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IN THIS ISSUE

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Improving Management of Livestock Disturbance in Riparian Zones on Federal Land

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Grazing on public lands has a long history in the west. Early livestock use on public lands was on a first-come, first-served basis and had a negative impact on rangeland and riparian areas. Even though much of the severe overgrazing that took place a century ago has been addressed, the impacts of current and historic grazing on landscape and stream processes are still evident today (Fleischner 1994; Floyd et al. 2003).

Livestock grazing practices have been devised to move landscapes towards healthier conditions (DelCurto et al. 2005; Wyman et al. 2006). Implementation of these

Figure 1: Changes in a riparian vegetation throughout the grazing season.

StreamNotes is an aquatic and riparian systems publication with the objective of facilitating knowledge transfer from research & development and field-based success stories to on-the-ground application, through technical articles, case studies, and news articles. Stream related topics include hydrology, fluvial geomorphology, aquatic biology, riparian plant ecology, and climate change.

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Figure 2: The three common types of livestock disturbance along streambanks.

strategies suggests a path towards sustainable livestock management on public lands. Although properly managed grazing can be sustainable, poor choices relative to livestock number, timing of grazing, or failure to implement the proposed grazing strategy as planned, can lead to degraded riparian and stream conditions (Fleischner 1994; Belsky et al. 1999). Excessive livestock use in riparian areas can alter channel structure and vegetative composition, degrading overall stream function (Figure 2, Figure 4; Clary and Webster 1989; Platts 1991). Direct, indirect, and cumulative effects of riparian grazing can modify fish numbers, production, and survival (Platts 1991; Saunders and Fausch 2007).

Over the last 20 years meeting grazing objectives have received increased scrutiny because of the listing of many salmonids (*Oncorhynchus*, and *Salvelinus*). Grazing decisions and concurrent Endangered Species Act (ESA) consultations set levels of permissible livestock disturbance near streams so as to maintain fish habitat. When these disturbance objectives are exceeded, ESA and other laws provide the nexus for litigation by organizations interested in holding federal agencies and grazing permittees accountable for meeting resource objectives in stream and riparian systems.

Stubble Height

To be effective, standards must protect streambank processes. Crider (1955) found excessive consumption of above-ground biomass halted root growth in terrestrial rangeland settings. Similarly, Kaufman et al. (2004) observed that livestock removal of 40 to 60% of above-ground biomass in riparian vegetation reduced below-ground biomass by 25 to 40%. These corroborated findings in upland areas suggesting that moderate (40 to 45%) utilization of above-ground biomass may maintain rangeland conditions while 30 to 35% utilization is needed to improve rangeland vegetation (Holecheck et al. 1999). Setting stubble height standards to meet these utilization objectives can vary by species but >15 cm of residual stubble height would be required if only 30 to 40% of the biomass was to be utilized from riparian species such as redtop bentgrass (*Agrostis stolonifera*), bluejoint reedgrass (*Calamagrostis canadensis*), water sedge (*Carex aquatilis*), Nebraska sedge (*C. nebrascensis*) and Baltic rush (*Juncus balticus*) based on their average heights (Kinney and Clary 1994). Even at this level of utilization there could be some reduction in root growth and streambank cohesion (Figure 3).

The maintenance of stubble heights >15 cm would protect other sensitive species on federal land. Saunders and Fausch (2007) found resident trout growth increased in areas where grazing regimes provided additional streamside vegetation. Additionally, Crawford et al. (2004) showed an increase in juvenile sage grouse (*Centrocercus urophasianus*) survival when their upland herbaceous height exceeded 18 cm.

A stubble height standard >15 cm is similar to current direction within the interior Columbia River Basin in areas with listed salmonid species (Haugen 1995). This standard is higher than the 10 cm recommended by Clary and Leininger (2000) but comparable to the ≥15 cm standard that Clary and Webster (1990) suggested might be desirable in areas with sensitive fish species. A 15 cm standard increases the probability livestock activity in riparian areas will meet daily forage requirements thereby lowering the amount of streambank alteration.

One concern with promoting higher stubble height standards would be if livestock and wild ungulate streambank alteration have an additive effect on stream habitat conditions. This is unlikely given the presence of livestock often limits the presence of wild ungulates (Loft et al. 1991; Stewart et al 2002).

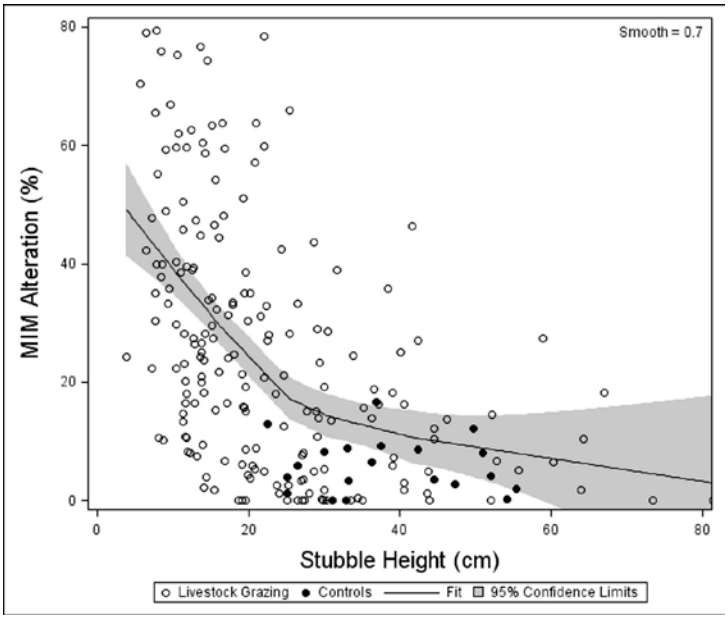

Figure 3: The relationship between stubble height (x-axis) and streambank alteration measure using the Multiple Indicator Monitoring (MIM) protocol (y-axis).

Streambank Alteration

Measures of streambank alteration provide redundant as well as novel information concerning stream habitats in grazed riparian areas and stubble height. In reaches with high streambank alteration (>20% of the bank disturbed), livestock disturbance likely has or will reduce the quality of stream conditions important to fish through time. Two situations where streambank alteration standards may not work are areas with compacted soils near the streambank that make current year alteration difficult to detect or a precipitation event that obfuscates current year's streambank alteration.

In streams with ESA listed salmonid species there is sufficient published information to suggest a starting point for stubble height standards should be > 15 cm and streambank alteration < 20%. These standards could either be increased or decreased based on local data that warrants such an exception. Additionally, setting standards with a high likelihood of improving riparian and stream conditions should allow for occasional implementation failures. Not meeting a higher standard every year would likely have minimal effect on long-term conditions across salmonid major population groups. Furthermore, insisting standards can be met 100% of the time contradicts experience across multiple disciplines (Silver 2012) and sets any program up for failure. A failure to meet stubble height or streambank alteration standards may simply reflect unexpected, rapid concentrations of livestock and/or wildlife, which will not likely have long-term consequences on stream conditions if incidents are rare (e.g., once every ten years) and corrective action is taken quickly. However, stream reaches that habitually fall below standards are more likely to be in poor condition and represent failure of either the land management agency to enforce the rules or permittees to implement them. Such an outcome benefits neither the federal land management agency nor the permittee.

Management Implications

In determining how much livestock disturbance should be allowed in riparian areas, managers need to:

1) protect processes so as to maintain or improve stream and riparian conditions
2) protect other sensitive stream and riparian biota
3) incorporate historic wildlife disturbance
4) account for thresholds where livestock behavior shifts
5) credit managers and permittees who generally comply with implementing standards.

Acknowledgements

Special thanks goes to Lindsey Goss whose master's thesis on this topic helped formulate the ideas concerning livestock grazing on public lands presented above.

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Figure 4: A stream reach that has had severe livestock impacts for an extensive period of time, with little riparian vegetation present, channel incision, bank instability, and poor aquatic habitat.

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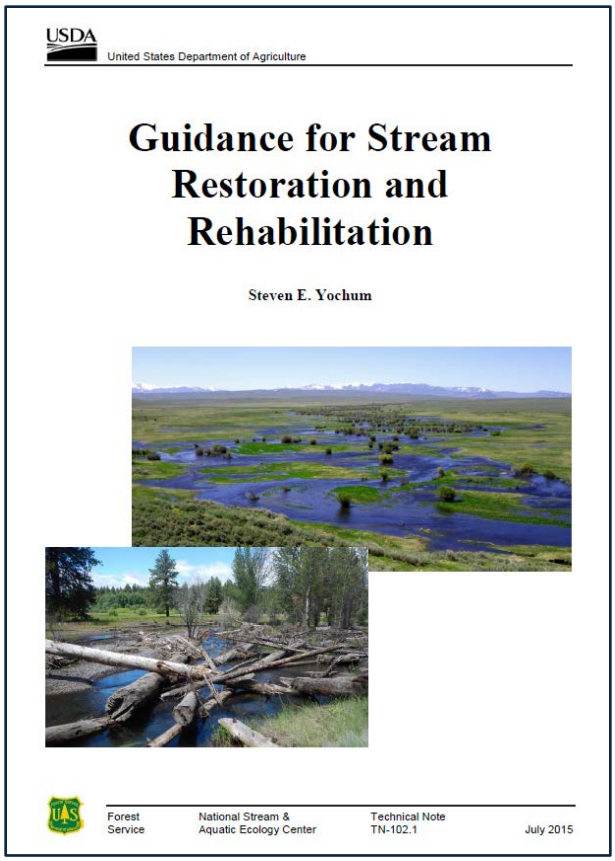
Notices and Technical Tips

- The National Stream and Aquatic Ecology Center has released a new technical note: Guidance for Stream Restoration and Rehabilitation. It will be updated annually. The abstract follows:

  A great deal of effort has been devoted to developing guidance for stream restoration and rehabilitation. The available resources are diverse, reflecting the wide ranging approaches used and expertise required to develop stream restoration projects. To help practitioners sort through all of this information, a technical note has been developed to provide a guide to the wealth of information available. The document structure is primarily a series of short literature reviews followed by a hyperlinked reference list for the reader to find more information on each topic. The primary topics incorporated into this guidance include general methods, an overview of stream processes and restoration, case studies, and methods for data compilation, preliminary assessments, and field data collection. Analysis methods and tools, and planning and design guidance for specific restoration features, are also provided. This technical note is a bibliographic repository of information available to assist professionals with the process of planning, analyzing, and designing stream restoration and rehabilitation projects.



- A tool called FVS-WRENSS is now available for estimation of water yield in forested stands. It operates as a post-processor to the Forest Vegetation Simulator (FVS) model, and is included in the FVS installation package. FVS-WRENSS uses the stand attributes and vegetative data projected by FVS, along with monthly precipitation data, to calculate stand water yield using the methodology described in Chapter III of the Water Resources Evaluation of Non-point Silvicultural Sources (WRENSS) Handbook. The purpose of FVS-WRENSS is to predict annual water yield changes caused by silvicultural actions or stand disturbance. The model is applicable to the contiguous United States.

- The National Ecosystems Services Partnership has released a report that provides recommendations on best practices for ecosystems services assessments in federal decision making. Partners in this effort include individuals from Duke University, Clark University, The Nature Conservancy, The University of Minnesota, The Institute for Natural Resources, Resources for the Future, The University of Maryland, and the Socio-Environmental Synthesis Center.

- A Climate-Aquatics Blog is being hosted by Dan Isaak and the Rocky Mountain Research Station, Air, Water, & Aquatic Environments Program. Its intent is to provide a forum for field biologists, hydrologists, managers, researchers, and students to discuss issues associated with aquatic ecosystems and climate change. This blog can be followed on Twitter @DanIsaak.

- Are you interested in learning about some of the massive floods that have occurred in the Northwest? A YouTube video is available that provides a summary of huge lava floods (Columbia River Basalts), and the Lake Missoula and Bonneville Ice Age Floods. From Central Washington University.

New Tools for Velocity and Flow Resistance Prediction in High-Gradient Streams

Steven E. Yochum

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Hydrologists and engineers are often asked to provide estimates of velocity and flow resistance in high-gradient headwater streams (slopes > ~3%). Such predictions are necessary for channel analyses and designs, geomorphic analyses, and ecological studies. These stream types are common on National Forest lands. As a complication, flow resistance and velocity vary substantially by stage in such streams, with higher discharges associated with lower in-channel flow resistance and higher velocities. Both photographic guidance and quantitative tools using readily-measured geometric characteristics are helpful for practitioners to make informed predictions of flow resistance and velocity. Publications have recently been published that provide such guidance for practitioners called upon to perform analyses in these stream types. A summary of these tools is provided, for field application.

Channel bedforms can be the most distinctive characteristics of steep headwater streams, with flow through steps, pools, and cascades (Figure 5) causing higher flow resistance than lower-gradient channels. High-gradient streams typically have plane bed, step-pool, cascade, and transitional forms, with more sediment transport capacity than supply (Montgomery and Buffington 1997). Cascade channels are characterized by tumbling flow, with jets and wakes over and around large clasts and wood features, while step-pool channels have bed features dominated by a regular series of channel-spanning steps formed from clasts alone or in combination with in-channel wood. Plane-bed reaches have minimal bedforms, although small-scale bed variability is often present. Transitional reaches reflect the range in transitional forms between plane-bed, step-pool, and cascade morphologies. Instream wood often provides a substantial portion of flow resistance in these stream types, as both a component of steps as well as in more dispersed locations. In general, flow resistance is caused by: (1) grain roughness, from viscous and pressure drag on grains of the bed surface; (2) form roughness, from pressure drag on bed and bank undulations; and (3) pressure and viscous drag on sediment in transport (Griffiths 1989). Additionally, spill resistance associated with hydraulic jumps and wave drag on elements protruding above the water surface can be the dominant flow resistance mechanism in high-gradient channels (Curran and Wohl 2003, Comiti et al. 2009, David et al. 2011).

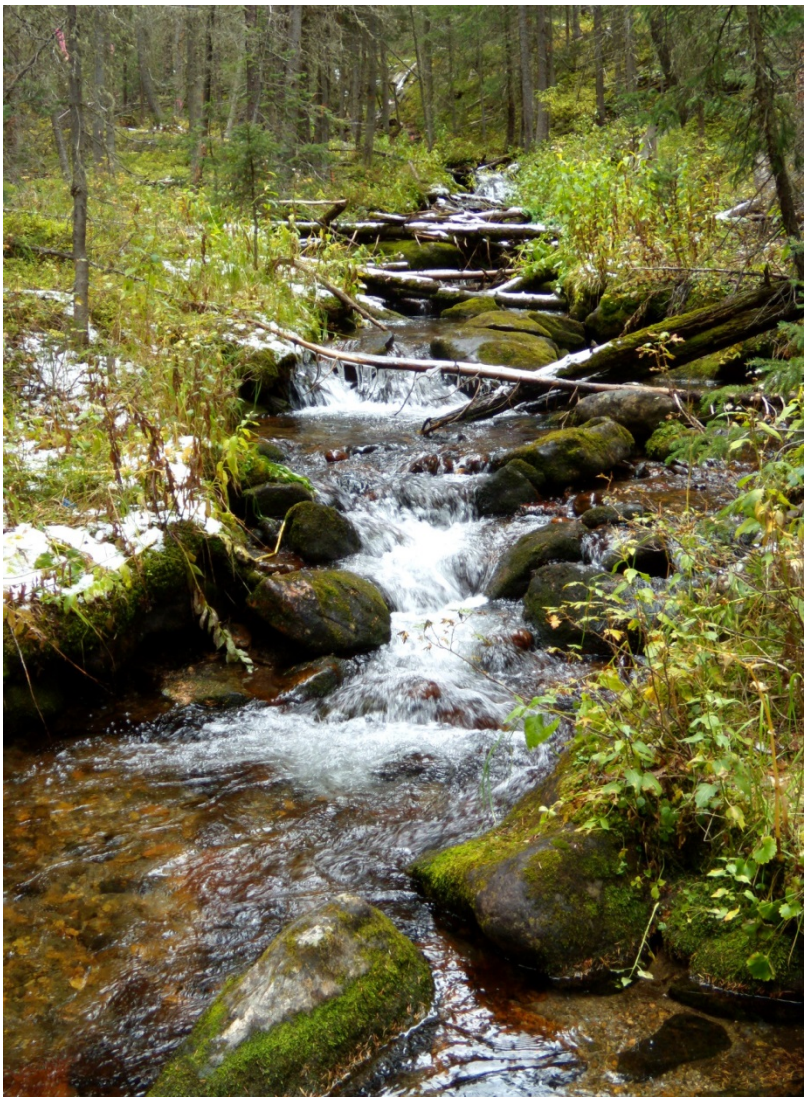

Figure 5: East Saint Louis Creek, in the Fraser Experimental Forest and Arapaho National Forest.

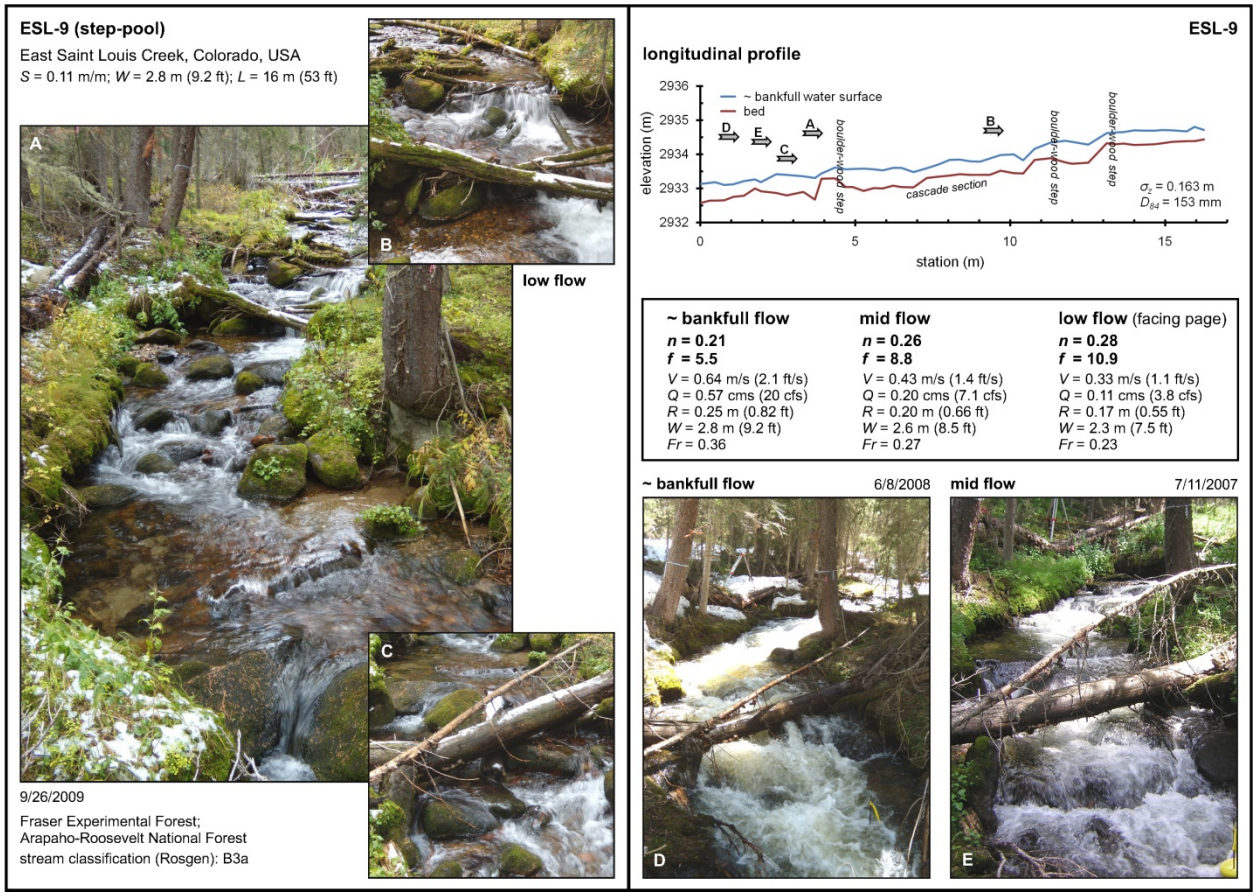

Figure 6: Example of flow resistance coefficient selection guidance available in RMRS-GTR-323, Photographic Guidance for Selecting Flow Resistance Coefficients in High-Gradient Channels.

The Manning equation is the most common approach used by practitioners for estimating velocity and energy loss in streams. While Manning's n is the preferred method for prediction by many practitioners and is the method most typically coded into computational models, the Darcy-Weisbach equation is a dimensionless alternative argued to be more appropriate for use (Ferguson 2010). The Manning and Darcy-Weisbach equations are:

$$V = \frac{R^{2/3} S_f^{1/2}}{n} = \sqrt{\frac{8gRS_f}{f}}$$

where V is the reach-average velocity (m/s); n is the Manning's roughness coefficient; f is the Darcy-Weisbach friction factor; S_f is the friction slope (m/m); g is the acceleration due to gravity; R, the hydraulic radius, is computed as A/P_w; A is the cross-sectional area (m^2); and P_w is the wetted perimeter (m).

For flow resistance coefficient selection, a General Technical Report (GTR) titled "Photographic Guidance for Selecting Flow Resistance Coefficients in High-Gradient Channels" was developed to present assistance with the qualitative estimation of Manning's n and Darcy-Weisbach f in high-gradient channels (Figure 6; Yochum et al. 2014). Using data collected in 19 stream channels in Colorado and the Eastern Italian Alps, on slopes ranging from 2.4 to 21 percent, guidance is provided for low through bankfull flows, on streams both with and without instream wood present. Guidance for low flow resistance estimation is additionally provided using data collected in 29 channels in Washington state, New Zealand, Chile, and Argentina. Presented bankfull n values range from 0.048 to 0.30 and low flow n values range from 0.057 to 0.96. Discussions of flow resistance mechanisms and quantitative prediction tools are also presented. The report is available at this link.

While qualitative tools such as this photographic guidance are quite useful for application in the field, quantitative tools are needed for estimating stream velocity and flow resistance coefficients. A journal article titled "Velocity Prediction in High-Gradient Channels" was developed to provide such a quantitative tool (Yochum et al. 2012). Using data collected in the Fraser Experimental Forest, this

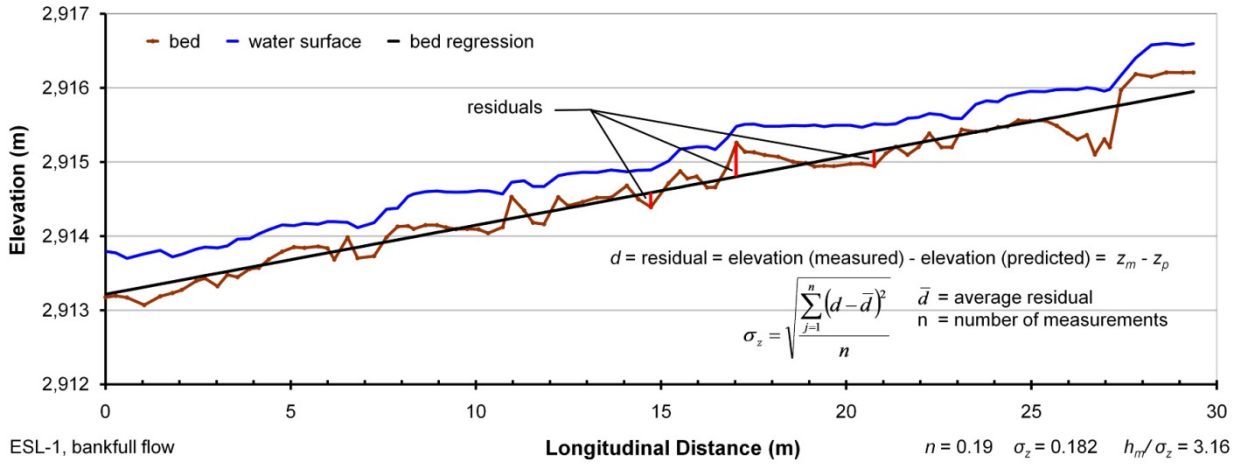

Figure 7: Longitudinal profile illustrating the σ_z computation, for reach ESL-1 (photo provided in Figure 5).

report first assesses the accuracy of previously-published velocity prediction techniques for naturally-formed high-gradient channels. It then combines these Fraser data with the results of other studies to develop general methods for predicting velocity and flow resistance coefficients in alluvial, high-gradient streams, in channels both with and without step-forming instream wood present. For these stream types, bed material size was found to be a poor predictor of flow resistance, due to interactions between instream wood and clasts in steps; this is contrary to the results of studies performed in lower-gradient streams, where the D_{84} bed material size has been found to be useful for prediction. Instead, methods that implemented the detrended standard deviation of bed elevations (σ_z, Figure 7) as a relative submergence term (h/σ_z), where h is the flow depth, explained up to 84% of the variance of the flow resistance coefficients. The prediction equations are

$$n = 0.41\left(\frac{h_m}{\sigma_z}\right)^{-0.69} \quad (R^2 = 0.78)$$

$$f = 29\left(\frac{h_m}{\sigma_z}\right)^{-1.56} \quad (R^2 = 0.82)$$

where h_m is the median thalweg flow depth for the stream reach, at the flow of interest. The report detailing the methods and finding is available at this link.

Management Implications

- Proper selection of flow resistance coefficients in high-gradient streams is required to predict stream velocities for channel analyses and design, geomorphic analyses, and ecological studies. These coefficients have been oftentimes underestimated in steeper streams (slopes > ~3%), resulting in velocity overestimation.
- Both photographic guidance and quantitative prediction tools have been recently developed to aid field practitioners with the selection of flow resistance coefficients in high-gradient stream channels.

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Instream Cover and Shade Mediate Avian Predation on Trout in Semi-Natural Streams

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Figure 8: Coastal Cutthroat Trout concealing under instream cover with another trout.

Piscivory by birds can be important, particularly on fish in small streams and during seasonal low flows when available cover from predators can be limited. We conducted an experiment at the Oregon Hatchery Research Center to evaluate size-selective survival of Coastal Cutthroat Trout (Figure 8; *Oncorhynchus clarkii clarkii*) in replicated semi-natural stream sections. Our findings, published in the Ecology of Freshwater Fish highlights that availability of instream cover and overhead shade from riparian vegetation can increase trout survival by reducing the effect of predation by Belted Kingfishers *Megaceryle alcyon* and potentially other avian predators (Figure 9).

Although avian predation is widely recognized as a key factor influencing the survival of fishes in streams, it can be difficult to measure. The only predator we observed was the Belted Kingfisher, a piscivorous bird that is known to prey heavily on fish. There are, however, a host of other predators naturally found in the region that are capable of preying upon fish. Such predators common to the area include stream amphibians (Coastal Giant Salamander *Dicamptodon tenebrosus*), other birds (Western Screech-owl *Megascops kennicottii*), and mammals (North American river otter *Lontra canadensis*). Conservation strategies for trout should consider management practices that maintain or improve stream habitat using both instream cover and riparian shade, especially as broad-scale change alters stream conditions.

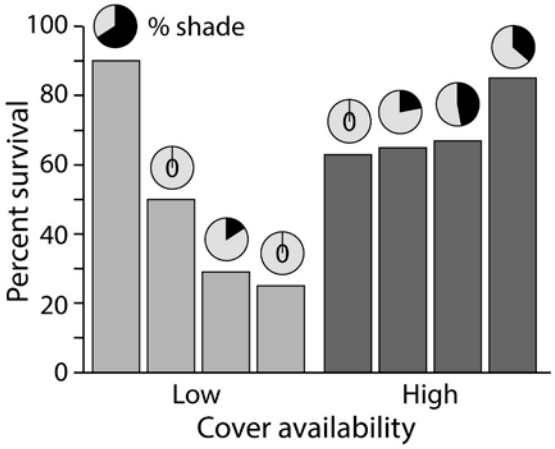

Figure 9: Percent survival of adult Coastal Cutthroat Trout in low-density (light grey, n = 4) and high-density (dark grey, n = 4) instream cover stream sections due to predation by Belted Kingfisher and potentially other avian predators. Pie charts show the amount of shade over each stream section

Management Implications

- Availability of instream cover increases trout survival by mediating the effect of predation by birds. Conservation strategies for trout should consider management practices that maintain or improve stream habitat of instream cover in areas that have recently been harvested.

- Shade from overhead riparian vegetation helps reduce avian predation, especially in streams where instream cover is limiting. Shade, in addition to maintaining the natural variability of stream temperatures, provides a zone where fish have reduced threats from visual predators.

Drought Update: West Coast Record-Dry Conditions Continue

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As discussed in the June 2015 issue of StreamNotes, drought conditions continue to impact water supply and availability across the western U.S. California remains the primary area of concern, with no lessening of the official drought categories from Severe to Exceptional (D2-D4) according to the most recent U.S. Drought Monitor (Figure 10). However, drought conditions have worsened and expanded across the Pacific Northwest since early summer, with large areas of Extreme Drought (D3) developing in western Montana, northern Idaho, western Oregon, and a significant portion of the Cascade Range and the Olympic Peninsula in Washington.

Precipitation was well below normal across much of the Pacific Northwest this summer, with many areas experiencing record low accumulations. The extremely dry conditions resulted in many areas experiencing worsening drought by 2-3 classification categories since mid-June across much of Oregon, Washington and northern Idaho. Drought conditions across most of western Montana have worsened by 4 classification categories (from D0-Abnormally Dry to D4-Exceptional Drought) since mid-May. The rapid intensification of meteorological drought has led to a severe wildfire season across much of the Pacific Northwest and Northern Rockies, with numerous large fires currently active across the region and National Preparedness at Level 5 (see NIFC for more information). Much attention is now on the potential hope for drought relief from the strong El Niño that has developed this summer in the eastern and central tropical Pacific. This will be addressed in detail in the upcoming fall issue of StreamNotes, since it is still early to ascertain the teleconnections and potential impacts of the developing El Niño on precipitation and drought conditions across the West.

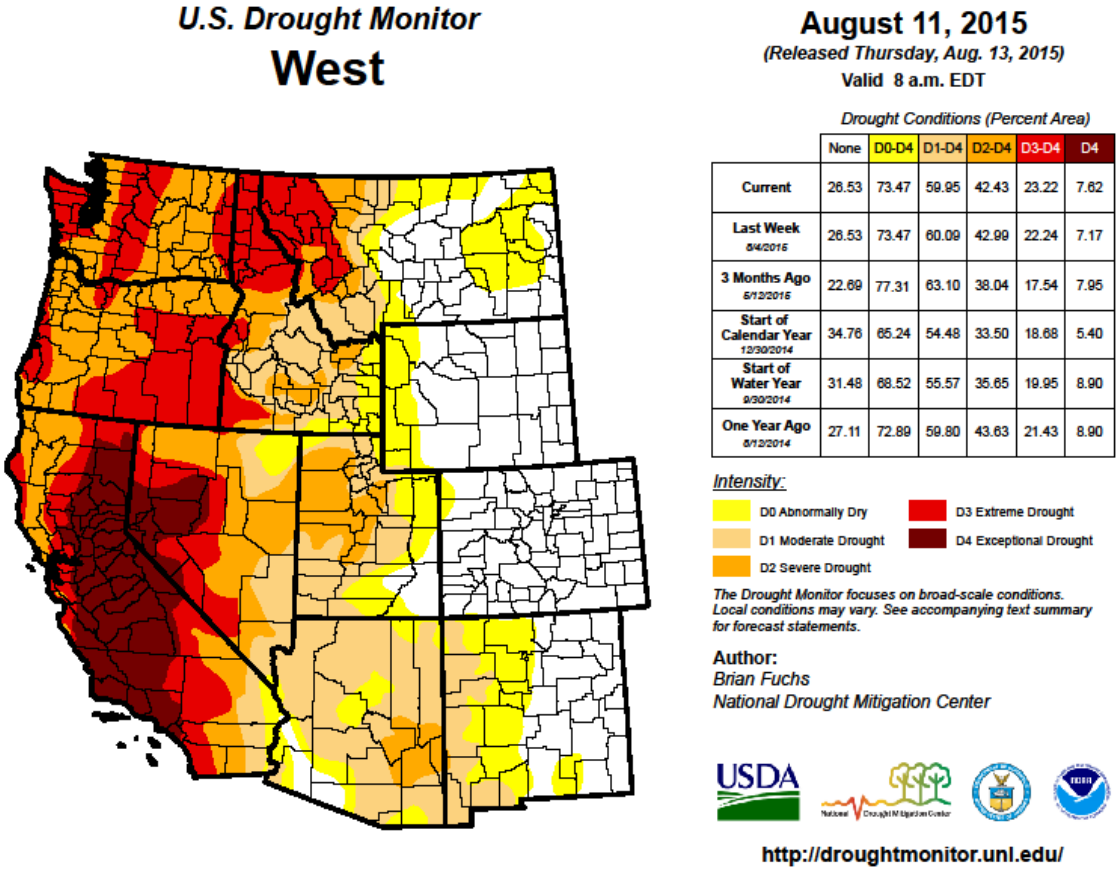

Figure 10: U.S. Drought Monitor analysis from August 11, 2015 for the western U.S. (author: Brian Fuchs NOAA/NWS/NCEP/CPC, and the National Drought Mitigation Center).