Miscellaneous

574) Abe, K., and R.R Ziemer. 1991. Effect of tree roots on shallow-seated landslides. In: Proceedings, Geomorphic Hazards in Managed Forests, XIV IUFRO World Congress, 5-11 August 1990, Montreal, Canada. USDA Forest Service, General Technical Report PSW-130. Pages 11-20. (K)

Author abstract: Forest vegetation, especially tree roots, helps stabilize hillslopes by reinforcing soil shear strength. To evaluate the effect of tree roots on slope stability, information about the amount of roots and their strength should be known. A simulation model for the root distribution of *Cryptomeria japonica* was proposed where the number of roots in each 0.5.cm diameter class can be calculated at arbitrary depths. The pull-out strength of roots was used to analyze the stability of four different types of forested slopes. Root reinforcement is important on slopes where roots can extend into joints and fractures in bedrock or into a weathered transitional layer between the soil and bedrock. Root reinforcement of soil increases quickly after afforestation for about the first 20 years, then remains about constant thereafter.

575) Alabyan, A.M., and R.S. Chalov. 1998. Types of river channel patterns and their natural controls. Earth Surface Processes and Landforms. 23: 467-474. (A, G)

Author abstract: River channel patterns are thought to form a morphological continuum. This continuum is two-dimensional, defined by plan features of which there are three (straight, meandering, branching), and structural levels of fluvial relief of which there are also three (floodplain, flood channel, low-water channel). Combinations of these three categories define the diversity of patterns. One of the most important factors in channel development is stream power, defined by water discharge and river slope. The greater the stream power, the stronger the branching tendency, but threshold values of stream power are different for the three different hierarchical levels of channel relief. The critical stream power values and hydrological regime together define the channel pattern, and analysis of the pattern type can be undertaken using effective discharge curves.

576) Anderson, L., and M. Bryant. 1980. Fish passage at road crossings: An annotated bibliography. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, General Technical Report PNW-117. 10pp. (K)

Author abstract: A report of special interest to fishery biologists, resource managers, hydrologists, and road engineers, this bibliography lists publications pertinent to road crossings of salmon and trout streams. Topics include bridge and culvert installation, design criteria, mechanics, hydraulics, and economics, as well as their biological effects.

577) Anonymous. 2000. abstracts. International Conference on Wood in World Rivers, 23-27 October 2000, Oregon State University, Corvallis. 139pp. (A, C, D, F)

Compiler abstract: This document contains all of the abstracts from plenary sessions, contributed papers, and posters presented at the International Conference on Wood in World

Rivers. Major topics included geomorphology, budgets and modeling, and biological relationships and restoration.

578) Armour, C.L. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. US Fish and Wildlife Service, Fort Collins, Colorado, Biological Report 90(22). 13pp. (J)

Author abstract: Procedures are presented for evaluating temperature regimes for fish. Although examples pertain to spring chinook salmon (*Oncorhynchus tshawytscha*), the principles apply to other species. Basic temperature tolerance relationships for fish are explained and three options are described for comparing alternative temperature regimes. The options are to base comparisons on experimental temperature tolerance results, suitability of a simulated temperature regime for key life stages, or population statistics and predicted responses to simulated temperatures.

579) Bartholow, J.M. 2000. Estimating cumulative effects of clearcutting on stream temperatures. Rivers. 7: 284-297. (H, J)

Author abstract: The Stream Segment Temperature Model was used to estimate cumulative effects of large-scale timber harvest on stream temperature. Literature values were used to create parameters for the model for two hypothetical situations, one forested and the other extensively clearcut. Results compared favorably with field studies of extensive forest canopy removal. The model provided insight into the cumulative effects of clearcutting. Change in stream shading was, as expected, the most influential factor governing increases in maximum daily water temperature, accounting for 40% of the total increase. Altered stream width was found to be more influential than changes to air temperature. Although the net effect from clearcutting was a 4^{o}C warming, increased wind and reduced humidity tended to cool the stream. Temperature increases due to clearcutting persisted 10 km downstream into an unimpacted forest segment of the hypothetical stream, but those increases were moderated by cooler equilibrium conditions downstream. The model revealed that it is a complex set of factors, not single factors such as shade or air temperature, that governs stream temperature dynamics.

580) Belt, G.H., J. O'Laughlin, and T. Merrill. 1992. Design of forest riparian buffer strips for the protection of water quality: Analysis of scientific literature. Idaho Forest, Wildlife and Range Policy Analysis Group Report No. 8. written by the Idaho Forest, Wildlife and Range Policy Analysis Group, and the Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow. 35pp. (C, D, E, F, H, I, J)

Author abstract (Author Executive Summary): The primary purpose of this report is to identify, evaluate, and synthesize research-based information relating riparian buffer strips to forest practices, water quality, and fish habitat.

Scientific literature documenting the role and importance of buffer strips in reducing the impacts of forest practices is extensive. More than 300 scientific papers were located and reviewed; nearly 100 papers and documents were found to be relevant and are cited in this report. Information was extensive on some topics and surprisingly limited on others. A substantial amount of information was found regarding stream temperature changes resulting from the removal of riparian vegetation. Much recent research has focused on the importance of large organic debris (LOD) and how it can be affected by timber harvest. In contrast, little information was found on slash burning and sediment production within buffer strips. Research on some topics was in a case study format, making generalization difficult.

Objectives for this report are stated as five focus questions around which the report is organized: [1] What is a buffer strip? [2] How do forest practices within buffer strips affect water quality and fish habitat? [3] How effective are buffer strips in reducing impacts of forest practices? [4] What are the issues in buffer strip design? [5] What models are available for use in buffer strip design? A summary of replies to these focus questions is provided in a short section immediately following this executive summary.

This literature review suggests that scientists are at different stages in their understanding of the several important functions provided by buffer strips, which include temperature moderation, sediment filtration, and LOD recruitment. The importance of buffer strips in moderating the impacts of forest practices on water quality and fish habitat is generally understood, even though quantitative relationships are difficult to establish. Research on the effects of canopy removal on stream temperature has resulted in a practical understanding of the problem and some useful predictive models. In two other areas that have received recent emphasis--the impacts of forest practices on LOD recruitment and the aquatic food chain--knowledge is more descriptive. Some predictive models have been developed, but their utility is limited.

Information on the sediment filtering function of riparian buffer strips is limited. Much of what is known is inferred from the special case of buffer strips between a road and a stream. The important problem of cumulative effects within buffer strips has not yet been satisfactorily addressed. Existing studies, including those on slash burning, point out the potential for the accumulation of nutrients and chemicals along with sediment from both agricultural and forestry operations in riparian areas and the possible impacts on water quality and fisheries.

Studies describing different approaches to establishing buffer strip widths are limited. Despite literature describing the utility of variable width buffer strip models and their use in other states in the Pacific Northwest, no studies were found documenting the advantages or disadvantages of variable width buffer strips, as compared to minimum fixed width buffer strips.

Based on this literature review, two ideas seem to stand out as having some potential to enhance the effectiveness of buffer strips: (1) the use of a simplified field procedure (such as the TFW model in the State of Washington) for determining the impact of canopy removal on stream temperature, and (2) the use of variable width buffer strip models to address site-specific biological or physical requirements of the stream or riparian zone.

581) Bragg, D.C., and J.L. Kershner. 2002. Influence of bank afforestation and snag angle-of-fall on riparian large woody debris recruitment. In: Proceedings of the Symposium on the Ecology and Management of Dead Wood in Western Forests, 2-4 November 1999, Reno, Nevada. W.F. Laudenslayer, Jr., P.J. Shea, B.E. Valentine, C.P. Weatherspoon, and T.E. Lisle, Technical Coordinators. USDA Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-181. Pages 65-70. (D)

Author abstract: A riparian large woody debris (LWD) recruitment simulator (Coarse Woody Debris [CWD]) was used to test the impact of bank afforestation and snag fall direction on

delivery trends. Combining all cumulative LWD recruitment across bank afforestation levels averaged 77.1 cubic meters per 100 meter reach (both banks forested) compared to 49.3 cubic meters per 100 meter reach (one side timbered). Both bank afforestation and snag fall patterns generated significant differences in riparian LWD delivery, but there was no noticeable interaction. Scenarios with only one bank forested delivered 15 to 50 percent less LWD than their two bank counterparts. Snag fall patterns also produced statistically different LWD recruitment, with some registering only 35 to 52 percent of the most productive fall patterns. These results suggest testing the assumptions of random snag fall from two forested banks before modeling riparian LWD recruitment.

582) Braudrick, C.A., and G.E. Grant. 2000. When do logs move in rivers? Water Resources Research. 36: 571-583. (D)

Author abstract: throughout the world, yet we know little about hydraulic thresholds for movement and transport of logs. We developed theoretical models of entrainment and performed flume experiments to examine thresholds for wood movement in streams. Both the model and the experiments indicate that log entrainment is primarily a function of the piece angle relative to flow direction, whether or not the log had a rootwad, the density of the log, and the piece diameter. Stability increased if the pieces had rootwads o r were rotated parallel to flow. Although previously reported as the most important factor in piece stability, piece length did not significantly affect the threshold of movement in our experiments o r our physically based model, for logs shorter than channel width. These physically based models offer a first-order approach to evaluating the stability of either naturally derived woody debris or material deliberately introduced to streams for various management objectives. Large woody debris is an integral component of forested, fluvial systems

583) Center for Transportation and the Environment. 2002. Aquatic organism passage at road-stream crossings. CTE Information Services, North Carolina State University, Raleigh. 39pp. (K)

Compiler abstract: This document summarizes research projects on aquatic organism passage at road-stream crossings that were in progress at the time the literature search was conducted. Projects summaries include abstracts as well as contact information, funding sources, project status, and funding amount. Project summaries are divided into sections on hydrology, culverts, habitat, and fish passage.

584) Center for Transportation and the Environment. 2002. Impacts of culverts on anadromous and non-anadromous fish passage II. CTE Information Services, North Carolina State University, Raleigh. 10pp. (K)

Compiler abstract: This annotated bibliography focused on the effects of culverts on aquatic organisms. The references focused primarily on the effects of culverts on fish passage. Few of the studies mention bridges, and none of them addressed bridges versus culverts.

585) Church, M., and B. Eaton. 2001. Hydrological effects of forest harvest in the Pacific Northwest. Riparian Decision Tool Technical Report #3 written by the Department of Geography, University of British Columbia, Vancouver. Written for the Joint Solutions Project, reporting to the Central Coast Land and Resource Management Plan. 55pp. (B, D, F, G, I)

Author abstract (Author Introduction): This report reviews experience in the coastal part of the Pacific Northwest region of North America of the effects of forest harvest upon hydrological regime and water quality, upon sediment mobilisation and delivery to stream systems, and their impacts upon hydroriparian habitat and ecosystems. For purposes of review, the "Pacific Northwest" is understood to encompass the forested Pacific slope between northern California and southern Alaska. This forested coastal region of broadly similar marine climate is distinguished by the massive size and remarkable longevity of the principal coniferous tree species. Climate and physiography impose a distinctive hydrological regime throughout the region. In consequence, practice and effects of forest management, including road building and forest harvest, are also in many respects regionally distinctive. These circumstances dictate that a review of land management impacts upon hydrology and sedimentation be regional in character. Knowledge of the environment and patterns of environmental disturbance within the Pacific Northwest are at least qualitatively indicative of conditions that may be expected at any particular place within the region.

The report has two major sections. The first gives a review of hydrological and sediment-related effects of forestry practices in the coastal Pacific Northwest. The second makes an interpretation of hydrological and sediment-related effects and presents recommendations for management of hydrology and hydroriparian zones, based on the documented experience, that should lead to sustainable land use. These recommendations are similar to ones made in the final report of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound.

586) Copstead, R.L., K. Moore, T. Ledwith, and M. Furniss. 1998. An annotated bibliography. San Dimas Technology and Development Center, San Dimas, California. 160pp. (G, I))

Author abstract (Author Introduction—First paragraph): This document contains references comprises a snapshot of references relating to interactions between low volume roads and hydrology, particularly for forested land. It is intended to be a companion to the water/road interaction technology series of publications coordinated by the San Dimas Technolo gy Development Center and sponsored by USDA Forest Service Engineering Staff to identify information and methods on hydrological aspects of developing, operating, and managing forest roads. The goals of the effort are to 1) help communicate state-of-the-art water/road interaction information effectively among field personnel, 2) identify knowledge gaps, and 3) provide a framework for addressing future research, development and technology needs on this subject.

587) Cordone, A.J., and D.W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game. 47: 189-228. (I)

Author abstract (Author Scope): This report is essentially a review of investigations made of the effects of inorganic sediment on the aquatic life of streams. It is not a complete literature review but rather a summary of most of the pertinent investigations that we believe will assist the fisheries worker faced with sediment problems. No references are included on studies of any type of chemical pollutants even though the waste material contained large amounts of sediment, such as when tailings from heavy-metal mining operations are discharged to waterways. In such cases, the physical influence of inorganic sediment on aquatic life cannot readily be separated from damage done by toxic heavy metals in solution. This is true also for chemicals used in floatation processes during mineral extraction.

Of fundamental importance in comprehending the modes by which sediment modifies the aquatic habitat is knowledge of the physical nature of sediment and its movements in flowing waters. Sediment arises from a multitude of soil types, varies greatly in shape, size and density, and enters flowing waters which vary in velocity, temperature, flow, and turbulence. The complex problems involved here are studied by the geologist, the soil scientist, and the hydraulic engineer. Fisheries biologists working on sedimentation problems should be aware of this work and familiar with the basic concepts of erosion and sedimentation, but a review of the literature on this subject was beyond the scope of this report. We mention it here only to mark its extreme importance.

For comprehensive reviews of the problems created by sediment in our waterways which confront land and water uses other than aquatic life, see Einstein and Johnson (1956) and Gleason (1958). See Cordone (1956) for a review of the literature on the effects of logging on fish production.

Detailed physical descriptions of how rainfall and runoff erode soil were presented by Osborn (1955) and Gottschalk and Jones (1955). These reports are helpful in understanding the factors governing sediment movement into or within a streambed.

588) Fischer, R.A., and J.C. Fischenich. 2000. Design recommendations for riparian corridors and vegetated buffer strips. US Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, Mississippi, ERDC TN-EMRRP-SR-24. 17pp. (B, C, F, I, J)

Compiler abstract: Effective riparian buffers are those that are designed to meet specific management objectives, such as protection of water quality, wildlife habitat, or steam bank stabilization. As a result, there is no one-size-fits-all riparian buffer that can achieve all objectives. General design criteria for riparian buffers include placement within watersheds, composition and density of vegetation, buffer width and length, and slope. For example, buffers along headwater streams (i.e. 1^{st}-3^{rd} order) are the most effective for protecting water quality, and continuous buffers are more effective at moderating stream temperatures and reducing gaps in protection from non-point source pollution. The authors summarize recommended buffer widths identified in the scientific literature for various management objectives. Tables of recommended buffer widths are provided for water quality considerations; for maintaining plant species diversity, reptiles and amphibians, mammals, invertebrates, fish, and birds; stream stabilization; flood attenuation; and detrital input. The authors also identify the relative effectiveness of different vegetation types (i.e. grass, shrub, tree) for specific benefits, such as stabilizing bank erosion, trapping sediment, filtering nutrients, preventing bank failures, providing aquatic habitat, providing wildlife habitat, providing visual diversity, and providing economic products.

589) Fortino, K., A.E. Hershey, and K.J. Goodman. 2004. Utility of biological monitoring for detection of timber harvest effects on streams and evaluation of Best Management Practices: A review. Journal of the North American Benthological Society. 23: 634-646. (C, I)

Author abstract: Best Management Practice (BMP) guidelines have been developed to reduce the negative impacts of timber harvest on streams. BMPs are widely implemented, but the effectiveness of timber harvest BMPs has not been evaluated using modern biological monitoring techniques. Most current biological monitoring is based on 1 of 2 main approaches: multimetric monitoring or predictive modeling. These approaches differ considerably, and their respective merits and failings have been debated extensively in the literature. Our review evaluated the ability of these biological monitoring approaches to detect timber harvest effects and to assess the effectiveness of BMPs. Both techniques detect impairment via changes in macroinvertebrate community structure, despite their differences in approach. Most of the negative effects of timber harvest result in changes in the macroinvertebrate community, so we have concluded that both techniques should be effective for the evaluation of timber harvest and BMPs.

590) Gende, S.M., R.T. Edwards, M.F. Willson, and M.S. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. BioScience. 52: 917-928. (C, D, E)

Compiler abstract: Salmon runs have been declining for many years in the Pacific Northwest. Interest in preserving these runs and the importance of salmon derived nutrients has sparked much research on the impacts of salmon on both freshwater and riparian communities. This article reviews what is currently understood about how salmon can function as important elements in ecological systems. Focus is directed on five species of Pacific salmon which have similar life histories: chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*), chum (*O. keta*), and pink (*O. gorbuscha*). The authors expand on previously written reviews involving salmon and include current research that has changed and expanded earlier notions about how salmon contribute to ecosystem processes. The authors also give details on the magnitude, composition, and distributions of salmon inputs into both terrestrial and aquatic systems and consider how natural variations may affect them. A schematic is drawn based on previously conducted studies, which depicts the pathways and products of salmon-derived nutrients and how they are retained in other systems. The authors discuss how variation in salmonid ecosystems could influence the efforts of managers and conservationists and offer some new direction for research to fill in existing gaps in our understanding.

591) Gomi, T., R.C. Sidle, and J.S. Richardson. 2002. Understanding processes and downstream linkages of headwater systems. BioScience. 52: 905-916. (A, B, C, D, E, F, G, H, I, J)

Compiler abstract: The authors of this article state that the roles of headwater streams in a watershed and the linkages between headwaters and down stream systems are poorly understood. The objectives of this article as per the authors are to review characteristics of headwaters and larger watershed systems and the differences that exist between them. The authors also demonstrate both spatial and temporal variations of biological and geomorphic processes in headwater systems and how they link to downstream systems. The primary area of focus in this article is on steep headwater systems of >4^{o} gradient in forested areas. The authors cite many studies conducted in this area of research and present an informative table of characteristics of hydrological, biological, and geomorphic processes that occur specifically in the Pacific Northwest. Conclusions reached by the authors are bulleted points on how headwater systems are characterized by the above mentioned processes that occur in and along hillslopes, transition channels, zero-order basins, and first- and second-order channels. One such conclusion is that the expansion of hydrologically active areas increases the chance of mass movements and can alter the flow paths between the aquatic and terrestrial environments in periods of increasing wetness. Conclusions are also offered as to how hydrological, geomorphic, and biological processes are affected by headwater tributaries that flow into the downstream reaches. One such example is that spatial and temporal variations in processes that occur in headwater streams are critical in the dynamics of the ecosystems of streams and can affect the heterogeneity of channel networks in riparian and riverine landscapes.

592) Gregory, S.V., K.L. Boyer, and A.M. Gurnell (Editors). 2003. The ecology and management of wood in world rivers. American Fisheries Society, Bethesda, Maryland, Symposium 37. 444pp. (D)

Electronic abstract: This book is the proceedings of the "International Conference on Wood in World Rivers" held in Corvallis, Oregon. The volume (1) synthesizes world knowledge about large wood in streams and rivers in relation to physical and ecological processes and stream restoration; (2) presents the status of knowledge of the physical dynamics and ecological interactions of large wood in streams and rivers in different geographical regions; (3) creates a framework for interpreting and potentially applying the results of research in different geographical regions and management systems; (4) identifies different management systems for large wood in rivers; (5) assesses physical and biological responses of large wood in stream restoration; and (6) explores links between primary information of the physical and ecological dynamics of large wood resource management systems, and the communities and cultures in which they are applied.

593) Gregory, S.V., A.M. Gurnell, K.J. Gregory, S. Bolton, L.A. Medvedeva, A. Semenchenco, A.N. Mahkinov, D. Sobota, J. Baurer, and K. Staley. 2000. Bibliography: World literature on wood in streams, rivers, and riparian areas. International Conference on Wood in World Rivers, 23-27 October 2000, Oregon State University, Corvallis. 74pp. (D)

Compiler abstract: This bibliography is the first draft of an effort by researchers in the United States, England, and Russia to assemble a comprehensive bibliography of wood in aquatic systems and riparian areas as part of the International Conference on Wood in World Rivers. The document contains 1,192 citations.

594) Gurnell, A.M., H. Piégay, F.J. Swanson, and S.V. Gregory. 2002. Large wood and fluvial processes. Freshwater Biology. 47: 601-619. (A, D, G, I)

Electronic abstract:

1. Large wood forms an important component of woodland river ecosystems. The relationship between large wood and the physical characteristics of river systems varies greatly with changes in the tree species of the marginal woodland, the climatic and hydrological regime, the fluvial geomorphological setting and the river and woodland management context.
2. Research on large wood and fluvial processes over the last 25 years has focussed on three main themes: the effects of wood on flow hydraulics; on the transfer of mineral and organic sediment; and on the geomorphology of river channels.
3. Analogies between wood and mineral sediment transfer processes (supply, mobility and river characteristics that affect retention) are found useful as a framework for synthesising current knowledge on large wood in rivers.
4. An important property of wood is its size when scaled to the size of the river channel. 'Small' channels are defined as those whose width is less than the majority of wood pieces (e.g. width < median wood piece length). 'Medium' channels have widths greater than the size of most wood pieces (e.g. width < upper quartile wood piece length), and 'Large' channels are wider than the length of all of the wood pieces delivered to them.
5. A conceptual framework defined here for evaluating the storage and dynamics of wood in rivers ranks the relative importance of hydrological characteristics (flow regime, sediment transport regime), wood characteristics (piece size, buoyancy, morphological complexity) and geomorphological characteristics (channel width, geomorphological style) in 'Small', 'Medium' and 'Large' rivers.
6. Wood pieces are large in comparison with river size in 'small' rivers, therefore they tend to remain close to where they are delivered to the river and provide important structures in the stream, controlling rather than responding to the hydrological and sediment transfer characteristics of the river.
7. For 'Medium' rivers, the combination of wood length and form becomes critical to the stability of wood within the channel. Wood accumulations form as a result of smaller or more mobile wood pieces accumulating behind key pieces. Wood transport is governed mainly by the flow regime and the buoyancy of the wood. Even quite large wood pieces may require partial burial to give them stability, so enhancing the importance of the sediment transport regime.
8. Wood dynamics in 'Large' rivers vary with the geometry of the channel (slope and channel pattern), which controls the delivery, mobility and breakage of wood, and also the characteristics of the riparian zone, from where the greatest volume of wood is introduced. Wood retention depends on the channel pattern and the distribution of flow velocity. A large amount is stored at the channel margins. The greater the contact between the active channel and the forested floodplain and islands, the greater the quantity of wood that is stored.

595) Heintz, R.A., B.D. Nelson, J. Hudson, M. Larsen, L. Holland, and M. Wipfli. 2004. Marine subsidies in freshwater: Effects of salmon carcasses on lipid class and fatty acid composition of juvenile coho salmon. Tansactions of the American Fisheries Society. 133: 559–567. (C, E)

Author abstract: Returning adult salmon represent an important source of energy, nutrients, and biochemicals to their natal streams and may therefore have a quantitative effect on the energy levels of stream-resident salmonids. We tested this hypothesis by constructing simulated streams for coho salmon *Oncorhynchus kisutch* to which we added 0, 1, and 4 carcasses/m^2 (0, 0.71, and 2.85 kg wet mass/m^2) of pink salmon *O. gorbuscha*. After 60 d we evaluated the lipid class and fatty acid composition of rearing coho salmon from the simulated streams; the lipid content and triacylglycerols of the coho salmon increased with increasing carcass density whereas phospholipids decreased. Increased amounts of triacylglycerols accounted for most of the lipid increase. In addition to increasing in concentration, the fatty acid composition of the triacylglycerols also changed with carcass density. Triacylglycerols of juvenile coho salmon from the control streams had significantly higher omega-3 : omega-6 ratios as a result of fivefold and sixfold increases in the concentrations of eicosapentanoic and docosahexanoic fatty acids, respectively. These data demonstrate an immediate nutritional benefit resulting from the introduction of salmon carcasses in juvenile coho salmon rearing habitat and indicate the utility of fatty acid and lipid class analysis for examining the effects of marine-derived nutrients on juvenile salmonids.

596) Kahler, T.H., and T.P. Quinn. 1998. Juvenile and resident salmonid movement and passage through culverts. Research Report No. WA-RD 457.1 written by the Fisheries Research Institute, School of Fisheries, and the Washington State Transportation Center (TRAC), University of Washington, Seattle. Written for the Washington State Department of Transportation, Olympia, Washington, in cooperation with the US Department of Transportation, Federal Highway Administration. Research Project T9903, Task 96. 38pp. (K)

Author abstract: An outcome of the Washington State Department of Transportation's Juvenile Fish Passage Workshop on September 24, 1997, was agreement that a literature review was necessary to determine the state of knowledge about juvenile salmonid movement and passage through culverts at road crossings. This report summarizes the findings of the literature review. The conclusion of this literature review is that stream dwelling salmonids are often highly mobile. Upstream movement was observed in nearly all studies that were designed to detect it, and in all species, age classes, and seasons. There are variations in the movement patterns of fish populations both between and within river systems. The role of turbulence in affecting the ability of fish to pass through culverts is poorly understood and deserves further investigation. Countersunk culverts have proved to be better for fish passage than culverts with or without other modifications for fish passage.

597) Kepkay, M., and J. Cathro. 1998. Riparian ecosystem management literature review. Silva Forest Foundation, Slocan Park, British Columbia, Canada. 21pp. (D, E, I, J)

Author abstract (Author Introduction): The value of a fully functioning ecosystem cannot be overstated. Sensitive ecosystems, such as riparian zones, are especially valuable because of the unique and essential ecological functions they perform. From high elevation sub-alpine tarns to wide intertidal estuaries, riparian ecosystems and the adjacent upland slopes provide protection to a natural system that performs a range of essential ecological functions from providing wildlife habitat to distributing nutrients across the landscape. One study suggests that the cleansing action alone of aquatic zones supported by riparian areas is worth anywhere from $400 to $1,500 per acre, per year (Tellman et al 1993).

This review encompasses a wide body of current literature on the ecological function of riparian ecosystems. The purpose is to examine the scientific rationale behind establishing protected riparian ecosystems, and discuss riparian zone management options in practice today. Specifically, this review is comprised of the following five sections: Section 2 presents several definitions of the term *riparian ecosystem* and explores the particular role this ecosystem plays in the fully functioning forest including wildlife habitat, nutrient cycling, temperature regulation, and movement corridors for plants and animals. Section 3 examines a number of studies which help us to understand the ecological sensitivity to disturbance of riparian ecosystems, including windthrow, stream bank wasting, and downstream sedimentation. Section 4 discusses the effects of modification, in particular logging, on riparian ecosystem ecological function. Several studies that focus on the impact of industrial modification on the ecological function of riparian ecosystems are examined. Section 5 documents selected riparian ecosystem management policies in place in North America today, with special attention paid to the protective riparian buffer widths recommended in the Forest Practices Code of British Columbia.

We hope that this literature review will help clarify the importance of protecting fully functioning riparian ecosystems within an adequate margin of safety. In this light, timber management may progress towards truly ecologically responsible practices.

598) Kondolf, G.M. 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society. 129: 262-281. (B)

Author abstract: Much of the recent literature on salmonid spawning gravels has been devoted to the search for a single statistic drawn or computed from the streambed particle size distribution to serve as an index of gravel quality. However, a natural gravel mixture cannot be fully described by any single statistic, because gravel requirements of salmonids differ with life stage, and thus the appropriate descriptor will vary with the functions of gravel at each life stage. To assess whether gravels are small enough to be moved by a given salmonid to construct a redd, the size of the framework gravels (the larger gravels that make up the structure of the deposit) is of interest, and the *d50 or d84* of the study gravel (the sizes at which 50% or 84% of the sediments are finer) should be compared with the spawning gravel sizes observed for the species elsewhere. To assess whether the interstitial fine sediment content is so high as to interfere with incubation or emergence, the percentage of fine sediment of the potential spawning gravel should be adjusted for probable cleansing effects during redd construction, and then compared with rough standards drawn from laboratory and field studies of incubation and emergence success. An assessment should also consider that the fine sediment content of gravel can increase during incubation by infiltration, that the gravels may become armored over time, or that downwelling and upwelling currents may be inadequate. These considerations are incorporated in a ninestep, life-stage-specific assessment approach proposed here.

599) Lassettre, N.S. 1999. Annotated bibliography on the ecology, management, and physical effects of large woody debris (LWD) in stream ecosystems. Written by the Department of Landscape Architecture and Environmental Planning, University of California, Berkeley. Written for the California Department of Forestry. 124pp. (A, D, F)

Compiler abstract: This annotated bibliography focuses on large woody debris (LWD) and its interaction with stream ecosystems. The bibliography is indexed by various categories, including: LWD dynamics and functions (e.g. abundance, accumulation rate, bar formation, bedload transport, sediment storage, wood movement); various fish species referenced in the citations; geomorphic function of LWD; harvesting impacts on LWD; various water bodies (e.g. lakes, high mountain streams, coastal streams); locations referenced in the citations (i.e. states and countries); log jams; logging debris; macroinvertebrates; tree species referenced in the citations; and various forest types referenced in the citations (e.g. old growth forests, mixed-conifer forests, northern hardwoods, deciduous forests).

600) Lisle, T.E. 1983. The role of structure in the physical habitat of anadromous salmonids. In: Report of the First California Salmon and Steelhead Restoration Conference, 22-23 January 1983, Bodega Bay, California. C. Toole, B. Wyatt, S. Sommarstrom, and K. Hashagen, Editors. California Sea Grant College Program. Pages 43-46. (A, D, G)

Author abstract: A fundamental difference between a canal and a natural stream is structure. Structure includes all the typical anomalies of natural streams that deflect the general downstream flow, such as bends, bars, bedrock knobs, boulders, landslide deposits, and large woody debris. This results in the storage of watershed products in the channel, and in a great heterogeneity in depth, velocity, stream gradient, and substrate conditions. In this paper, I will discuss these functions of structure in salmon habitat and some implications for restoration of habitat.

601) Lisle, T.E. 1987. Overview: Channel morphology and sediment transport in steepland streams. In: Erosion and Sedimentation in the Pacific Rim. Proceedings of the Corvallis Symposium, August 1987, Corvallis, Oregon. R. Beschta, T. Blinn, G. E. Grant, F. J. Swanson, and G. G. Ice, Editors. International Association of Hydrological Sciences Publication No. 165. Pages 287-297. (A)

Author abstract: New understanding of how steepland channels are formed is being pursued over a large range of scales, from entrainment of bed particles to the transfer of stored sediment down channel systems. Low submergence of bed particles during transport and wide heterogeneity in particle sizes strongly affect bedload transport. At the scale of a reach, scour-lobes are becoming widely recognized as common constructional units governing behavior of braided, meandering, and pool-riffle channels. Channel morphology and sediment transport can be radically altered by infrequent debris flows and torrents, however, which provide a common linkage between mass movement on hillslopes and sediment transport in channels. Because of the impracticality of monitoring the downstream progress of sediment over meaningful periods, sediment routing is best approached by mathematical models that incorporate the age and volume of sediment in storage reservoirs.

602) Lisle, T.E. 2002. How much dead wood in stream channels is enough? In: Proceedings of the Symposium on the Ecology and Management of Dead Wood in Western Forests, 2-4 November 1999, Reno, Nevada. W.F. Laudenslayer, Jr., P.J. Shea, B.E. Valentine, C.P. Weatherspoon, and T.E. Lisle, Technical Coordinators. USDA Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-181. Pages 85-93. (D)

Author abstract: Private forest managers often seek guidelines on how much dead wood should be retained in streams in order to adequately fulfill ecosystem functions. There are three approaches to answering this question for a particular reach of channel. The first approach uses an understanding of *ecologic functions* of dead wood in streams to determine the amount needed to fulfill ecologic and geomorphic functions. This approach fails because the complexities of sizes, shapes, and arrangements of dead wood in a variety of lotic ecosystems overwhelm any scientific specification of target loadings. Another approach uses *reference loadings* to evaluate departures in amounts of dead wood in streams from reference amounts in unaltered systems. A precise threshold cannot be defined using this approach because dead wood volumes are highly variable, even within pristine channels in similar settings, and distributions for managed and pristine channels overlap. A third approach constructs a *wood budget* by evaluating past, present, and projected supplies in streams and riparian areas. This is a cumulative-effects analysis that shifts the focus from channels to riparian forests. In combination, the three approaches provide the best information to determine how much wood is enough, but they do not offer simple, formulaic prescriptions. The demands for performing the necessary analyses before harvesting riparian wood suggest that management of riparian forests will continue to be guided most often by general prescriptions.

603) Luce, C.H., and T.A. Black. 2001. Spatial and temporal patterns in erosion from forest roads. In: Influence of Urban and Forest Land Uses on the Hydrologic-Geomorphic Responses of Watersheds. M.S. Wigmosta and S.J. Burges, Editors. Water Resources Monographs, American Geophysical Union, Washington, D.C. Pages 165-178. (K)

Author abstract: Erosion from forest roads is an important contribution to the sediment budget of many forested basins, particularly over short time scales. Sediment production from 74 road segments was measured over three years to examine how road slope, segment length, cutslope height, and soil texture affect sediment production and how these relationships change with time. In the first year, differences in sediment production between plots could be explained by differences in sediment transport capacity of the plots. With time, differences between plots of different slope, length, cutslope height, and soil were reduced as all plots produced less and less sediment. Recovery was rapid with around 70% recovery between by the second year and 90% recovery by the third year.

604) McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to chinook salmon. US Environmental Protection Agency, Water Division, Region 10, Seattle, Washington, Water Resources Assessment EPA 910-R-99-010. 279pp. (J)

Author abstract (from author Introduction): The objectives of this review of the literature are to: (1) interpret and synthesize the literature on temperature effects to salmonids and other coldwater species and their life stages, (2) consider not simply effects during a single short-term exposure to a sustained high temperature but effects of altered temperature regimes under short-term and long-term exposure to constant or fluctuating temperatures, (3) compare and contrast response to temperature of several coldwater fish species, stocks, or family groups, (4) recommend standards that are biologically defensible, (5) review and recommend methods for evaluating water temperature regime to determine whether it meets biological requirements.

To meet these objectives this review will focus on the life stages of spring chinook (*Oncorhynchus tshawytscha*) as a template. Upon this foundation the results and conclusions from related studies on other coldwater fish species will be evaluated. This approach to review of salmonid response is reasonable because of the high degree of similarity exhibited among these species. Frequently, it will be found that when information on certain effects of temperature are lacking in chinook technical literature, information will be available for other salmonids. Taking the salmonid literature as a whole and by comparing and contrasting, the understanding of response to thermal experience by salmon and trout can become very robust. Selected coldwater non-salmonid literature will be considered to indicate those temperature conditions that both salmonids and other coldwater species would find suitable. Temperature requirements for common warmwater exotic species will also be noted to indicate the ecological problems faced by salmonids in competitive and predator-prey interactions and to provide a relative index by which to judge salmonid requirements (e.g., contrasting optimum conditions for coldwater and warmwater fishes). Significant differences among salmonids occur frequently via separate life histories. For example, spring chinook, which immigrate in the spring and spawn in 3rd to 5th order streams, face different migration and adult holding temperature regimes because of life history variation, fish size, and habitat selection than do summer or fall chinook, which spawn in streams of 5th order or greater as a rule. However, for similar life stages experiencing the same thermal regime (e.g., if spring and summer chinook juveniles have overlapping habitats), biological responses do not vary so much that different temperature standards are warranted, with a few exceptions.

It is important to gain a comprehensive understanding of responses to temperature regimes in order to adequately evaluate their suitability with respect to a given life stage or the entire life cycle. This kind of understanding can only be gained by synthesizing both field and laboratory observations. This review is an attempt to synthesize experience on salmonids during their life stages and their associated responses (avoidance, preference, growth, survival, reproductive success, migration (upstream, downstream, intrabasin) success, disease, feeding, territoriality, aggressiveness). All of these aspects of fish ecology are useful in identifying temperature requirements and the potential consequences of temperature modification. Cursory evaluations of the literature can be prone to overlooking synergistic effects, cumulative effects during the life cycle, and can mistake tolerable for optimal in the short term and long term.

605) Moore, K., M. Furniss, S. Firor, and M. Love. 1999. Fish passage through culverts: An annotated bibliography. Six Rivers National Forest Watershed Interactions Team, Eureka, California. 38pp. (K)

Author abstract: This bibliography includes 96 annotated citations on culvert design for fish passage, risk analysis, and fish swimming ability. This collection is a subset of a larger bibliography on culverts and sizing, repair, maintenance, installation, failure, hydraulics, and hydrology. Author's abstracts were included if available, if not, each paper was read and abstracted. This work was funded, in part, by the San Dimas Technology and Development Center of the USDA-Forest Service. See also: Copstead, Moore, Ledwith and Furniss. 1998. Water/road interaction: An annotated bibliography. Water/road interactions technology series. USDA Forest Service, Technology and Development Program. (http://www.stream.fs.fed.us/water-road).

606) Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience. 50: 996-1011. (A, C, D, F, H)

Compiler abstract: Because riparian areas are so ecologically complex, there have been large research efforts on a global scale to understand the dynamics and managerial consideration in the last twenty years. In this article, the authors summarize the research advances that have been made in the last ten years on the understanding of the ecology of riparian zones in the Pacific coastal ecoregion. This article also focuses on how the advances made have contributed overall to better stream and watershed management. The authors discuss what was known about riparian zones before the 1990s and then delve into the important advances that have been made in the last ten years. Specifically the authors discuss watershed processes, debris flows, large woody debris, riparian plants, forest structure, species richness, microclimes, and exotic plants. Hyporheic zones are also considered, as well as how animals use and shape riparian corridors. Several schematic drawings are included to depict relationships among processes and disturbance regimes in riparian systems. Graphs are also included which show the relationship between many factors (such as tree height and soil moisture) that are integral parts of riparian ecosystems. Management implications for riparian zones are also discussed.

607) Nakano, S., and M. Murakami. 2001. Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs. Proceedings of the National Academy of Sciences. 98: 166-170. (C)

Author abstract: Mutual trophic interactions between contiguous habitats have remained poorly understood despite their potential significance for community maintenance in ecological landscapes. In a deciduous forest and stream ecotone, aquatic insect emergence peaked around spring, when terrestrial invertebrate biomass was low. In contrast, terrestrial invertebrate input to the stream occurred primarily during summer, when aquatic invertebrate biomass was nearly at its lowest. Such reciprocal, across-habitat prey flux alternately subsidized both forest birds and stream fishes, accounting for 25.6% and 44.0% of the annual total energy budget of the bird and fish assemblages, respectively. Seasonal contrasts between allochthonous prey supply and *in situ* prey biomass determine the importance of reciprocal subsidies.

608) O'Loughlin, C., and R.R. Ziemer. 1982. The importance of root strength and deterioration rates upon edaphic stability in steepland forests. In: Proceedings of I.U.F.R.O. Workshop P.1.07-00, Ecology of Subalpine Ecosystems as a Key to Management, 2-3 August 1982, Oregon State University, Corvallis. 70pp. (K)

Author abstract: The additional strength provided by roots to the soil is generally considered to be in the form of a cohesive strength hC which may range in magnitude from 1 kPa to 20 kPa. Studies of the tensile strength of tree roots show that small roots sampled from living trees range in mean tensile strength from about 10 MPa to about 60 MPa. After tree felling small roots lose their strength at average rates between 300 and 500 kPa per month. Root biomass also decreases rapidly after clearfelling. The reduction in K after forest removal is a prime cause of landsliding on many steep slopes.

609) Oregon Forest Industries Council and Washington Forest Protection Association. 2000. Annotated bibliography: Information and studies relevant to temperature, salmonids, and water quality. Written for the US Environmental Protection Agency, Region 10; the U.S. Fish and Wildlfie Service; and the National Marine Fisheries Service. 32pp. plus 5 page cover letter. (A, H, J)

Author abstract (Author Introduction): This annotated bibliography of *Information and Studies Relevant to Temperature, Salmonids, and Water Quality* has been prepared in response to the April 20, 2000 request by the US EPA Region 10; the States of Oregon, Washington, and Idaho; and the US Fish and Wildlife Service and the National Marine Fisheries Service. It was prepared as a joint effort of the Oregon Forest Industries Council, the Washington Forest Protection Association, and their members.

The information and studies are relevant to the interagency regional temperature criteria guidance development project. All are believed to be pertinent to the regional temperature criteria guidance that US EPA expects to deliver to states and tribes, and any proposed revisions by US EPA to temperature standards in the Pacific Northwest. None of the information and studies included in this annotated bibliography is included in the Literature List currently in possession of the project's Technical Workgroup.

The annotated bibliography is organized primarily by the six categories of information that are of special interest to US EPA Region 10:

1. Physiological response of salmonids to water temperature.
2. Behavioral responses of salmonids to water temperature.
3. Changes in salmonid population distributions attributable to changes in water temperature.
4. Multiple stressors that may interact with water temperature to affect salmonids.
5. Expected patterns of water temperature across space and time at multiple scales and anthropogenic changes thereto (including cumulative effects).
6. Measurement and monitoring of water temperature.

Within each of the six information categories, information and studies are listed by title. Each contribution contains:

1. A complete bibliographic citation.
2. A statement of the objectives or subjects addressed.
3. A summary of the significant findings.
4. A conclusion suggesting the relevance of the information to the regional temperature criteria guidance development project.

Full copies of cited papers, reports, and pertinent excerpts are included in a separate attachment.

Note: The cover letter attached to this bibliography contains the key findings that the authors recommended be incorporated into the development of regional temperature standards.

610) Pentec Environmental, Inc. 1991. The importance of riparian vegetation to salmonid habitat in lakes and estuaries. Project No. 44-004 Information Report written by Pentec Environmental, Inc., Edmonds, Washington. Written for Sealaska Corporation, Juneau, Alaska. 13pp. (C, D, F, H, J)

Compiler abstract: The riparian standard (i.e. 66-ft buffer) mandated by the 1990 revised Alaska Forest Resources and Practice Act (FRPA) along Type A water bodies on private land is intended to protect fish habitat and water quality from potential adverse effects of timber harvest. The riparian standard was designed to maintain physical and biological functions of stream habitats because most of the anadromous fish spawning and rearing habitat is located in streams. Many of the physical and biological functions intended to be maintained by FRPA through retention of riparian buffers do not apply to lakes and estuaries, and FRPA does not offer guidance on this issue. This report identifies physical and biological relationships between riparian vegetation and fish habitats in both lakes and estuaries, and provides an evaluation of the importance of these relationships to salmonid habitat. Salmonid habitat features discussed in this report include: (1) influence of shading on water temperature and hiding cover, (2) influence of slope stabilization, (3) influence of debris input as hiding cover and as a detrital food source, and (4) influence of riparian vegetation as habitat for salmonid predators.

611) Poole, G.C., and C.H. Berman. 2001. An ecological perspective on in-stream temperature: Natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management. 27: 787-802. (A, G, H, J)

Author abstract: While external factors (drivers) determine the net heat energy and water delivered to a stream, the internal structure of a stream determines how heat and water will be distributed within and exchanged among a stream's components (channel, alluvial aquifer, and riparian zone/floodplain). Therefore, the interaction between external drivers of stream temperature and the internal structure of integrated stream systems ultimately determines channel water temperature. This paper presents a synoptic, ecologically based discussion of the external drivers of stream temperature, the internal structures and processes that insulate and buffer stream temperatures, and the mechanisms of human influence on stream temperature. It provides a holistic perspective on the diversity of natural dynamics and human activities that influence stream temperature, including discussions of the role of the hyporheic zone. Key management implications include: (1) Protecting or reestablishing in-stream flow is critical for restoring desirable thermal regimes in streams. (2) Modified riparian vegetation, groundwater dynamics, and channel morphology are all important pathways of human influence on channel-water temperature and each pathway should be addressed in management plans. (3) Stream temperature research and monitoring programs will be jeopardized by an inaccurate or incomplete conceptual understanding of complex temporal and spatial stream temperature response patterns to anthropogenic influences. (4) Analyses of land-use history and the historical vs. contemporary structure of the stream channel, riparian zone, and alluvial aquifer are important prerequisites for applying mechanistic temperature models to develop management prescriptions to meet in-channel temperature goals.

612) Rice, R.M., J.S. Rothacher, and W.F. Megahan 1972. Erosional consequences of timber harvesting: An appraisal. In: Proceedings of the National Symposium on Watersheds in Transition. American Water Resources Association, Ft. Collins, Colorado. Pages 321-329. (K)

Author abstract: This paper summarizes our current understanding of the effects of timber harvesting on erosion. Rates of erosion on mountain watersheds vary widely but the relative importance of different types of erosion and the consequences of disturbances remain fairly consistent. Therefore these conclusions seem to be valid for most circumstances: Most of man's activities will increase erosion to some extent in forested watersheds; erosion rarely occurs uniformly; sediment production declines rapidly following disturbance; landslides and creep are the chief forms of natural erosion in mountainous regions; cutting of trees does not significantly increase erosion, but clearcutting on steep unstable slopes may lead to increased mass erosion; accelerated erosion is a possible undesirable side effect of use of fire in conjunction with logging; the road system built for timber harvesting far overshadows logging or fire as a cause of increased erosion; and potentially hazardous areas can be identified in advance of the timber harvest.

613) Schuett-Hames, D., B. Conrad, A. Pleus, and K. Lautz. 1996. Literature review and monitoring recommendations for salmonid spawning gravel scour. Timber, Fish, and Wildlife Ambient Monitoring Program. TFW-AM-9-96-001. 23pp. (A, B)

Author abstract (Author Introduction): Salmonid eggs and larvae undergo a critical period of early development while buried in stream bed gravel. During this time eggs and alevin are vulnerable to scour and disturbance of the stream bed. Mortality at this early stage in the life cycle can affect recruitment to later life stages. Scour to the depth of salmonid egg pockets typically occurs during peak discharges when bedload transport processes are active. The magnitude and frequency of peak flow discharge and sediment transport are influenced by watershed conditions that affect the hydrologic and sediment regimes. A variety of land-use activities alter peak flows and sediment transport dynamics. The Watershed Analysis fish habitat module recommends using information on the frequency of redd scour to identify potential changes in peak flow hydrology and channel stability, but does not contain methods to document scour. A standard procedure is needed to assess and monitor spawning gravel scour in the context of Watershed Analysis.

The purpose of this report is to: 1) present information on scour from the literature; 2) identify the features required in a scour monitoring method for Watershed Analysis; 3) identify key issues that need to be resolved in the development of a scour method; 4) examine how existing studies have addressed these issues, and 5) make recommendations for the design of the Watershed Analysis scour module.

614) Sullivan, K., T.E. Lisle, C.A. Dolloff, G.E. Grant, E. Gordon, and L.M Reid. 1987. Stream channels: The link between forests and fishes. In: Streamside Management: Forestry and Fishery Interactions. Proceedings of a symposium, 12-14 February 1986, University of Washington, Seattle. E.O. Salo and T.W. Cundy, Editors. Institute of Forest Resources, Seattle, Washington, Contribution No. 57. Pages 39-97. (A, D, F, G, I)

Author abstract: The hydraulic characteristics of flow through channels are an important component of fish habitat. Salmonids have evolved in stream systems in which water velocity and flow depth vary spatially within the watershed and temporally on a daily, seasonal, and annual basis. Flow requirements vary during different phases of the freshwater life cycle of salmonids: free passage is necessary during migration of adults; clean and stable gravel beds ensure successful incubation of eggs; and adequate velocity and depth of flow provide space for summer rearing and overwintering. The life cycles of salmonid species have adapted to the temporal variations in flow conditions by timing the phases of the life cycle to take advantage of the seasonal discharge characteristics. Spatial variability enhances species diversity by creating a variety of habitats within stream reaches; these are partitioned among individual species and age groups having different tolerances for velocity, depth, and cover conditions.

Channel morphology is determined largely by sediment and water input to the channels, and is formed during storm events when flow is great enough to transport the coarse sediments lining the channel bed. The resulting channel shape consists of a sequence of recognizable units known as riffles, pools, and boulder cascades. Water flowing down the stream is forced continually to adjust its velocity and depth in response to the changing channel shape: flow is shallow and fast in riffles, and slow and deep in pools. Large obstructions such as woody debris, boulders, and bedrock outcrops alter channel width, increasing the variation in velocity and depth in the vicinity of the obstruction and anchoring the position of pools. Discharge also varies through time, creating additional variations of hydraulic conditions.

Forest management can affect channel morphology by changing the amount of sediment or water contributed to the streams, thus disrupting the balance of sediment input and removal. Excessive input of coarse sediments from landslides can smooth the channel gradient by filling pools. Removing large woody debris from channels reduces sediment storage and eliminates the local hydraulic variability associated with the obstruction. Loss of habitat diversity by either mechanism may reduce or change the fish species found in a stream reach. If the changes result in decreased space, populations may also decrease. Strategies to minimize the effects of land management on channel morphology and fish habitat should include practices that minimize increases in coarse sediment input, and that preserve the morphologic complexity of the channel.

615) Teti, P. 1998. The effects of forest practices on stream temperature: A review of the literature. B.C. Ministry of Forests, Cariboo Forest Region, Williams Lake, British Columbia. 10pp. (J)

Author abstract (Author Introduction): A literature search was done in 1998 by a combination of computer searches at the UBC Library, searches of a personal collection, and a search of the World Wide Web. This yielded more than 40 references spanning 30 years. The list is not considered exhaustive but it is sufficiently complete to reflect the history and current state

of knowledge on the effects of forest management on stream temperature. Emphasis in obtaining and reviewing the references was placed on:

- increases in summertime stream temperature associated with logging, and
- publications from the last 10 years.

The literature review did not address the following topics:

- the biological effects of high stream temperatures on aquatic biology or
- the effect of lakes on stream temperature.

616) Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent, and vegetation. Written for the Office of Public Service & Outreach, Institute of Ecology, University of Georgia, Athens. 59pp. (D, E, F, H, I, J)

Compiler abstract: This document presents the results of a review of 140 articles and books with the intent to establish a legally-defensible basis for determining riparian buffer width, extent, and vegetation within the state of Georgia. This review document is organized into several sections:

- Background and Introduction;
- Sediment—Including sediment in surface runoff and channel erosion
- Nutrients and other contaminants—Phosphorus, nitrogen, other contaminants such as organic matter and biological contaminants, pesticides and metals;
- Other factors influencing aquatic habitat—Woody debris and litter inputs, temperature and light control;
- Terrestrial wildlife habitat;
- Development of riparian buffer guidelines—Review of models to determine buffer width and effectiveness, factors influencing buffer width, buffer guidelines for water quality protection, other considerations.

Based on the review of the literature, the author proposes three buffer guidelines, all of which are legally defensible based on the scientific literature.

617) Wilson, M., and J.G. Imhof. Undated. Literature review: Overview of the state of the science. An examination of the functions of riparian zones. Written in conjunction with a Riparian Zone Workshop, 28-29 October 1998, Cambridge, Ontario. 31pp. (C, D, F, G, I, J)

Compiler abstract: This document summarizes the natural functions and processes of riparian zones based upon a review of the world literature. Approximately 200 papers, annotated bibliographies and books were reviewed. Based on the review, a subset of 54 papers were summarized in four summary tables: hydrology, geomorphology, water quality and nutrient flux, and ecological characteristics. Two additional tables were also provided:

1. A proposed hierarchy for the determination of the scale of measurement for geographic, geomorphic and biotic data collection and analysis within watershed systems; and
2. Literature derived suggested riparian zone widths for the protection of water quality.

618) Wood, P.J., and P.D. Armitage. 1997. Biological effects of fine sediment in the lotic environment. Environmental Management. 21: 203-217. (A, C, I)

Electronic abstract: Although sedimentation is a naturally occurring phenomenon in rivers, land-use changes have resulted in an increase in anthropogenically induced fine sediment deposition. Poorly managed agricultural practices, mineral extraction, and construction can result in an increase in suspended solids and sedimentation in rivers and streams, leading to a decline in habitat quality. The nature and origins of fine sediments in the lotic environment are reviewed in relation to channel and nonchannel sources and the impact of human activity. Fine sediment transport and deposition are outlined in relation to variations in streamflow and particle size characteristics. A holistic approach to the problems associated with fine sediment is outlined to aid in the identification of sediment sources, transport, and deposition processes in the river catchment. The multiple causes and deleterious impacts associated with fine sediments on riverine habitats, primary producers, macroinvertebrates, and fisheries are identified and reviewed to provide river managers with a guide to source material. The restoration of rivers with fine sediment problems are discussed in relation to a holistic management framework to aid in the planning and undertaking of mitigation measures within both the river channel and surrounding catchment area.

619) Ziemer, R.R. 1981. Roots and the stability of forested slopes. In: Proceedings of the International Symposium on Erosion and SedimentTransport in Pacific Rim Steeplands, 25-31 January 1981, Christchurch, New Zealand. T.R.H. Davies and A.J. Pearce, Editors. International Association of Hydrological Sciences Publication No. 132. Pages 343-361. (K)

Author abstract: Root decay after timber cutting can lead to slope failure. In situ measurements of soil with tree roots showed that soil strength increased linearly as root biomass increased. Forests clear-felled 3 years earlier contained about one-third of the root biomass of oldgrowth forests. Nearly all of the roots < 2 mm in diameter were gone from 7-year-old logged areas while about 30 percent of the < 17 mm fraction was found. Extensive brushfields occupied areas logged 12 to 24 years earlier. The biomass of brushfield roots < 2 mm in diameter was 80 percent of that in the uncut forest, and fewer large roots were found there than in the forest. Roots < 17 mm in diameter in the brushfield accounted for 30 percent of that found in the forest, and for total root biomass, only 10 percent. Individual, live brush roots were twice as strong as conifer roots of the same size. This difference may partially compensate for reduced root biomass in brushfields. Net strength of the soil-root matrix in brushfields was about 70 percent of that in uncut forests. If soils are barely stable with a forest cover, the loss of root strength following clear-felling can seriously.

620) Ziemer, R.R. 1981. The role of vegetation in the stability of forested slopes. In: Proceedings of the International Union of Forestry Research Organizations, XVII World Congress, 6-17 September 198l, Kyoto, Japan. Volume I: 297-308. (K)

Author abstract (Author Summary): Vegetation helps stabilize forested slopes by providing root strength and by modifying the saturated soil water regime. Plant roots can anchor through the soil mass into fractures in bedrock, can cross zones of weakness to more stable soil, and can provide interlocking long fibrous binders within a weak soil mass. In Mediterranean-type climates, having warm, dry summers, forest evapotranspiration can develop a substantial soil moisture deficit which can reduce both piezometric head and slope mass. Pore water pressures change seasonally in response to precipitation and are often the driving mechanism which ultimately leads to slope failure. When trees are cut, the root system begins to decay, and the soil-root fabric progressively weakens**.** The loss of root strength or increased soil moisture content or both after-tree removal can lower the slope safety factor sufficiently that a moderate storm and associated rise in pore water pressure can result in slope failure. After trees are removed, the frequency of landslides can increase.

621) Ziemer, R.R., J. Lewis, T.E. Lisle, and R.M. Rice. 1991. Long-term sedimentation effects of different patterns of timber harvesting. In: Proceedings of the Symposium on Sediment and Stream Water Quality in a Changing Environment: Trends and Explanation. XX General Assembly, International Union of Geodesy and Geophysics, 11-24 August 1991, Vienna, Austria. International Association of Hydrological Sciences Publication No. 203. Pages 143-150. (B, I)

Author abstract: It is impractical to address the long-term effect of forest management strategies on erosion, sedimentation, and the resultant damage to fish habitat experimentally because to do so would require studying large watersheds for a century or more. Monte Carlo simulations were conducted on three hypothetical 10 000 ha, fifth-order forested watersheds. One watershed was left undisturbed, one was completely clearcut and roaded in a decade, and one was cut at the rate of 1% each year. Each cutting strategy was repeated in succeeding centuries.