Scope of Work

State Board of Forestry and Fire Protection

Draft date: September 22, 2006

Project Title:

Literature Review for Threatened and Impaired Watershed (T/I) Rules

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1. Overview

The State Board of Forestry and Fire Protection (BOF) has statutory responsibility for a comprehensive set of Forest Practice Rules that govern planning and conduct of timber operations on private timberlands in the State. Interim Forest Practice Rules for protection of listed anadromous salmonids (termed the Threatened or Impaired, or T/I rules, under 14 CCR §§ 916.9, 936.9, and 956.9) will expire in December, 2007. Concurrently, the California Department of Fish Game in conjunction with the California Department of Forestry and Fire Protection, landowners and scientific experts, has been directed by the Fish and Game Commission to monitor and review existing timber harvesting regulations for the protection of Coho salmon resulting from a recent listing of the species. These situations necessitate consideration by the Board for the renewal, amendment, or repeal of T/I rules.

The scientific literature review (Project) is being conducted for two primary reasons: 1) statute (PRC 4553) requires the Board to continuously review and revision regulations to ensure regulatory effectiveness; and 2) the existing T/I rule expires on December 31, 2007. The Project is expected to help the Board determine effectiveness, necessity, amendments, and any additional extension or permanent adoption of the rules.

2. Goal, Project Description and Review Topics

Goal

The goal of the Project is to identify information that contributes to the Board's decision-making process for rules for the protection and restoration of anadromous salmonids, domestic water uses, and related issues addressed in the rules "*Protection and Restoration in Watersheds with Threatened or Impaired Values*" (14 CCR 916.9, 936.9, 956.9). The information to achieve this goal will be generated from a methodical scientific review of recent information related to forest management effects on anadromous salmonids (see literature review topics below under Project Description). The Project is intended to result in summarized literature findings and answers to "Key Questions" on the basis of which the Board can evaluate the existing rules and the effects of commercial timber harvesting on anadromous salmonids.

Project Description

The Project in this Scope of Work is an independent scientific literature review of technical literature related to forest management effects on anadromy and forest riparian habitat while considering ancillary factor. The literature review will be summarized in a designated format and will be reviewed to answer "Key Questions". Finally, the Project includes a synthesis of the literature review findings relative to forest riparian habitat while considering ancillary factors.

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Literature to be reviewed includes studies relevant to forest management planning and conduct affecting all life stages of anadromous salmonids or domestic water uses. Studies should focus on key ecological features of functional riparian habitats (see list below), riparian buffer zones ancillary factors relevant to forestry and anadromous fisheries interactions.

Types of Literature to be reviewed:
Key ecological features of functional forest riparian habitats

1. Nutrients;
2. Root strength affecting bank and channel stability;
3. Vegetative canopy, shade, and coarse woody debris;
4. Microclimates;
5. Sediments;

Secondary studies to be reviewed include:

- Peak flows or large flood frequency;
- Cumulative watershed effects;
- Natural variation of riparian systems;
- Affects of natural disturbances (fire, flood, pests, windrow, landslides);
- Life cycle needs of anadromous salmonids.

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3. Work Statement

Task 1. Administration

See Appendix A for a complete description of the administrative task, requirements and deliverables under this agreement.

Task 2. Identify and obtain relevant literature to be reviewed.

The goal of this Task is to ensure that a comprehensive compendium of literature is obtained and reviewed and all literature is relevant to the goal of the Project. The Board intends to include a wide breadth of literature as part of the review. This includes peer reviewed, non peer reviewed (grey literature including monitoring results, pilot projects, resource assessments, and conference proceeding etc.), and master's and doctoral research.

The Performing Entity shall:

Task 2.1 Prepare a written assessment of the preliminary list of literature compiled by the Board (see Appendix B) relative to its completeness, relevance and adequacy towards meeting the goal of the Project and answering the Key Questions.

Task 2.2 Identify and revise list in Appendix B to best meet literature review topics listed in the Project Description, Project Goal, and Key Questions. Consider files submitted by the public as part of a Board Public Information Request.

Task 2.3 Upon approval of Board Contract Representative, procure all literature in Appendix B.

Task 2.4 Catalog all literature in Task 2.3 in a "Literature Tracking Log" database format shown in Appendix C.

Task 2.5 Submit one hard copy of literature reviewed as listed in Appendix B and provide a CD of same material. Compiled literature shall have a cover, index of literature in bibliographic format, and pagination.

Deliverable:

- ☐ Assessment of the preliminary list of literature compiled by the Board (see Appendix B).
- ☐ Final list of literature to be reviewed in Literature Tracking Log format (Appendix C).
- ☐ Paper copy and CD of compendium of literature reviewed.

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Task 3. Conduct Literature Review.

The Goal of this Task is to perform review of scientific literature identified in Task 2. Identify and Procure relevant literature to be reviewed.

The Performing Entity shall:

Task 3.1 Identify and group relevant literature according to each key ecological features listed in the Project Description and by key or additional questions.

Task 3.2 Review the literature and for each individual scientific article, document the review as shown in Appendix E: Literature Review Format. Documentation of each scientific article shall be provided by the Performing Entity in hard copy and CD format.

Deliverable:

- ☐ Completed literature review for each scientific article and document review in hard copy and CD format.

Task 4: Provide summary and synthesis of literature review

The required literature review outlined in Task 3 will result in a large number of articles individually reviewed related to key ecological features and key or additional questions. To help the Board better understand the full breath of the articles reviewed, the Performing Entity will provide a summary of all articles reviewed by each key ecological feature and key or additional question and provide a synthesis for TAC review for each key feature or key question.

The Performing Entity shall:

For each key ecological feature and key or additional question, provide in writing and cd format, Performing Entity's description of:

Task 4.1 Extent to which literature findings lead to a uniform conclusion, and are consistent or inconsistent with each other.

Task 4.2 Extent to which aggregate literature findings are generally reliable and specifically applicable to the key feature or question.

Tasks 4.3 Synthesize aggregate findings for each key question of ecological feature.

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Deliverable:

- ☐ Summary and synthesis of all articles reviewed by key ecological features and key or additional questions in hard copy and CD format.

Task 5: Prepare and present final submission of all Project Tasks

The Board envisions all completed literature review components of the Project will be consolidated into a single report and the report will be presented in writing/CD and orally to the Board. The Board finds it will be desirable to have the Performing Entity report in person to the Board at approximately half way through its contract completion to inform the Board on the status and achievement of the project to date towards meeting the Project Goal.

The Performing Entity shall:

Task 5.1 Report in person to the Board on the progress and status of Project when approximately 50% of the project is completed. The report shall include written documentation of progress and projected completion date, summary of contract implementation problems/issues, and highlights of Projects findings to date.

Task 5.2 Upon completion of the Project, report in person to the Board on the outcome of the Project. The report shall include an overview of the methodology used by the Performing Entity, summary of Task 5. synthesis of literature review, and recommendation for additional needs to better achieve the Project Goal.

Task 5.3 Appear in person, be available to respond to questions, and participate in the Board's "Technical Specialist Forum". Attendance at the Forum will be limited to an 8 hour period.

Deliverable:

- ☐ Summary or synthesis of all articles reviewed by Topic or Key Question in hard copy and CD format.
- ☐ Written and orally progress report presentation to the Board.
- ☐ Written and oral presentation to the Board on final Project.
- ☐ Attendance and interaction at a one day/8 hr. Technical Specialist Forum.

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4. Appendicies

Appendix A: Administration

1. **Performing Entity Representative:** Performing entity will assign a Representative with authority for all Tasks, amendments to the contract, and financial responsibilities.

2. **Payment by Board for Performing Entity services:** Upon completion of Task 2 and 3, 50 % of the initial contract value will be remitted to Performing Entity. Upon completion of Tasks 4 and 5, 40% of the initial contract value will be remitted to Performing Entity. Upon completion of Task 6, balance of contract payment will be remitted to Performing Entity.

3. **Performing Entity consultation with Board contract representative:** Performing Entity shall meet with Board representatives by phone or in person periodically during the contract two times per month for purposes of Project coordination, progress check and quality control.

4. **Revisions and amendments:** The Board representative may request contract revisions and amendments for purposes of improving Performing Entity conformance with Project Tasks or for purposes of adding additional Tasks or Deliverables. Revisions shall be performed by Performing Entity. Amendments shall be by mutual agreement.

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Appendix B: Preliminary List of Literature to be reviewed (also see CD of others lists) (Highlighted documents are high priority for review)

1. Abbe, T.B., and Montgomery, D.R., 2002, Patterns and process of wood debris accumulation in the Queets River basin, Washington: Geomorphology, Volume 51, pp. 81-107.

2. Abernethy, B., and Rutherford, I.D., 2000, The effects of riparian tree roots on the mass-stability of rivebanks: Earth Surface Processes and Landforms, Volume 25, pp. 921-927.

3. Acker, S.A., S.V. Gregory, G. Lienkaemper, W.A. McKee, F.J. Swanson, and S.D. Miller. 2003. Composition, complexity, and tree mortality in riparian forests in the central Western Cascades of Oregon. Forest Ecology and Management 173:293-308. [high priority]

4. Adams, P., and J. Ringer. 1994. The effects of timber harvesting and forest roads on water quantity and quality in the Pacific Northwest: Summary and annotated bibliography. Pages 147. The Oregon Forest Resources Institute, Corvallis, OR.

5. Alabyan, A.M., and Chalov, R.S., 1998, Types of River Channel Patterns and their Natural Controls: Earth Surface Processes & Landforms, Volume 23, Number 5, pp. 467-475.

6. Allan, J.D.; Wipfli, M.S.; Caouette, J.P.;Prussian, A.; Rodgers, J. 2003. Influence of streamside vegetation on inputs of terrestrial invertebrates to salmonid food webs. Canadian Journal of Fisheries and Aquatic Sciences. 60(3): 309-320.

7. Allen, M., and L. Dent. 2001. Shade conditions over forested streams in the Blue Mountain and Coast Range Georegions of Oregon. Pages 101. Oregon Department of Forestry, Portland, OR.

8. Amaranthus, M., H. Jubas and D. Arthur. 1989. Stream shading, summer streamflow and maximum water temperature following intense wildfire in headwater streams. In Berg, N.H. (Tech. Coordinator). 1988. Proceedings of the Symposium on Fire and Watershed Management. USDA Forest Service. Pacific Southwest Forest and Range Management Station. General Technical Report PSW-109. Berkeley, California.

9. Anderson, H.W. 1973. *Effects of Clearcutting on Stream Temperature: A Literature Review*. DNR Rep. No .29. Washington Department of Natural resources. Olympia, WA.

10. Beechie, T., and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. *Fisheries* 24: 6-15.

11. Belt, G.H. and J. O'laughlin. 1994. Buffer strip design for protecting water quality and fish habitat. *Western Journal of Applied Forestry*. 9(2): 41-45. [high priority]

12. 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. College of Forestry, Wildlife and Range Sciences. University of Idaho. [high priority]

13. Benda, L. 2005. Recruitment of large woody debris into watercourses: where is it coming from and how? PowerPoint Presentation prepared for the California Licensed Foresters Association Spring Meeting, March 3, 2005, Sacramento, California. [Key

Figure summarizing a recommendation for buffer strip design for LWD based on wood surveys in approximately 100 km of stream channel in CA exists as a separate file].

14. Benda and Associates. 2004a. Little North Fork Noyo River wood budget, Mendocino County, California. Unpubl. Final Report prepared for Campbell Timberland Management, Fort Bragg, CA. Lee Benda and Associates, Inc., Mt. Shasta, CA. 45 p. [electronic copy available]

15. Benda and Associates. 2004b. Wood recruitment to streams, Mendocino Coast, California. Final report prepared for Campbell Timberland Management, Fort Bragg, CA. Lee Benda and Associates, Inc. Mt. Shasta, CA. 14 p., found at: http://www.bof.fire.ca.gov/pdfs/WoodRecrutSreamsFinal.pdf

16. Benda, L., D. Miller, J. Sias, D. Martin, R. Bilby, C. Veldhuisen, and T. Dunne. 2003. Wood recruitment processes and wood budgeting. American Fisheries Society Symposium 37: 49-73. [hard copy]

17. Benda, L., P. Bigelow, and K. Andras. 2003. Wood recruitment to streams: Cascades and Klamath Mountains, Northern California. Prepared for Sierra Pacific Industries, Redding, California by Lee Benda and Associates, Inc., Mt Shasta, California. 44 pages and appendixes. [electronic copy available]

18. Benda, L., Poff, N.L., Miller, D., Dunne, T., Reeves, G., Pess, G., and Pollock, M., 2004, The network dynamics hypothesis: How channel networks structure riverine habitats: BioSciences, Volume 54, Number 5, pp. 413-427.

19. Benda, L.E., Bigelow, P., and Morsley, T.M., 2002, Recruitment of wood to streams in old-growth and second-growth redwood forests, northern California, U.S.A: Canadian Journal of Forest Research, Volume 32, pp. 1460-1477.[electronic copy available]

20. Berg, N. Carlson, A., and Azuma, D., 1998, Function and dynamics of woody debris in stream reaches in the central Sierra Nevada, California: Canadian Journal of Fisheries and Aquatic Sciences, Volume 55, pp. 1807-1820.

21. Berg, N., Azuma, D., and Carlson, A., 2002, Streamflow and fire effects on woody debris dynamics of Sierran streams: Watershed Management Council. http://www.watershed.org/news/win_00/7_woody_debris.htm.

22. Beschta, R.L. 1997. Riparian shade and stream temperature: an alternative perspective. *Rangelands* 19(2): 25-28.

23. Beschta, R.L. and R.L. Taylor. 1988. Stream temperature increases and land use in a forested Oregon watershed. *Water Resources Bulletin.* 24:19-25.

24. Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. pgs 191-231. In E.O. Salo & T.W. Cundy (eds) *Streamside Management: Forestry and Fisheries Interactions.* Contribution No. 57, Institute Of Forest Resources, University of Washington, Seattle. [electronic and hard copy available]

25. Bettinger, P., J. Sessions, and K. Johnson. 1998. Ensuring the compatibility of aquatic habitat and commodity production goals in eastern Oregon with a Tabu search procedure. *Forest Science* 44: 96-112.

26. Bettinger, P., K. Johnson, and J. Sessions. 1996. Forest planning in Oregon case study: Defining the problem and attempting to meet goals with a spatial analysis technique. *Environmental Management* 20: 565-577.

27. Bettinger, P., K. Johnson, and J. Sessions. 1998. Improving aquatic habitat conditions over time while producing wood products: An examination of options. *Journal of the American Water Resources Association* 34: 891-907.

28. Bilby, R.E., and Bisson, P.A., 1998, Function and distribution of large woody debris: in, Naiman, R.J., and Bilby, R.E., editors, River Ecology and Management: Lessons from the Pacific Coastal Ecoregion, Springer. [high priority]

29. Bisson, P.A. and R.E. Bilby. 1998. Organic matter and trophic dynamics. Pages 373-398 *in* Naiman, R.J., and R.E. Bilby, ed. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York.[high priority]

30. Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present and future. In, Proceedings: Stream temperature and aquatic habitat: fisheries and forestry interaction. University of Washington, Seattle, WA. Pp. 149-190. [high priority]

31. Bisson, P.A., Reeves, G.H., Bilby, R.E., and Naiman, R.J., 1997, Watershed Management and Pacific Salmon: Desired Future Conditions: In, Stouder, D.J., Bisson, P.A., and Naiman, R.J., editors, Pacific Salmon and their Ecosystems, New York, New York, Chapman & Hall, pp. 447-474. [high priority]

32. Boyd, M., and D. Sturdevant. 1997. The scientific basis for Oregon's stream temperature standard: Common questions and straight answers. Pages 32. Oregon Department of Environmental Quality, Portland.

33. Boyer, K.L., D.R. Berg, and S.V. Gregory. 2003. Riparian management for wood in rivers. pp 407-421 *in* Gregory, S.V., K.L. Boyer, and A.M. Gurnell, eds. The ecology and management of wood in world rivers. American Fisheries Society Symposium 37. International Conference on Wood in World Rivers held at Oregon State University, Corvallis, Oregon, 23-27 October 2000.[high priority]

34. Braudrick, C.A., and Grant, G.E., 2001, Transport and deposition of large woody debris in streams: a flume experiment: Geomorphology, Volume 41, pp. 23-283.

35. Brazier, J.R. and G.W. Brown 1973. Buffer strips for stream temperature control. Research Paper 15, Forest Research Laboratory, School of Forestry, Oregon State University, Corvallis, OR pg. 9. [hard copy]

36. Bren, L.J. 1995. Aspects of the Geometry of Riparian Buffer Strips and Its Significance to Forestry Operations. *Forest Ecology and Management.* 75: 1-10. [high priority]

37. Brooks, A.P., and Brierley, G.J., 2002, Mediated equilibrium: the influence of riparian vegetation and wood on the long-term evolution and behavior or a near-pristine river: Earth Surface Processes and Landforms, Volume 27, pp. 343-367.

38. Brosofske, K.D., J. Chen, R.J. Naiman, and J.F. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological

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Applications 7(4): 1188-1200., found at: http://research.eeescience.utoledo.edu/lees/pubs/brosofske1997.pdf

39. Brown, G.W. 1970. Predicting the effects of clearcutting on stream temperature. *Journal of Soil Science and Conservation*. 25: 11-13.

40. Brown, G.W. 1971. Water temperature in small streams as influenced by environmental factors and logging. pgs. 175-181 in *Proceedings of a Symposium: Forest Land Uses and Stream Environment*. 1970.

41. Brown, G.W. and J.T. Krygier. 1967. Changing water temperature in small mountain streams. *Journal of Soil and Water Conservation*. 22(60): 242-244.

42. Brown, G.W. and J.T. Krygier. 1970. Effects of clearcutting on stream temperature. *Water Resources Research.* 6: 1133-1140.

43. Brown, G.W., G.W. Swand and J. Rothacher. 1971. *Water Temperature in the Steamboat Drainage.* USDA For. Ser. Res. Pap. PNW-119. Pac. Northwest Forest and Range Research Experiment Station. Portland, Oregon. 17 pp.

44. Brownlee, M.J., B.G. Shepherd and D.R. Bustard. 1988. *Some Effects of Forest Harvesting on Water Quality in the Slim Creek Watershed in the Central Interior of British Columbia.* Department of Fisheries and Oceans, Vancouver, B.C. (Canada). Pac. Reg. Can. Tech. Rep. Fish. Aquat. Sci., no. 1613. 47 pp.

45. Budd, W.M., Cohen, P.L., Saunders, P.R., and Steiner, F.R., 1987, Stream corridor management in the Pacific Northwest: I. Determination of stream-corridor widths: Environmental Management Volume 11, pp. 587-597.

46. Cafferata, P., M. Berbach, J. Burke, J. Hendrix, R. Klamt, R. Macedo, T. Spittler, K. Vyverberg, and C. Wright-Shacklett. 2005. Flood prone area considerations in the coast redwood zone. Final Report of the Riparian Protection Committee. California Department of Forestry and Fire Protection. Sacramento, CA. 67 p. http://www.fire.ca.gov/php/rsrc-mgt_content/downloads/RiparianProtComWhitePaperfinal.pdf

47. Caldwell, J.E., K. Doughty and K. Sullivan. 1991. *Evaluation of Downstream Temperature Effects on Type 4/5 Waters. T/F/W Report No WQ5-91-004.* Prepared for the T/F/W CMER Water Quality Steering Committee and Washington Department of Natural Resources, Olympia, WA. 71 pp.

48. California Department of Forestry and Fire Protection (CDF). 1997. Coho salmon (*Oncorhynchus kisutch*) considerations for timber harvests under the California Forest Practice Rules. Mass mailing sent to Registered Professional Foresters in California dated April 29, 1997. 49 p. [hard copy]

49. Callaham, R.Z. 1987. Management of streambank zones in Northeastern California. Wildland Resources Center Report No. 12 pg. 44.

50. Castelle, A.J. and A.W. Johnson 2000. Riparian vegetation effectiveness. NCASI Technical Bulletin No. 799 pg. 32. [high priority]

51. CH_2MHill and Western Watershed Analysts. 1999. FEMAT riparian process effectiveness curves: what is science-based and what is subjective judgment? Oregon Forest Industries Council. Salem, OR. [electronic copy available]

52. Chamberlin, T.W., R.D. Harr and F.H. Everest. 1991. Timber harvesting, silviculture, and watershed processes. *Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats.*
53. American Fisheries Society Special Publication 19, Chap. 6: 181-205. [hard copy]

54. Chartrand, S.M., and Whiting, P.J., 2000, Alluvial architecture in headwall streams with special emphasis on step-pool topography: Earth Surface Processes and Landforms, Volume 25, pp. 583-600.

55. Chen, J., J.F. Franklin, and T.A. Spies. 1995. Growing-season microclimatic gradients from clearcut edges into old-growth Douglas-fir forests. Ecological Applications 5:74-86.

56. Chen, J., S.C. Saunders, T.R. Crow, R.J. Naiman, K.D. Brosofske, G.D. Mroz, B.L Brookshire, and J.F. Franklin. 1999. Microclimate in forest ecosystem and landscape ecology. BioScience 49(4): 288-297.

57. Church, M., 1999, Sediment sorting in gravel-bed rivers: Journal of Sedimentary Research, Volume 69, Number 1, pp. 20.

58. Cohen, T.J., and Brierley, G.J., 2000, Channel instability in a forested catchment: a case study from Jones Creek, East Gippsland, Australia: Geomorphology, Volume 32, Numbers 1-2, pp. 109-128.

59. Constantine, J.A., Pasternack, G.B., and Johnson, M.L., 2003, Floodplain evolution in a small, tectonically active basin of northern California: Earth Surface Processes and Landforms, Volume 28, pp. 869-888.

60. Correll, D. 2003. Vegetated Stream Riparian Zones: Their Effects on Stream Nutrients, Sediments, and Toxic Substances. An Annotated and Indexed Bibliography of the world literature. Includes buffer strips and interactions with hyporheic zones and floodplains Thirteenth Edition, April 2003. 890 citation references. Found at: http://www.unl.edu/nac/ripzone03.htm

61. Curran, H.H., and Wohl, E.E., 2003, Large woody debris and flow resistance in step-pool channels, Cascade Range, Washington: Geomorphology, Volume 51, pp. 141-157.

62. Custis, K., and Spittler, T.E., 2002, Evaluation of Watershed Recovery, Rockpile Creek, Sonoma County, California: California Geological Survey Memorandum to William Snyder, California Department of Forestry and Fire Protection, 10 p.

63. Dade, W.B., 2000, Grain size, sediment transport and alluvial channel pattern: Geomorphology, Volume 35, pp. 119-126.

64. Danehy, R., and B. Kirpes. 2000. Relative humidity gradients across riparian areas in eastern Oregon and Washington forests. *Northwest Science* 74: 224-233.

65. Dollogg, C. Andrew. 1999. Riparian Management in Forests of the Continental Eastern United States. CRC Press.

66. Dong, J., J. Chen, K. Brofoske, and R. Naiman. 1998. Modeling air temperature gradients across managed small streams in western Washington. *Journal of Environmental Management* 53: 309-321.

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67. Doughty K., J.E. Caldwell and K.S. Sullivan. 1991. *T/F/W Stream Temperature Method: User's Manual. TFW-WQ4-91-002.* Prepared for the T/F/W CMER Water Quality Steering Committee and Washington Department of Natural Resources, Olympia, WA. 40 pp.

68. Erman, D. 1999. Letter to the Board of Forestry and Fire Protection dated September 7, 1999, titled "Proposed regulatory action to amend and adopt new sections of Title 14 of the California Code of Regulations 895, 916 (Threatened and Impaired Watersheds). [hard copy]

69. Erman, D.C. and D. Mahoney 1983. Recovery after logging in streams with and without bufferstrips in Northern California. Contribution No. 186, Water Resources Center, University of California, Davis, CA pg. 55. [hard copy]

70. Erman, D.C. and F. Ligon. The response of algal communities in streams of the Jackson Demonstration State Forest to timber harvest activities. Report submitted to the State of California - Resources Agency, Department of Forestry, Sacramento, CA pg. 50. http://www.krisweb.com/biblio/ncc_cdffp_ermanetal_xxxx_jsdfligon.pdf

71. Erman, D.C., J.D. Newbold, and K.B. Roby. 1977. Evaluation of streamside bufferstrips for protecting aquatic organisms. California Water Resources Center, Contribution No. 165. University of California, Davis. 48 p. [hard copy]

72. Everest, F.H., R.L. Beschta, et. al. 1986. Fine sediment and salmonid production: A paradox. Chapter 4, Streamside Management: Forestry and Fishery Interactions, Ed. by E.O. Salo and T.W. Cundy, College of Forest Resources, University of Washington, Seattle, WA pg. 98 yo 142.

73. Everett, R.L., and S.H. Sharrow. 1985. Soil water and temperature in harvested and nonharvested pinyon juniper stands. USDA Forest Serv. Res. Pap. INT-342.

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75. FEMAT. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. U.S. Department of the Interior, U.S. Forest Service and Bureau of Land Management. [hard copy]

76. Fetherston, K.L., Naiman, R.J., and Bilby, R.E., 1995, Large woody debris, physical process, and riparian forest development in montane river networks of the Pacific Northwest: Geomorphology, Volume 13, Number 1-4, pp. 133-144. [high priority]

77. Ffolliot, Peter F., Malchus B Baker, Leonard F Debano, Daniel G Neary. 2003. Riparian Areas of the Southwestern United States. CRC Press.

78. France, R.L., 1997, Potential for soil erosion from decreased litterfall due to riparian clearcutting: Implications for boreal forestry and warm- and cool-water fisheries: Journal of Soil and Water Conservation, Volume 52, Number 6, pp. 452-455.

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81. FSP. 1998. Stream temperature sampling frequencies explored. Pages 4. Forest Science Project, Humboldt State University Foundation, Arcata, CA.

82. FSP. 2000. A fish-eye view of riparian canopy. Pages 4. Forest Science Project, Humboldt State University Foundation, Arcata, CA.

83. FSP. undated. Stream temperature protocol. Pages 21. Forest Science Project, Humboldt State University Foundation, Arcata, CA.

84. Furniss, M.J., and Renteria, Y., 2000, A partially annotated bibliography of small and intermittent streams (work in progress): Internet-supported bibliography, 79 p.

85. Garland, J.J. 1987. Aspects of practical management in the streamside zone. Proceedings of Symposium on Streamside Management: Forestry and Fishery Interactions, Contribution No. 57, College of Forest Resources, Univ. Washington, Seattle, WA pg. 277 to 288.

86. Gilvear, D.J., 1999, Fluvial geomorphology and river engineering: future roles utilizing a fluvial hydrosystems framework: Geomorphology, Volume 31, Numbers 1-4, pp. 229-246.

87. Grady, J. 2001. Effects of buffer width on organic matter input to headwater streams in the western Cascade Mountains of Washington State. Seattle, WA: University of Washington. 46p. M.S. thesis. [high priority]

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89. Grizzel, J., and N. Wolff. 1998. Occurrence of windthrow in forest buffer strips and its effect on small streams in northwest Washington. *Northwest Science* 72: 214-223.

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Appendix C: Format for Literature Tracking Log

National Marine Fisheries Service
Summary of Buffer Widths
LWD

Author	Buffer Studied	Buffer Function	Reference Type	Location	Notes	Source
Bilby and Bisson 1998	20-50 meters	70% - 90% of LWD recruitment				
Cederholm 1994	30-60 meters; 100-200 feet	Maintain natural levels of recruitment	Peer, Literature Review			
Hedrick et al. 1998	remove sections of deciduous riparian vegetation	increase periphyton biomass production, which increases number of aquatic invertebrates	Peer	Alaska	potential to increase number of fish	DH reviewed- Cafferata
MainTech 1996	One-site potential tree height	100% of LWD recruitment				
McDade et al. 1990	55 meters (one site-potential tree height)			Oregon and Washington		CA
	33 feet	50% LWD recruitment		Oregon and Washington		CA;JDSF EIR
	75 feet	85% LWD recruitment		Oregon and Washington		CA;JDSF EIR
	154 feet	100% LWD recruitment		Oregon and Washington		CA;JDSF EIR
	189 feet	90% LWD recruitment		Oregon and Washington		CA;JDSF EIR
Murphy and Koski 1989	30 meters	100% of LWD recruitment	Peer	Southeastern Alaska	Study sites were located in old-growth forests of Western hemlock and Sitka spruce	DH reviewed-Cafferata
O'Connor and Zisner	> 30 meters	90% of LWD recruitment				
Reid and Hilton 1998	One-tree-height width	86% of LWD recruitment		NF Caspar, Mendocino Co	Blowdown/MassFailures	CA;JDSF EIR
	4-5 tree heights' width	input zones for rates similar to undisturbed forests				
	35 meters	90% LWD recruitment (where forests have not been re-entered for logging)				
	50 meters	90% LWD recruitment (where forests have been clear-cut and forest buffers left)				
	20-50 meters	70% - 90% of LWD recruitment				
	20-50 meters	70% - 90% of LWD recruitment				
	20-50 meters	70% - 90% of LWD recruitment				
Van Sickle and Gregory 1990	1 SPTH	LWD beyond seldom reaches channel			Model	CA;JDSF EIR
Robison and Beschta 1990	1 SPTH	LWD beyond seldom reaches channel			Model	CA;JDSF EIR
Spence et al. 1996	1 SPTH	100% natural levels of recruitment of LWD	Literature Review			CA; JDSF EIR
Bisson et al. 1987	>12" DBH/39Ft Length Streams >66Ft Wide	Size of key piece				CA;JDSF EIR
Benda et al. 2002	20-40 meters	Wood recruitment		Humboldt County	Absence of landsliding; Old growth	CA;JDSF EIR
		18% Bank Erosion		Van Duzen River	Second growth	CA;JDSF EIR
		21% Mortality		Van Duzen River	Second growth	CA;JDSF EIR
		13% Landsliding		Van Duzen River	Second growth	CA;JDSF EIR
		50% Anthropogenic		Van Duzen River	Second growth	CA;JDSF EIR
	10 meters	90% wood recruitment			Second growth	CA;JDSF EIR
	15 meters (50 Feet)	90% prediction of wood recruitment	Theoretical Prediction Curve		Absent Landsliding	CA;JDSF EIR
	60 meters (200 Feet)		Theoretical Prediction Curve		Landsliding	CA;JDSF EIR
Benda 2004	14 meters (46 Feet)	90% wood recruitment		Ten Mile	Bank erosion; Stream-side Landsliding	CA;JDSF EIR
	8 meters (25 Feet)	90% wood recruitment		Noyo River	Bank erosion; Stream-side Landsliding	CA;JDSF EIR
Lienkaemper and Swanson 1987	20-30 meters	Zone of large wood input to ensure future supplies of large wood	Literature review			DH, in Lassettre and Harris 2001

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Appendix D: Key Questions

Key Questions

Introduction

Review of the scientific literature should focus on the interaction between riparian habitats, stream characteristics, and impacts, both positive and negative, from nearby forest management activities. The life cycle needs of salmonids are well understood and have been documented in the Scientific Review Panel report of 2000. (SRP) The Key Questions for the T or I rule review will focus on riparian habitat and potential impacts from forest management activities, but the linkage to salmonid biology is important. The initial focus of riparian Forest Practice Regulations is to limit or avoid significant impacts to existing riparian habitat irregardless of specific salmonid habitat needs. Enhancement or restoration of specific water quality or instream elements is a much more site specific analysis.

There are six ecological features (or structures and functions) that have been identified as critical components of functional riparian habitats. These features or functions are; 1) Nutrients, 2) Bank and Channel Stability, 3) Canopy and Shade, 4) Course Woody Debris, 5) Microclimates, and 6) Sediment. To make this review process consistent between ecological features, each feature and subsequent Key Question and Additional Question are structured following a specific format. Key Questions ask whether the scientific understanding of ecological theory is supported by research and then at what distance(s) from the stream channel does the feature contribute to the stream channel. Additional Questions may or may not have a direct bearing on forest management activities but may provide insight into understanding the larger ecological role of the ecological feature.

In addition to understanding the six ecological features, it is also important to assess natural variability and other more stochastic natural events. Natural Variability from watershed to watershed is typically due to a watersheds unique physical condition (i.e. space) and unique history of natural disturbances (i.e. time). The physical condition of a watershed can vary due to, but not limited to; geology, climate, precipitation patterns and resulting vegetation types. Riparian habitats are typically changed by natural disturbances such as fire, flooding, and windthrow. Stream channels can be changed by disturbances such as landslides, lateral channel erosion, peak flow flooding, and deposition of debris during peak flows. All of these disturbances help create a highly diverse riparian plant communities and complex stream channel habitats (*Gregory et al. 1991*). Accordingly, uncertainty caused by stochastic events requires that riparian habitats and stream channel protection measures be reviewed and assessed on a site-by-site basis as described in the Forest Practice Rules. The natural disturbance history is our attempt to measure time, but in fact the watershed or

stream channel is in constant change over time and review of scientific information should be aware of this variability.

Key and Additional Questions

Nutrients

Nutrients can be supplied to the stream channel through leaf litter fall.

Key Questions

1. Does leaf litter fall from riparian habitats have any bearing on the nutrient levels within stream zones?
2. At what distance(s) from the stream channel are nutrients supplied from leaf litter fall?

Additional Questions

Bank and channel stability

Root Strength by streamside trees can provide stream bank stability necessary for channel stabilization.

Key Questions

1. What is the contribution of roots to stream bank and channel stability in different types of channels and watersheds?
2. At what distances(s) from the stream channel does root strength from streamside trees provide stream bank stabilization?

Additional Questions

Vegetative Canopy -

Shade from vegetation can be an important component for regulating water temperature.

Key Questions

1. What factors (structural, hydrologic and physical) contribute to regulation of stream water temperature?
2. If shade-producing canopy has an effect on regulating water temperature, at what distances from the stream channel is shade-producing canopy effective?
3. What reductions in the shade-producing canopy are possible before significant effects occur?

Additional Questions

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Coarse Woody Debris

Coarse Woody Debris is recruited from vegetation and can contribute to complex fish habitats and sediment storage and metering.

Key Questions

1. What are the primary ecological process(s) that result in the recruitment of coarse woody debris into stream channels?
2. From each of these ecological process(s), at what distances is coarse woody debris recruited?

Additional Questions

Microclimates

Microclimates created by streamside vegetation, in addition to solar radiation, influence ambient air temperature, relative humidity, and wind speed which effect stream water temperature regimes.

Key Questions

1. What is the relationship between measurable riparian microclimate air temperatures, relative humidity and wind speed and stream water temperatures?
2. Do changes in microclimate air temperatures, relative humidity and wind speed impact, positively or negatively, the overall stream water temperature budget?
3. At what distance from the stream channel does microclimate impact, positively or negatively, stream water temperatures?

Additional Questions

Sediment

Sediment from overland flow can be filtered by riparian and upland habitat vegetation.

Key Questions

1. What are the primary types of overland flow sedimentation?
2. What kinds of potential disturbances can be associated with these primary types?
3. At what distance to the stream channel do riparian habitats ameliorate sediment flow to the stream channel?

Additional Questions

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Additional Questions for Consideration by TAC

A. Salmonid life-cycle needs

1. What water flow, quality (e.g., temperature, turbidity) and aquatic habitat (e.g., gravel size distribution, riffle and pool structure and depth) conditions are needed at each life stage (e.g., spawning, incubation, rearing, and migration) for population viability of each salmonid species and for their aquatic food organisms? Are there any consistent thresholds separating conditions that are optimal from those that are sub-optimal but sufficient to maintain population viability and from those that are insufficient?
2. What are the critical times of year for each life stage for each species?
3. What is the relative importance of each of these needs? Which are the more common and/or significant limiting factor(s) for salmonid populations?

B. Near-stream/riparian/floodplain beneficial functions

1. What are the beneficial functions of near-stream/riparian/floodprone areas (e.g., filtering sediment and other pollutants from entering streams, stabilizing stream banks, attenuating peak flows, minimizing channel migration; providing large woody debris, providing nutrients and food organisms, stabilizing air and water temperatures) in providing/maintaining the life-cycle needs of salmonid species either directly or indirectly though food organisms.
2. What characteristics of these areas (e.g., organic litter and debris, canopy structure and composition, bank armoring, imbedded large wood debris) improve or diminish each of these functions? In what manner and to what degree?
3. In what manner and to what degree have various types of near-stream timber operations or riparian management practices been shown to either increase or diminish each of these beneficial functions and/or the related characteristics? To what degree are they sensitive to disturbance by timber operations?

C. Near-stream and floodprone area hazards

1. What are the potential natural hazards associated with near-stream and floodprone areas (e.g., bank instability, lateral and vertical channel migration, flow obstruction or diversion of flow)?
   a. What characteristics of near-stream and floodprone areas increase or decrease each of these potential hazards? In what way and to what degree?
   b. What is the relative importance of each potential hazard to anadromous salmonids at each life stage, either directly or indirectly?

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2. In what manner and to what degree have various types of near-stream/floodprone area timber operations or riparian management practices been shown to either increase or diminish each near-steam hazard and its effects on the life-cycle needs of salmonids?

D. Hillslope geologic hazards which could have deleterious effects on riparian buffer zones and anadromous salmonid populations

1. What are the potential natural geologic hazards (e.g., mass wasting or accelerated erosion) associated with hillslopes outside the near-stream area?
2. What natural conditions make hillslopes prone to mass wasting and high erosion rates (e.g., slope, soil texture and composition, groundwater) if disturbed by timber operations?
3. In what manner and to what degree have geologic hazards triggered by hillslope timber operations been shown to harm (or harm the recovery of) salmonid populations either directly or indirectly? What varieties of hillslope timber operations (e.g., road construction, road drainage) are associated with each geologic hazard, and what is the strength of the association? What types of hillslope timber operations have been shown to diminish such geologic hazards?
4. What types of negative effects can the hillslope geologic hazards have on the beneficial functions of nearstream areas; how can they exacerbate near-stream hazards?
5. In what manner and to what degree have various types of near-stream timber operations or riparian management practices been shown to either increase or diminish the negative effects of each hillslope geologic hazard?
   a. What are the types of mass wasting or erosion events for which riparian buffer zones are not effective in preventing or reducing discharges of sediment or large woody debris into fish-bearing waters (e.g., debris torrents, gully flow and erosion) and those for which they are relatively effective (e.g., sheet and rill erosion)?
   b. What riparian buffer zone characteristics are most strongly associated with its effectiveness (or lack thereof) in minimizing discharges from hillslope hazards?
6. What is the relative contribution of hillslope geologic hazards to sediment and large woody debris discharges compared to nearstream areas?

E. Direct inputs from timber operations

1. In what manner and to what degree have discharges of petrochemicals, pesticides, fertilizers from timber operations been shown to harm (or harm the recovery of) salmonid populations either directly or indirectly?
2. What is the relationship between concentration of/exposure to any such pollutant and the type and degree of direct or indirect harm to salmonids?

F. Nutrients

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1. Does thinning within the WLPZ cause changes in the forest composition between conifers and deciduous hardwoods which then result in changes in the yearly pattern of litter fall?

G. Root Strength

Root Strength by streamside trees can provide stream bank stability necessary for channel stabilization.

1. Does the type (conifer or hardwood) or species of trees influence this relationship?
2. 4.How does harvesting impact the root strength contribution to channel stability?

H. Vegetative Canopy and Shade

What is the effect of shade-producing canopy on a specific stream's water temperature regime?

1. Are the different vegetative shade measurement devices comparable and are any differences important in predicting potential changes in water temperature due to harvest?

I. Coarse Woody Debris

Coarse Woody Debris is recruited from vegetation and contributes to complex fish habitats.

1. Can forest management activities impact natural wood recruitment processes?
2. Can the quality of large woody debris be artificially enhanced by forest management activities?
3. Is wood loading in streams associated with salmonid production?
4. Is there a relationship between wood loading and adjacent riparian composition and structure?
5. What portions and size of wood loads affect channel morphology?

J. Microclimates

Microclimates created by streamside vegetation, in addition to solar radiation, influence ambient air temperature, relative humidity, and wind speed which effect stream water temperature regimes.

1. What is the relationship between measurable riparian microclimate air temperatures, relative humidity and wind speed and stream water temperatures?

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2. Do changes in microclimate air temperatures, relative humidity and wind speed impact, positively or negatively, the overall stream water temperature budget?
3. At what distance from the stream channel does microclimate impact, positively or negatively, stream water temperatures?

K. Sediment

Sediment from overland flow can be filtered by riparian and upland habitat vegetation.

1. How does the overall percentage of stream sedimentation from overland flow vary with watershed characteristics?
2. What types of forest management activities impact different types of overland flow sediment sources?
3. What regulations exist to ameliorate sediment production in streamside zones and are they effective?

L. Natural Variability

Natural Variability from watershed to watershed is typically due to a watersheds unique physical condition (i.e. space) and unique history of natural disturbances (i.e. time). The physical condition of a watershed can vary due to, but not limited to; geology, climate, precipitation patterns and resulting vegetation types. The natural disturbance history is our attempt to measure time, but in fact the watershed or stream channel is in constant change over time and review of scientific information should be aware of this variability.

M. Stochastic Events

In addition to understanding the six ecological features and natural variability, it is also important to assess other more stochastic natural events. Riparian habitats are typically changed by natural disturbances such as fire, flooding, and windthrow. Stream channels can be changed by disturbances such as landslides, lateral channel erosion, peak flow flooding, and deposition of debris during peak flows. All of these disturbances help create a highly diverse riparian plant communities and complex stream channel habitats (*Gregory et al. 1991*). Accordingly, uncertainty caused by stochastic events requires that riparian habitats and stream channel protection measures be reviewed and assessed on a site-by-site basis as described in the Forest Practice Rules.

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N. Buffer Width

1. What widths and protection levels are supported in the literature for anadromous fish-bearing watercourses in coastal redwood-Douglas fir forests, the Klamath Province, and in the interior Sierra Nevada/Cascade Province [due to differing fire frequencies, conifer tree sizes, geologic factors, etc.]

2. What widths and protection measures are supported in the literature for different sizes of anadromous fish bearing watercourses in these different regions [stream size can be determined by active channel width. mean annual flow classes, etc.]

3. How do widths and protection measures vary by key function (large wood recruitment, shading, fine organic matter input, wildlife habitat, etc.)

4. How do site-specific factors affect proper buffer strip design.

   (A) What buffer width is needed for suitable recruitment of large wood?,

   (B) What buffer width is needed for suitable temperature and humidity control?,

   (C) What buffer width is needed to control temperature from solar radiation?,

   (D) What buffer width is needed for filtration of sediment ? (BOF 2005). Clearly the answer to these questions varies depending on the location (e.g., coast vs. interior) and size of the watercourse under consideration.

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Appendix E: Literature Review Format

Literature Review of Threatened or Impaired Watershed Regulations
Recommendations to Review Format
(DRAFT July 11, 2006)

Function Category
Bibliographic citation

Short paragraph: A paragraph that summarizes or quotes the key findings of the study.

Buffer Width Studied: Actual buffer width studied, if appropriate.

Type of study:
- Synthesis of regional literature of ecological theory
- Observational study of California aquatic/riparian function
- Correlation Study
- Response Study
- Cause-and-effect Study
- Biological Study
  - Fishbearing Yes or No

Type of Process: At a minimum, describe the type of process (es) that is the primary basis of the study. Is it physical, biological, or both? Examples might be a geological, vegetative, climate or biological process(s) such as forest type, stream size class (Class I, II, III, stream width, stream flow, etc…), floodplain, etc…

Methods: Methods used in study (e.g., managed/unmanaged, no cut/thinning, basal area/# trees, canopy retention, statistics, tools, treatments, etc…).

Timeframe: Timeframe of study and monitoring

Location: Location of research and application to California (e.g., inland, coastal)

Salmonid Life Stage Function: Yes/No to Spawning, Incubation, Rearing, Smoltification, Feeding

Population Viability: Yes/No to Abundance, Productivity, Genetic Diversity, Spatial Distribution, Diversity

Reference Type: Literature Review, Journal Article, Book Section, Book, Thesis, Conference Paper, Conference Proceedings, Report, Government Document, Unpublished Work, Legal Regulations, PhD Dissertation, Technical Bulletin

Reviewer:

Notes:

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End Scope of Work September 22, 2006

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