DEC 18 2014

FORMAT 1

Submit original with signatures + 1 copy + electronic copy to Faculty Senate (Box 7500).

See http://www.uaf.edu/uafgov/faculty-senate/curriculum/course-degree-procedures-/ for a complete description of the rules governing curriculum & course changes.

TRIAL COURSE OR NEW COURSE PROPOSAL

SUBMITTED BY:

Department	Fisheries Division	**College/School**	Fisheries & Ocean Sciences
Prepared by	Jeffrey A. Falke	**Phone**	907-474-6044
Email Contact	Jeffrey.Falke@alaska.edu	**Faculty Contact**	Jeffrey A. Falke

1. ACTION DESIRED (CHECK ONE): Trial Course [X] New Course [ ]

2. COURSE IDENTIFICATION: Dept FISH | Course # 694 | No. of Credits 3

Justify upper/lower division status & number of credits: This class meets for 3 hours per week for an entire semester. It is a graduate-level course because it contains complex material and is oriented toward graduate students. Diverse backgrounds are required owing to the multi-disciplinary nature of the material (e.g., physical and biological sciences).

3. PROPOSED COURSE TITLE: Physical Processes in Freshwater Ecosystems

4. To be CROSS LISTED? *YES/NO* YES | If yes, Dept: BIOL | Course # 694

NOTE: Cross-listing requires approval of both departments and deans involved. Add lines at end of form for additional required signatures.

5. To be STACKED? *YES/NO* NO | If yes, Dept. | Course #

How will the two course levels differ from each other? How will each be taught at the appropriate level?:

Stacked course applications are reviewed by the (Undergraduate) Curricular Review Committee and by the Graduate Academic and Advising Committee. Creating two different syllabi—undergraduate and graduate versions—will help emphasize the different qualities of what are supposed to be two different courses. The committees will determine: 1) whether the two versions are sufficiently different (i.e. is there undergraduate and graduate level content being offered); 2) are undergraduates being overtaxed?; 3) are graduate students being undertaxed? In this context, the committees are looking out for the interests of the students taking the course. Typically, if either committee has qualms, they both do. More info online – see URL at top of this page.

6. FREQUENCY OF OFFERING: Fall semester, odd-numbered years

Fall, Spring, Summer (Every, or Even-numbered Years, or Odd-numbered Years) — or As Demand Warrants

7. SEMESTER & YEAR OF FIRST OFFERING (AY2013-14 if approved by 3/1/2013; otherwise AY2014-15) Fall 2015

8. COURSE FORMAT:

NOTE: Course hours may not be compressed into fewer than three days per credit. Any course compressed into fewer than six weeks must be approved by the college or school's curriculum council. Furthermore, **any core course compressed to less than six weeks must be approved by the Core Review Committee.**

COURSE FORMAT: (check all that apply)	[ ]	*1*	[ ]	*2*	[ ]	*3*	[ ]	*4*	[ ]	*5*	[X] *6 weeks to full semester*
OTHER FORMAT (specify)											
Mode of delivery (specify lecture, field trips, labs, etc)	**Lecture plus student- and instructor-led discussion of required readings**										

9. CONTACT HOURS PER WEEK: 3 hrs LECTURE hours/weeks | [ ] LAB hours /week | [ ] PRACTICUM hours /week

Note: # of credits are based on contact hours. 800 minutes of lecture=1 credit. 2400 minutes of lab in a science course=1 credit. 1600 minutes in non-science lab=1 credit. 2400-4800 minutes of practicum=1 credit. 2400-8000 minutes of internship=1 credit. This must match with the syllabus. See http://www.uaf.edu/uafgov/faculty-senate/curriculum/course-degree-procedures-/guidelines-for-computing-/ for more information on number of credits.

OTHER HOURS (specify type)

RECEIVED
DEC 10 2014
Dean's Office
College of Natural Science & Mathematics

Governance
5 4-17-21

10. COMPLETE CATALOG DESCRIPTION including dept., number, title, credits, credit distribution, cross-listings and/or stacking (50 words or less if possible):

Example of a complete description:

FISH F487 W, O Fisheries Management
3 Credits Offered Spring
Theory and practice of fisheries management, with an emphasis on strategies utilized for the management of freshwater and marine fisheries. ***Prerequisites: COMM F131X or COMM F141X; ENGL F111X; ENGL F211X or ENGL F213X; ENGL F414; FISH F425; or permission of instructor.*** **Cross-listed with NRM F487. (3+0)**

FISH 694 Physical Processes in Freshwater Ecosystems
3 Credits Offered Fall, odd years
Theoretical background of habitat dynamics in freshwaters with focus on response of biota and practical application of current sampling methods. Prerequisites: BIOL 483 or FISH 425 or FISH 650 or permission of instructor, and graduate standing. Cross-listed with BIOL 694. (3+0).

11. COURSE CLASSIFICATIONS: Undergraduate courses only. Consult with CLA Curriculum Council to apply S or H classification appropriately; otherwise leave fields blank.

H = Humanities		S = Social Sciences	

Will this course be used to fulfill a requirement for the baccalaureate core? **If YES, attach form.**	**YES:**		**NO:**	X

IF YES, check which core requirements it could be used to fulfill:

O = Oral Intensive, **Format 6**		W = Writing Intensive, **Format 7**		X = Baccalaureate Core	

11.A Is course content related to northern, arctic or circumpolar studies? If yes, a "snowflake" symbol will be added in the printed Catalog, and flagged in Banner.

YES		NO	X

12. COURSE REPEATABILITY:

Is this course repeatable for credit?	**YES**		**NO**	X

Justification: Indicate why the course can be repeated (for example, the course follows a different theme each time).	

How many times may the course be repeated for credit?		**TIMES**
If the course can be repeated for credit, what is the maximum number of credit hours that may be earned for this course?		**CREDITS**
If the course can be repeated with variable credit, what is the maximum number of credit hours that may be earned for this course?		**CREDITS**

13. GRADING SYSTEM: Specify only one. Note: Changing the grading system for a course later on constitutes a Major Course Change – Format 2 form.

LETTER:	X	**PASS/FAIL:**	

RESTRICTIONS ON ENROLLMENT (if any)

14. PREREQUISITES	BIOL 483 or FISH 425 or FISH 650 or permission of the instructor, and graduate standing.

These will be *required* before the student is allowed to enroll in the course.

15. SPECIAL RESTRICTIONS, CONDITIONS	**Students must attend the course in person or by videoconference.**

16. PROPOSED COURSE FEES	$0

Has a memo been submitted through your dean to the Provost for fee approval? **Yes/No**

17. PREVIOUS HISTORY

Has the course been offered as special topics or trial course previously? **Yes/No**	**No**

If yes, give semester, year, course #, etc.:

18. ESTIMATED IMPACT

WHAT IMPACT, IF ANY, WILL THIS HAVE ON BUDGET, FACILITIES/SPACE, FACULTY, ETC.

Course requires classrooms and videoconferencing for 3 hours per week every other fall semester.

19. LIBRARY COLLECTIONS

Have you contacted the library collection development officer (kljensen@alaska.edu, 474-6695) with regard to the adequacy of library/media collections, equipment, and services available for the proposed course? If so, give date of contact and resolution. If not, explain why not.

No		Yes	X	**7/14/2014**

20. IMPACTS ON PROGRAMS/DEPTS

What programs/departments will be affected by this proposed action?
Include information on the Programs/Departments contacted (e.g., email, memo)

Students from the Biology & Wildlife and Natural Resources Management Departments would likely take this course.

21. POSITIVE AND NEGATIVE IMPACTS

*Please specify **positive and negative** impacts on other courses, programs and departments resulting from the proposed action.*

This course provides positive impact by enriching the SFOS fisheries program with a course on physical habitats in freshwaters. Because there is little to no overlap in content between this course and others, this course will not negatively affect other courses or programs. It will complement other courses offered by the department such as FISH 487 Fisheries Management and FISH 650 Fish Ecology.

JUSTIFICATION FOR ACTION REQUESTED

The purpose of the department and campus-wide curriculum committees is to scrutinize course change and new course applications to make sure that the quality of UAF education is not lowered as a result of the proposed change. Please address this in your response. This section needs to be self-explanatory. Use as much space as needed to fully justify the proposed course.

Knowledge of how physical processes form and maintain habitats, and how organisms adapt and respond to these dynamic habitats, is critical for conservation and management in aquatic systems. Prospective employers, especially state and federal natural resource agencies, increasingly look for knowledge and experience with habitat dynamics and sampling techniques as conditions for employment. This new course will provide a solid background into the theory behind physical processes in freshwater ecosystems as well as knowledge regarding sampling techniques and their practical implementation in the real world. There are currently no physical habitat courses at UAF.

APPROVALS: Add additional signature lines as needed.

See attached	Date	12.1.14
Signature, Chair, Program/Department of:	FB Heroes	

Ana M Aguilar-Islas	Date	12/9/14
Signature, Chair, College/School Curriculum Council for:		

	Date	12/9/14
Signature, Dean, College/School of:	SFOS	

Offerings above the level of approved programs must be approved in advance by the Provost.

	Date	
Signature of Provost (if above level of approved programs)		

ALL SIGNATURES MUST BE OBTAINED PRIOR TO SUBMISSION TO THE GOVERNANCE OFFICE

	Date	
Signature, Chair		

Faculty Senate Review Committee: ___Curriculum Review ___GAAC

___Core Review ___SADAC

ADDITIONAL SIGNATURES: (As needed for cross-listing and/or stacking)

	Date	12/10/14
Signature, Chair, Program/Department of:	Biology + Wildlife	

	Date	12-16-14
Signature, Chair, College/School Curriculum Council for:		

for Paul Layer	Date	12-16-14.
Signature, Dean, College/School of:	CNSM	

UNIVERSITY of ALASKA

Christina Neumann <clneumann@alaska.edu>

Course Proposal: FISH 694- Physical Processes in Freshwater Ecosystems

Shannon Atkinson <shannon.atkinson@alaska.edu> Mon, Dec 1, 2014 at 4:47 PM
To: Christina Neumann <clneumann@alaska.edu>

Hi Christina- Pls accept this email as my signature on the FISH 694 revised course proposal.

thanks!

Shannon
[Quoted text hidden]
--
Shannon Atkinson, PhD
Professor, Fisheries Division
Juneau Center
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
17101 Pt. Lena Loop Rd.
Juneau, AK 99801
(907) 796-5453
shannon.atkinson@alaska.edu

FISH 694/BIOL 694: Physical Processes in Freshwater Ecosystems

Course Syllabus

Course number/title: FISH 694/BIOL 694: Physical Processes in Freshwater Ecosystems

Credits: 3.0 Credits (letter grade)

Prerequisites: BIOL 483 or FISH 425 or FISH 650 or permission of the instructor, and graduate standing.

Location and meeting time: Classes meet for 3 hours per week during the fall semester in odd-numbered years. Class sessions meet in Lena 101 (Juneau), ONL 214 (Fairbanks), and other videoconference locations by request.

Instructor: Dr. Jeffrey A. Falke, phone: (907) 474-6044; email: Jeffrey.Falke@alaska.edu

Office location/hours: 209B Irving I, Wednesdays (1-2PM), or by appointment.

Course readings/materials:

No text is required for this course. Required and supplementary readings will be provided in class or posted weekly on Blackboard (http://classes.uaf.edu/).

Course catalog description: *Theoretical background of habitat dynamics in freshwaters with focus on response of biota and practical application of current sampling methods.*

Course introduction: The overall goal of aquatic ecology is to better understand the interactions among aquatic taxa and their environments. As such, knowledge of how physical processes form and maintain habitats, and how organisms adapt and respond to these dynamic habitats, is critical for conservation and management in aquatic systems. Recent advances in quantifying the characteristics and distribution of habitats (e.g., remote sensing, GIS, etc.) have increased our understanding of the importance of habitat dynamics on population regulation, community composition, and ecosystem function across spatial and temporal scales. A combination of lectures, readings, and group projects will cover these topics with specific applications from around the world and Alaska.

Course goals: The goal of this course is for students to develop a broad understanding of physical processes that form and maintain freshwater habitats.

Student learning outcomes:

By the end of the semester, students enrolled in this class will have the following:

1. An understanding of how physical processes create, maintain, and structure habitats for freshwater taxa
2. Knowledge of current methods to classify, measure, and sample physical habitats in freshwaters.
3. Familiarity with current important topics in the field: environmental flows, ecological/process-based restoration, climate impacts

4. Appreciation of the technical literature as related to physical processes in freshwater ecosystems
5. Improved ability to be creative, synthesize, and present complex information through a group proposal writing exercise.

Instructional methods: Each week, two class meetings will consist of lectures by the instructor or guest speakers, and the other meeting will be a paper discussion and/or time set aside to work on group projects. Lectures will provide background on physical processes in freshwater ecosystems , whereas readings will focus on specific examples of the effects of said processes on a biological response. Required readings include journal articles, book chapters, agency sampling protocols and other relevant documents. Electronic copies of all readings will be placed on Blackboard (http://classes.uaf.edu/). Each student will lead and co-lead class discussions on 1-2 topics, depending on class size. Other class discussions will be led by the instructor. All lectures will be given by the instructor or an occasional guest speaker. For each discussion, students are expected to be conversant on the required readings as demonstrated through their active participation. Additionally, a group project will be required. Half-way through the semester, students will be divided into groups of 3-5 individuals with diverse interests and experiences. Each group will be tasked with using what they have learned in this and other courses to develop a multi-scale habitat survey design for a specific physical process and biological response in an Alaskan hydroecosystem (e.g., effects of sediment regimes on coastal cutthroat trout distribution in Southeast Alaska).

Course policies: Students are expected to attend all lectures and discussions. Cheating, plagiarism, or other forms of academic dishonesty are unacceptable. Please adhere to the UAF Student Code of Conduct (http://uaf.edu/catalog/catalog_13-14/academics/regs3.html). Violations of the UAF Student Code of Conduct will result in immediate failure of the course.

Evaluation: The following letter grading system will be applied based on absolute scores:

A = 90-100%
B = 80-89
C = 70-79
D = 60-69
F < 60

The following is the overall grading basis for this course:

45%	Group proposal
20%	Group presentation
10%	Personal and peer evaluations
15%	Attendance and active participation in discussions
10%	Leadership of class discussion
100%	Total Grade

Group proposal points allocation (20% each):

1) Grammar, format, and presentation
2) Organization
3) Well-developed idea and perspective
4) Incorporates concepts covered in class
5) Citations and references

Group presentation points allocation (20% each):

1) Equal member participation
2) Clear and focused delivery
3) Presentation is well-organized
4) Presentation includes details
5) Visuals complement and do not detract from message

Discussion leadership evaluation (33% each):

1) Preparation
2) Discussion facilitation
3) Quality of questions

Students are expected to attend all class sessions (unless absence is approved in advance) and demonstrate comprehension of assigned reading materials by active participation in discussion sessions by answering questions posed by the instructor and by asking informed questions about the reading material. Each student is also expected to lead and co-lead 1-2 class discussions (depending on class size) on assigned readings. Assignments for leaders and co-leaders of class discussions will be arranged during the first class session. Group project proposals will be graded based on ability of the group to integrate concepts presented in the course, logic, presentation, and grammar. Group presentations will be scored based on content, clarity, and professionalism. Each student and group will evaluate themselves as part of the proposal and presentation development process. At the end of the semester each student will submit an anonymous evaluation of the other members in their group, as well as document and evaluate their own contributions to the team. These evaluations will count for 25% of the combined group presentation and proposal grade (i.e., 10% of overall grade). There are no exams.

Fees: N/A.

Support services: The Writing Center (http://www.uaf.edu/english/writing-center/) offers tutorial and fax-tutorial assistance with grammar, composition, and style. Students connected to the UAF network (Ethernet or wireless on-campus or through VPN off-campus) have access to UAF Library catalogs, electronic journal holdings, and interlibrary loan resources. Miscellaneous support services (e.g., tutorial services, instruction in mathematics skills, academic advising, mentoring and personal support, cultural and social engagement, use of laptop computers, labs, and other technology resources, and direct financial assistance to qualified low-income participants) are available through UAF Student Support services (http://www.uaf.edu/sss/).

Disabilities services: The instructor will work with the UAF Office of Disability Services (208 WHITAKER BLDG, 907-474-5655) to provide reasonable accommodation to students with disabilities.

Course calendar: The class meets for the entire semester. The course will cover the following topics in the following draft order:

Date		Topic	Reading
September			
	4	Course Overview	No readings
	7	No class – Labor Day	No readings
	9	Fluvial geomorphology	Wetzel 2001 (p 9-22)
	11	Discussion	Ward 1998
	14	Lacustrine geomorphology	Wetzel 2001 (p 22-42)
	16	Drainage networks	Knighton 1998 (p 9-56)
	18	Discussion	Benda et al. 2004
	21	Catchment and channel processes	Knighton 1998 (p 65-95)
	23	Sediment dynamics	Montgomery et al. 1996
	25	Discussion	Bowerman et al. 2014
	28	Groundwater dynamics – regional	Winter 2007
	30	Hyporheic flows – microhabitat to reach	Boulton et al. 1998
October			
	2	Discussion	Baxter & Hauer 2000
	5	Hydrology & hydrologic regimes	Olden & Poff 2003
	7	Climate impacts – hydro	Coopersmith et al. 2014
	9	Discussion	Wenger et al. 2011
	12	Thermal regimes & heat budgets	Cassie 2006
	14	Climate impacts – thermal	Arismendi et al. 2013
	16	Discussion	Johnson & Jones 2000
	19	Disturbance I – hydrologic	Resh et al. 1998
	21	Disturbance II – fire, geologic	Dunham 2003
	23	Discussion	Reeves et al. 2005
	26	Environmental flows – theory	Poff et al. 1997
	28	Environmental flows – practice	Poff et al. 2009
	30	Discussion	Arthington et al. 2006
November			
	2	Human impacts on physical processes	Karr 1999
	4	Process-based restoration	Palmer et al. 2005
	6	Discussion	Beechie et al. 2012
	9	Habitat classification – pattern	Bisson et al. 1982
	11	Habitat classification – process	Montgomery & Buffington 1998
	13	Discussion	Poole et al. 1997
	16	Sampling methods – site-based	Bain & Stevenson 1999

	18	Sampling methods – reach-scale	CHaMP 2014
	20	Group proposal development	No readings
	23	Sampling methods – watersheds	
	25	New approaches to habitat sampling	
	27	No class – Thanksgiving	No readings
	30	Synthesis and new directions	Thorp 2014
December			
	2	OPEN (catch-up)	No readings
	4	Group proposal development	No readings
	7	Group proposal presentations	No readings
	9	Group proposal presentations	No readings
	11	Group proposal presentations	*Group proposals due*

Required readings:

Arismendi, I., S. L. Johnson, J. B. Dunham, and R. Haggerty. 2013. Descriptors of natural thermal regimes in streams and their responsiveness to change in the Pacific Northwest of North America. Freshwater Biology 58(5):880-894.

Arthington, A. H., S. E. Bunn, N. L. Poff, and R. J. Naiman. 2006. The challenge of providing environmental flow rules to sustain river ecosystems. Ecological Applications 16(4):1311-8.

Bain, M. B., and N. J. Stevenson. 1999. Aquatic habitat assessment: Common methods. American Fisheries Society, Bethesda.

Baxter, C. V., and F. R. Hauer. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (salvelinus confluentus). Canadian Journal of Fisheries and Aquatic Sciences 57(7):1470-1481.

Beechie, T., J. S. Richardson, A. M. Gurnell, and J. Negishi. 2012. Watershed processes, human impacts, and process-based restoration. Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats:11-49.

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

Bisson, P. A., J. L. Nielsen, R. A. Palmason, and L. E. Grove. 1982. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low streamflow. Acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Western Division, Bethesda, Maryland:62-73.

Boulton, A. J., S. Findlay, P. Marmonier, E. H. Stanley, and H. M. Valett. 1998. The functional significance of the hyporheic zone in streams and rivers. Annual Review of Ecology and Systematics 29:59-81.

Bowerman, T., B. T. Neilson, P. Budy, and C. T. Marshall. 2014. Effects of fine sediment, hyporheic flow, and spawning site characteristics on survival and development of bull trout embryos. Canadian Journal of Fisheries and Aquatic Sciences 71(7):1059-1071.

Caissie, D. 2006. The thermal regime of rivers: A review. Freshwater Biology 51(8):1389-1406.

Columbia Habitat Monitoring Program [CHaMP]. 2014. Scientific Protocol for Salmonid Habitat Surveys within the Columbia Habitat Monitoring Program (CHaMP) v4.0. Available: https://www.champmonitoring.org/Program/Details/1#protocol~#protocol2020.

Coopersmith, E. J., B. S. Minsker, and M. Sivapalan. 2014. Patterns of regional hydroclimatic shifts: An analysis of changing hydrologic regimes. Water Resources Research 50(3):1960-1983.

Dunham, J. B., M. K. Young, R. E. Gresswell, and B. E. Rieman. 2003. Effects of fire on fish populations: Landscape perspectives on persistence of native fishes and nonnative fish invasions. Forest Ecology and Management 178(1-2):183-196.

Johnson, S. L., and J. A. Jones. 2000. Stream temperature responses to forest harvest and debris flows in Western Cascades, Oregon. Canadian Journal of Fisheries and Aquatic Sciences 57:30-39.

Karr, J. R. 1999. Defining and measuring river health. Freshwater Biology 41(2):221-234.

Knighton, D. 1998. Fluvial Forms and Processes: A New Perspective. Arnold, London.

Kondolf, G. M., and M. G. Wolman. 1993. The sizes of salmonid spawning gravels. Water Resources Research 29(7):2275-2285.

Montgomery, D. R., J. M. Buffington, N. P. Peterson, D. Schuett-Hames, and T. P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. Canadian Journal of Fisheries and Aquatic Sciences 53(5):1061-1070.

Montgomery, D. R., and J. M. Buffington. 1998. Channel processes, classification, and response. River Ecology and Management. Springer-Verlag, New York:13-42.

Olden, J. D., and N. L. Poff. 2003. Redundancy and the choice of hydrologic indices for characterizing streamflow regimes. River Research and Applications 19(2):101-121.

Palmer, M. A., E. S. Bernhardt, J. D. Allan, P. S. Lake, G. Alexander, S. Brooks, J. Carr, S. Clayton, C. N. Dahm, J. Follstad Shah, D. L. Galat, S. G. Loss, P. Goodwin, D. D. Hart, B. Hassett, R. Jenkinson, G. M. Kondolf, R. Lave, J. L. Meyer, T. K. O'Donnell, L. Pagano, and E. Sudduth. 2005. Standards for ecologically successful river restoration. Journal of Applied Ecology 42(2):208-217.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime. Bioscience:769-784.

Poff, N. L., B. D. Richter, A. H. Arthington, S. E. Bunn, R. J. Naiman, E. Kendy, M. Acreman, C. Apse, B. P. Bledsoe, M. C. Freeman, J. Henriksen, R. B. Jacobson, J. G. Kennen, D. M. Merritt, J. H. O'Keeffe, J. D. Olden, K. Rogers, R. E. Tharme, and A. Warner. 2010. The ecological limits of hydrologic alteration (eloha): A new framework for developing regional environmental flow standards. Freshwater Biology 55(1):147-170.

Poole, G. C., C. A. Frissell, and S. C. Ralph. 1997. In-stream habitat unit classification: Inadequacies for monitoring and some consequences for management. Journal of the American Water Resources Association 33(4):879-896.

Reeves, G., L. Benda, K. Burnett, P. A. Bisson, and J. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the pacific northwest. Pages 334-349 in American Fisheries Society Symposium.

Resh, V. H., A. V. Brown, A. P. Covich, M. E. Gurtz, H. W. Li, G. W. Minshall, S. R. Reice, A. L. Sheldon, J. B. Wallace, and R. C. Wissmar. 1988. The role of disturbance in stream ecology. Journal of the North American Benthological Society 7(4):433-455.

Thorp, J. H. 2014. Metamorphosis in river ecology: From reaches to macrosystems. Freshwater Biology 59(1):200-210.

Ward, J. V. 1998. Riverine landscapes: Biodiversity patterns, disturbance regimes, and aquatic conservation. Biological Conservation 83(3):269-278.

Wenger, S. J., D. J. Isaak, C. H. Luce, H. M. Neville, K. D. Fausch, J. B. Dunham, D. C. Dauwalter, M. K. Young, M. M. Elsner, B. E. Rieman, A. F. Hamlet, and J. E. Williams. 2011. Flow regime, temperature, and biotic interactions drive differential declines of trout species under climate change. Proc Natl Acad Sci U S A 108(34):14175-80.

Wetzel, R. G. 2001. Limnology: lake and river ecosystems. Academic Press, San Diego.

Winter, T. C. 2007. Role of ground water in generating streamflow in headwater areas and in maintaining base flow. Journal of the American Water Resources Association 43(1):15-25.