings into guidelines to help guide and improve future restoration and mitigation attempts.
Rosenfeld (2003)	The assessment of fish habitat requirements.	Looks at the different scales at which habitat assessment take place, and some of the factors that affect these. States the need for clearly defined habitat requirements to be understood to make habitat restoration and species management more effective. Review discusses the importance of understanding the optimal habitat configurations for fish species.
Schmetterling et al. (2001).	Effects of riprap bank reinforcement on stream salmonids	This review looks at the effects of using riprap to reinforce river and stream banks, and find that although it may provide some benefits on stream banks that have been severely degraded, the use of riprap goes against current restoration philosophy and impedes future attempts to restore the stream reach. Concludes that riprap does not provide an alternative to riparian cover and the benefits this offers to Salmonids, such as LWD, undercut banks and cover.
Summers et al (1996)	Restoration of Riverine Trout Habitats	This guidance manual describes the methods used for restoring riverine habitats, specifically for trout species.
Thompson (2006)	The pre-1980 use of instream structures to improve streams and fish populations.	This review looks at studies from pre-1980, which attempt to show the positive effects of instream structures. The review finds that little evidence exists to show that instream structures improve fish populations and concludes that their effectiveness to increase fish populations should not be presumed. The author also notes that many of the studies are confounded, as fishing pressures are not accounted for.
Ward & Ward (2004)	Hydroelectric development mitigation	Looks at habitat restoration initiatives aimed at mitigating the effects of hydroelectric operations within the Columbia River Basin.

PRIMARY STUDIES

Reference	Subject	Intervention	Outcome	Summary findings	Methodology
Bank cover deflectors					
Champoux et al (2003)	N/A	Bank-cover deflectors	N/A	Concludes that the siting of bank cover deflectors needs to be considered in relation to the different geomorphic contexts encountered in river reaches as effectiveness is dependent on other factors.	Looks at the long-term changes in river morphology, and as a by-product, fish habitat suitability, before and after installation of bank-cover deflectors. Data sets from 1963, 66 and 99.
Bouldering					
Huusko & Yrjäna¨ (1997).	Brown Trout	Channel modification and boulder structure placement	Habitat suitability	The effects of channel modification and boulder structure placement using PHABSIM suggests that increased diversity created conditions more likely to sustain a larger trout population.	PHABSIM based on before and after field site data
Maki-Petays et al (2000)	Brown Trout and Grayling	Heterogenous substrate and flow level	Location	Looked at microhabitat preference of age-0 brown trout and grayling in two artificial streambeds at high and low flow. Found that trout spatial patterns were different in flume types. Concludes that rehabilitation programmes should aim to provide a broad range of microhabitats, and restoration aimed at one particular species may not provide suitable environmental conditions for other species in the same habitat.	Laboratory conditions experiment of fish habitat preference in both an artificial channel and a "restored" channel, with highly heterogenous substrate
Smith et al (2005)	Rainbow Trout	Prismatoidal shapes (producing turbulence)	Fish occupancy	Paper concludes that the angular nature of instream devices could promote higher turbulence than natural objects, meaning potentially reduced habitat occupancy by drift-feeding salmonids.	Measured fish location and focal points in relation to flow turbulence in a laboratory flume.
Confounded – multiple factors					
Binns (1994)	Trout	Habitat management – riprap and improvement	Population density	Instream improvement structures were found to increase numbers of trout of different age classes over a long time period. The degraded habitat had been restocked prior to works. Wooden plunges	Triple-pass electrofishing using block nets at sampling sites. No variance measures are presented for fish parameters. Controls established after treatment.

		devices		seemed to be easy to install and created good pool habitat.	
Connolly & Jezorek (2001)	Steelhead and other salmonids	Different Habitat sites-unclear as to what	Biomass of salmonids	Monitored fish abundance at a number of different habitat sites but do not state which samples relate to what habitat types	Electrofishing and PIT-tagging
De Jong et al (1997)	Atlantic salmon and brook trout	Boulder clusters, v-dams and half-log covers	Salmonid density	Suggests that the restoration techniques were successful although success is not solely attributed to the devices.	BACI with one control site. Multiple-pass electrofishing using nets. Population estimates made using MICROFISH 3.0.
Environment Agency (2003)	Salmon	Multiple-riparian, fish pass, water quality	Greater fish stocks through an Action Plan	Project to improve river habitat for salmonids included much riparian restoration- costed actions are presented	Assessment and creel data assembled and assessed to decide what steps to take next to restore the River Wye.
Everest et al (1986)	Chinook, Coho salmon and steelhead	Off-channel ponds, instream bouldering, berms (v-dams) and LWD, gravel	Population and smolt production	Several interventions used in an attempt to improve the habitat for salmonids in the river system, which was previously degraded and lacked suitable microhabitats for sheltering and smolting.	Data provided in other papers covered by the search with longer time-spans
Everest et al (1985)	Chinook, Coho salmon and steelhead	Off-channel ponds, instream bouldering, berms (v-dams) and LWD, gravel	Population and smolt production	Several interventions used in an attempt to improve the habitat for salmonids in the river system, which was previously degraded and lacked suitable microhabitats for sheltering and smolting.	Data provided by other papers covered in the search with longer time-spans
Goldberg et al (1995)	Chinook and sockeye salmon	Debris structures and channel modifications	Microhabitat preference	Use of instream devices to mitigate effects of flow alteration downstream of a hydroelectric dam showed that fish preferred debris structures to engineered instream structures and both over natural (comparator) sites.	Snorkeller observations and electrofishing surveys using stopnets around structures. Data not extracted as species figures presented as percentages of total fish counted.
Hale (1969)	Trout	Habitat improvement-artificial deflectors and log shelters	Changes in angling and standing crop	Increase in fish abundance in treated sections after improvement work in YOY and older trout. Angling catch rate (fish per man hour) increased in treated sections but decreased in the reference sections.	Electrofishing of control and altered sections and angling creel data collected.

Hubert & Joyce (2005)	Cutthroat Trout(Age-0)	Habitat type (artificially created)	Presence of trout	Stream modified with artificial pools and riffles and riparian (willow) planting is sampled for Cutthroat Trout (age-0) at riffle, riffle margin, pool margin and backwater. Stream margin habitats more popular with trout than riffles.	Field survey using electrofishing
Hunt (1976a)	Trout	Stream bank covers and current-deflector devices	Brook trout production	Studies showed habitat was degraded and so major renovation was undertaken, leading to changed morphology and an increase in fish numbers. Labour and equipment proved to be highly costly compared to the actual cost of the devices.	Semi-annual electrofishing surveys to measure the number of fish stock in the river. Data extracted from other papers by author.
Hunt (1969)	Trout (Brook trout)	Bank covers and current deflectors	Increased production	Increases in trout numbers attributed to higher overwinter survival than recruitment or growth.	Electrofishing to enable mark-recapture. Multiple papers by author cover experiment and so data extracted from another source.
Hunt (1976b)	Trout	Bank covers and current deflectors	Biomass, size and number	Paper shows that although increases were observed during the first few years after installation of devices, the greatest improvements in fish size and number became apparent after a longer time scale (after the initial three years).	Electrofishing to enable mark-recapture. Multiple papers by author cover experiment and so data extracted from another source.
Keith et al (1991)	Salmonids	Riparian and instream cover	Abundance	Findings showed that abundance decreased in all stream sections, but at a greater rate in the closed canopy cover sections. In streams with and without instream cover, the only noticeable result reported was greater abundance in Age-1 and older fish in streams with instream cover than without.	Instream cover removed from pools. Alder brush bundles placed in sections and overhead alder cover removed from some sections. Some sections were stocked with fish to increase numbers. Electrofishing technique used for fish measurement.
Lacey & Millar (2004)	Salmonids-Coho salmon and steelhead	Instream LWD and rock groyne structures	Modelled fish habitat increases	Paper reports that modeling simulations suggest greatest increase in the weighted useable area at periods of high flow.	Use of 2D monitoring software (River2D) based on field survey data.
Lamouroux and Capra (2002).	Fish	Habitat alteration	Modeled outcomes.	Simple predictions of instream habitat model outputs for target fish populations- suggest they should be used as part of the restoration planning process.	Use of habitat modeling software compared to real site derived data.
Mamorek et al	Salmonids	Multiple	Population	Report on multiple watersheds which have had	Data assembly and synthesis of projects

(2004)			increase	restoration work carried out- Findings ask for more and better information on projects; hypotheses and monitoring were lacking; data retrieval requires significant effort; space & timing need more thought in experiments; scale of studies and comparative scale of inferences are not appropriate.	carried out in the region to evaluate their successes.
O'Grady (1995)	Salmonid rivers	Enhancement works	Increased fish production	Looks at river enhancement in Ireland, including cost-benefit factors and the importance of monitoring. Concludes that instream and riparian-pruning methods are more effective than stocking or smolt ranching.	Reviews and discusses the costs and effects of a number of instream enhancement projects
Shields et al (1998)	Fish- mainly cyprinids and centrarchids.	Addition of spurs to stone toe- also included willow planting	Fish and fish habitat.	Found that the addition of the spurs to the stone toe created different habitat features that may be of preference to different fish species than the straight run sections present before- fish populations reflected this but in part was confounded by beaver dams.	Stone spurs added to toe and willow planted on opposite bank. Physical habitat characteristics and fish types and numbers monitored. Beaver dams affected fish populations.
Summers et al (1996)	Trout	Rehabilitation	Restoration of populations	Guidance manual on restoring rivers for trout populations. Discusses limitations of knowledge.	Contains further reading at each section on each type of habitat alteration intervention although no useable data
Swales & O'Hara (1983)	Dace, chub and other species	Low dams, current deflectors and artificial cover structures	Fish distribution and abundance	Paper found that fish populations increased after habitat improvement had taken place, but also that fish relocation had occurred, with large densities of fish being found around the improvement structures, especially the artificial cover devices and the pools associated with the low dams.	Boat electrofished using stopnets for each study section before and after the devices were installed.
Tarzwell (1938)	Trout	Instream devices- unclear	Fish yield and creel counts	Stream improvement devices increase the food production, and the growth rate and number of trout compared to an unimproved stream.	Several studies carried out including invertebrates and creel counts but stocking had taken place in control reach at different levels.
Thompson (2002)	Channel Morphology	Instream Habitat improvement	Long term changes in	Paper found over a long term many instream structures had lead to levels of unintended bank	Fieldwork involved site histories and measurement of 40 instream structures.

		structures	morphology and environment	erosion and a loss of riparian vegetation and overhead cover in modified reaches.	
Vehanen et al (2003)	Grayling (*Thymallus thymallus*)	Constructed islands, reefs, and cobble and boulder structures	Habitat preference	Paper reported the importance of awareness of other factors operating on a river system that has been identified for restoration, as these may impact on any improvement attempts. High fishing pressures, and underlying issues such as nutrient load are two such factors mentioned.	2D hydraulic modeling used on data from echo sounder, Doppler device, tachometer and scuba surveys. Tagged grayling were monitored and tracked.
Wu et al. (2000).	Steelhead Trout	Stream Bank Improvements (Vegetation Stability Index)	Abundance	Looks at the economic effects of stream restoration projects in Oregon but also includes some data from case studies regarding vegetation cover and fish numbers.	Data sets used from other studies.
Yrjana et al (2002)	Salmon	Confounded habitat changes & stocking	Density of wild salmon fry	Stocking and wild fry densities in modified river channels undergoing restoration have limited success, wider work needs to be undertaken	Field surveys using electrofishing; catch data
Yrjana et al (2002)	Salmon	Spawning, habitat & nursery improvement measures and fishways.	Increase populations	Despite a number of measures to improve habitat and increase numbers, recovery of salmon numbers appears to be slow. Concludes that instream restoration and stocking are not enough, and wider schemes such as integrated river management are needed to increase salmon numbers.	Rod catch data, electrofishing for parr, smolt trapping and mark recapture have been used to measure fish numbers following habitat enhancement- rivers stocked heavily throughout.
Flow modification					
Biggs et al (1998)	Macrophytes and aquatic macroinvertebrates	River channel restoration e.g. remeandering	Species richness, rarity and abundance	Plant species showed recolonisation to at least pre-works levels during the survey time, whereas macroinvertebrates took longer to recover. Abundance increased but species richness was slower to recover.	BACI design with upstream control sections. Macroinvertebrates surveyed using kick and sweep sampling or core sampling.
Booker & Dunbar (2004)	Chub, roach and dace	Channel modification-straightening	Modelled habitat suitability	Models channelled urban rivers to measure impact of channelling on available habitat.	PHABSIM used based on data from two study sites using degrees of modification
Capra et al	Brown trout	Natural and	Fish abundance	Software to predict trout populations in streams	EVHA and MODYPOP modeling software

(2003)		bypassed stream reaches		suggests discharge fluctuations effect populations positively as ease effects of high discharge	used, compared with electrofishing data
Connor et al. (2003)	Chinook salmon	Summer flow augmentation	Survival	Measure survival of tagged salmon in a flow augmented river but control is hypothetical model- predicts summer flow augmentation enhances survival	Field sampling and PIT-tagging but using a modelled control
Connor & Pflug (2004)	Salmon – Pink, Chum and Chinook	Water flow	Distribution and density (abundance)	Measure abundance and spatial distribution of salmon in three reaches before and after flow management measures- suggests salmon numbers improved after implementation.	Field study for flow retrieval, fish data acquired from WDFW and compared for before and after
Covington & Hubert (2003)	Brown Trout	Summer flows	Abundance and biomass	Measure trout abundance at sites with natural flow and "less than natural" flow, suggestion higher and lower numbers and biomass of trout respectively.	Sites surveyed, fish abundance estimated for control and intervention
Hagen & Baxter (2004)	Rainbow Trout	Habitat types and channelisation	Population size	Investigate habitat use and abundance of trout in watershed system using radio telemetry- showed fish preferred deeper pools in low flow and didn't like channelised sections.	Radio telemetry of angled catches and diver counts
Jutila et al (2001)	Brown Trout	Instream and catchment characteristics in dredged streams	Density	Study of rivers with both dredged and non-dredged sample sites to assess abundance of trout, shows trout prefer the more complex habitats and pools	Field surveys using electrofishing at control and treated sites
Oscoz et al (2005)	Fish - various	Channelisation	Fish density and biomass	The effects of channeling a stretch of river during highway construction on fish populations upstream, downstream and in the channeled section. Compares channeled with natural, and finds lower density and biomass of fish in modified sections.	Field sampling using electrofishing with control and treatment sections
Habitat characteristics					
Bryant et al (2005)	Anadromous salmonids	Habitat variables	Population estimates	Monitoring aquatic habitat for salmonids can give good estimates of population. Relationships between habitat features are not always clear but can be demonstrated with pools and LWD.	Used statistical models to calculate fish populations and compared to field data from correlative data from multiple sites.
Franco & Budy	Trout and	Biotic and	Distribution,	Looks at trout and salmon populations along a river	Field sampling using electrofishing,

(2005)	salmon	abiotic habitat components	abundance and condition	in relation to biotic and abiotic factors inc substrate size	dissection
Legalle et al. (2005).	Bullhead	Microhabitat features	Weighted useable area predictions	Compares stretches of reach with differing habitat characteristics with Bullhead distribution	Field sampling using electrofishing
Legalle et al. (2005)	Bullhead	Stream width, slope and substrate	Population density	Compares stretches of a river with differing habitat characteristics with Bullhead distribution	Field sampling using electrofishing
Rich et al (2003)	Bull Trout	Local habitat features	Fish occurrence	Bull trout were positively associated with presence of LWD and channel width, other associations detailed too.	Correlative data compiled on habitat conditions of 112 streams, which were single-pass electrofished to assess fish occurrence.
Roni (2002)	Oncorhynchus sp.	Habitat charicteristics	Fish density, size and weight	Greater numbers of often larger fish were found in pools compared with riffles. Suggests reach or watershed scale characteristics are better predictors of fish density than microhabitat characteristics.	Correlative study of 30 streams comparing habitat variables with fish and salamander densities using multiple-removal electrofishing.
Sharma & Hilborn (2001)	Coho salmon	Watershed characteristics	Smolt abundance	Study reports that pool and pond densities in streams act as an indicator of smolts and productivity.	Correlative study comparing watershed characteristics at different sites in relation to smolt abundance, ascertained from fish count studies.
Land management & catchment scale works					
Erman & Mahoney (1983)	Macro-invertebrates	Logging buffer strips	Macro-invertebrate diversity	Study observed a positive association between buffer width and macro-invertebrate diversity. Concludes that narrow buffers are no more effective than rivers without buffer strips in the recovery of logged ecosystems.	Water was sampled, river characteristics were recorded and macro invertebrate diversity measured using Surber sampling.
Knapp et al (1998)	Golden Trout	River width and bank vegetation	Age-0 trout and redd density	Compares stream morphology on trout spawning at both narrow, vegetated sites and grazed wider reaches- grazed areas had higher densities of smaller fish, and spawning habitat was the limiting factor.	Field survey using electrofishing on narrow and grazed river sections
Koed et al (2006)	Atlantic	Dyke removal	mortality	Restoration works caused development of a lake	Tagging and tracking individuals,

	salmon and brown trout	and re-meandering		which led to increased threat of predation for migratory fish.	electrofishing for smolts suspected of being predated.
Opperman & Merenlender (2004)	Steelhead	Riparian restoration	Improved fish habitat	Paper finds that, when compared to in-stream devices, riparian restoration produces more comprehensive and sustainable benefits, as well as being more cost-effective.	Riparian restoration and use of exclusion fencing on treatment reaches- changes in habitat compared with those in control reaches. Compares cost and performance of in-stream v riparian restoration.
Rieman et al (2001)	Salmonids	Federal land management alternatives	Predicted status and distribution of salmonids	Findings from this study suggest that an active but cautious management plan would yield the best results, with an aggressive scheme providing the worst results, and the status quo falling somewhere in the middle.	Used Bayesian Belief Networks to estimate effects of different management schemes on salmonid populations over 100 years.
VanDusen et al. (2005).	Brook Trout	Logging	Density and biomass	Brook Trout habitat preferences at sites that have been subjected to logging shows recently logged areas have smaller populations than areas logged previously.	Field survey using electrofishing
Log Jams					
Pess et al (2005)	Salmonids	Engineered log jams	Fish density	Engineered log jams appear to increase number of juvenile salmonids and provide preferential habitat compared with control sites.	Control and treatment data collected, some before data available. Fish counts using snorkel lanes.
Revetments					
O'Grady et al (2002)	Salmon and trout	Log bank revetment (and minor debraiding)	Fish density	Log bank revetments were used along a degraded Irish river. Results indicate altered channel morphology and the beginnings of plant recolonisation. Increases of fish stocks were reported for the modified reaches compared to control sections.	Electrofishing data used to measure abundance. Not all sections monitored over same time period. Insufficient data presented for robust extraction.
Riffles					
Gore et al (1998)	Benthic (macro invertebrate) communities	Artificial riffles	Habitat suitability	Model effects of two artificial riffles put into a stream using PHABSIM, focuses on the benthic macro invertebrate populations suitable habitat	PHABSIM habitat simulation
Weirs					

Gowan (1995)	Trout	Low log weirs	Population	Found that abundance and biomass of adult fishes increased, but believed to be due to immigration rather than population increase.	Used mark-recapture to look at trout responses to low log weirs. Data not extracted as thesis abstract only obtained.
Woody Debris					
Bilby & Fransen (1992)	Fish inc Steelhead and dace	LWD	Fish density	Addition of LWD increased pool area in treatment sections. Fish numbers were found to increase at all sites. Dace increased most in the enhanced reach containing LWD.	Methodology not presented. Data gathered at three sites, one with added LWD, and two without. Of the two without, one had canopy cover and the other did not.
Brooks et al (2004)	Fish- Australian species	Woody Debris	Fish abundance, species richness	Engineered logjams appear to improve species richness and abundance in Australian fish species.	BACI field surveys using electrofishing
Bunt et al (1999)	Brown Trout	Flow (pulsed discharge), woody debris & pools	Fish movement	Looks at effects of high and low flow on Brown Trout populations by measuring fish movements to show microhabitat preference- pools and LWD most popular.	2D modeling of available habitat, fish radio-tagging
Coulston & Maughan (1983)	Salmonids	Removal of natural woody debris	Trout numbers	Looking at the effects of removal on trout populations, so the habitat restoration in this example is removal of woody debris	BACI experimental design whereby restoration is removal of LWD (degradation)
Fausch & Northcote (1992)	Coho salmon and cutthroat trout	LWD	Biomass	Individual and overall fish biomass was greater in the complex sections that contained LWD than those where the LWD had been removed.	Naturally occurring LWD was removed from sections of a stream and these were compared with reaches where LWD had not been removed. Not included for meta-analysis as LWD removal was a form of habitat degradation and so is not the same as addition or natural variation.
Gore & Hamilton (1996)	trout & benthic macroinvertebrate potential habitat	weirs	increase in potential habitat	Models effects of weirs in variable flow conditions on fish (trout) and benthic macroinvertebrate populations.	Comparison of PHABSIM and published data on a comparable water body.
Harvey (1998)	Cutthroat trout	Naturally occurring LWD	Retention and immigration	Measuring pairs of complex and simple ponds (complex ponds containing naturally occurring	Multiple pass electrofishing used to collect fish, which were injected with a PIT tag

				instream matter, usually LWD, tree roots and boulder) fish were tagged and measured over time to see which pools were preferred. Concludes that the presence of woody debris appeared to affect retention but not immigration or growth.	into body cavity and monitored at river sites.
Keim et al (2002)	Salmonids	LWD	Increase in physical habitat	Paper looks at effects of LWD in creating physical habitat for salmonids when LWD source is from riparian alder rather than conifers.	Site surveys in stream sections before and after the addition of LWD to monitor changes in the channel morphology.
Larson et al (2001)	Streams	Large woody debris addition	Habitat condition and benthic macro-invertebrates	Looks at a number of projects within the Puget Sound Lowland urban basin in Washington, and the effects of LWD on benthic macro invertebrates and environmental conditions. Found less effectiveness of LWD addition in urban rivers than has been reported for forested rivers, and concluded that LWD did not improve the biological conditions.	Selected six restoration projects and measured characteristics. Used a Surber sampler to identify macro invertebrate populations.
Neumann & Wildman (2002)	Brook trout and brown trout	LWD	Habitat use	Findings indicate that both LWD and FWD correlate with trout density, and that woody debris is an important part of habitat.	Site inventories and fish counts by snorkel counts.
Nicol et al (2004)	Carp and Australian native species	Habitat restoration using LWD	Distribution and abundance	Findings showed that Carp were not strongly associated with habitat features, whereas native species were strongly associated with LWD.	Compared treatment and control reaches, fish measured using boat mounted electrofishing
Nislow et al. (1999)	Atlantic Salmon, Invertebrates	Instream remediation e.g. large woody debris	Amount of potential habitat, fish retention	Suggests that addition of large woody debris increases the amount of potential habitat and foraging habitat, increasing salmon retention.	Mathematical modeling based on field and lab observations, compared with real findings.
Roni and Quinn (2001)	Oncorhynchus sp.	Large woody debris	Densities of fish	Suggests that woody debris placement leads to higher densities of salmonids, especially during winter.	Correlative study on amount of LWD and number of fish in treatment and reference sites using multiple-removal electrofishing.
Rosenfeld & Huato (2003)	Pool formation	Large Woody Debris	Pool frequency and quality	LWD with a diameter of >60cm is likeliest to cause pool formation, especially across wider channels.	Field survey and statistical analysis
Sundbaum & Naslund (1997)	Brown Trout	Woody debris	Growth and behaviour	Study found that although individual fish biomass decreased in both control and treatment streams, the	Experiments comparing woody debris and non-LWD streams carried out outdoors

					biomass decrease was less in those streams with LWD. Concludes that the LWD decreases intraspecific competition through visual isolation.	with wild fish and also indoors with hatchery stock. No population density data measured.
Sundbaum, K. (2001)	Brown trout	woody debris	multiple		Study of effects of LWD on Brown Trout in both stream and artificial conditions- data not included but author contactable	Concludes that trout prefer WD as habitat, and addition of LWD increases the number of feeding sites and visual isolation.