United States Department of Agriculture

Natural Resources Conservation Service

Agricultural Wildlife Conservation Center

The Nature Conservancy

Colorado State University

July 2009

Fish and Wildlife Insight

Improved Grazing Management Increases Terrestrial Invertebrate Inputs that Feed Trout in Wyoming Rangeland Streams

Issued July 2009

Information for this publication was adapted from the graduate research conducted by **Carl Saunders** under the supervision of **Dr. Kurt Fausch**, Department of Fish, Wildlife, and Conservation Biology, Colorado State University. Funding was provided by the Natural Resources Conservation Service (NRCS) Agricultural Wildlife Conservation Center (AWCC) (formerly the Wildlife Habitat Management Institute); West Denver and Cutthroat chapters of Trout Unlimited; and The Nature Conservancy.

Suggested citation:

U.S. Department of Agriculture, Natural Resources Conservation Service. 2009. Improved grazing management increases terrestrial invertebrate inputs that feed trout in Wyoming rangeland streams, by W. Carl Saunders and Kurt D. Fausch. Fish and Wildlife Insight. Washington, DC.

Cover photo: Cattle grazing, western riparian area (*photo by Carl Saunders*)

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW., Washington, DC 20250–9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Improved Grazing Management Increases Terrestrial Invertebrate Inputs that Feed Trout in Wyoming Rangeland Streams

Conservation of trout in western rangeland streams may benefit from providing adequate invertebrate prey resources in addition to improving instream habitat

Conventional efforts to sustain trout populations in rangeland streams of the West have focused on improving instream habitat for fish and invertebrates that has been damaged by poorly managed grazing. However, recent research suggests that terrestrial invertebrate prey that come directly from riparian vegetation and fall, crawl, or blow into streams may also play a key role in supporting trout. Studies in Virginia, Alaska, and New Zealand, showed that about half the biomass of trout diets during summer afternoon periods consisted of these terrestrial prey, and research in Japan revealed that consumption of terrestrial invertebrates can exceed 80 percent of the summer diet and provide 50 percent of the energy budget required to sustain trout throughout the year. The Japanese researchers also showed that when stream reaches were covered with mesh greenhouses that reduced input of terrestrial invertebrates by 70 percent, the larger trout emigrated, resulting in a 50 percent decrease in trout biomass. These results imply that poorly managed livestock grazing in riparian areas may have substantial effects on trout populations not only by degrading instream habitat but also by reducing or changing riparian vegetation that supplies terrestrial invertebrates on which trout rely.

Researchers at Colorado State University compare the role of terrestrial invertebrates in supporting trout under two different grazing management systems

Researchers measured riparian vegetation, terrestrial and aquatic invertebrates, fish diets, and fish abundance and biomass during summers 2004 and 2005 in five streams with riparian areas under season-long (SL) continuous grazing versus five paired streams where grazing management was prescribed to fit the range conditions within different pastures (upland vs. riparian pastures). Study sites on ranches practicing prescribed grazing were located in riparian pastures managed to achieve high-density, short-duration (HDSD) grazing (fig. 1). For example, one such riparian pasture under HDSD management measured 110 acres and was grazed by 400 cow-calf pairs for 10 days after 310 days of rest. At each site, riparian vegetation was measured by clipping in plots and described in detail to identify how grazing management affected both biomass and composition of streamside vegetation. Biomass of terrestrial invertebrates falling into streams, as well as emerging adult aquatic invertebrates (e.g., mayflies) that returned to streams, was measured monthly throughout the summer period. At each stream, the biomass of terrestrial invertebrates and both larval and adult aquatic invertebrates in trout diets was measured by capturing fish and flushing stomachs, and trout abundance and biomass were measured using removal electrofishing. This system of prescribed grazing achieves a more even distribution of grazing throughout the range while managing the timing, intensity, and duration of defoliation. The goals of this project were to understand the importance of

Figure 1 HDSD grazing is accomplished by rotating a single herd of cattle through relatively small pastures for short periods (10–21 days).

invertebrates entering from the riparian zone as a prey resource for trout in rangeland streams and whether prescribed grazing can increase their availability by promoting streamside vegetation.

Vegetative biomass and overhead cover were much greater under HDSD grazing management than SL grazing

Aboveground vegetative biomass was three times greater and overhead cover was two times greater at sites under HDSD grazing management compared to those under SL grazing (fig. 2). Vegetative communities in the riparian zone had similar species richness under both grazing regimes, but at HDSD sites a greater number of species contributed substantially to ground cover adjacent to the stream than at SL sites, where a few species tolerant to grazing (white clover and dandelion) made up the majority of ground cover.

Inputs of terrestrial and adult aquatic insects were also much greater under HDSD grazing management

In general, the total input of invertebrates to HDSD sites had peaks in early summer, when input of adult aquatic insects was greatest, and in August, when input of terrestrial invertebrates was greatest (fig. 3). In contrast, neither peak was evident at SL sites, indicating that invertebrate input at HDSD sites was greater than at SL sites. Sites under HDSD grazing received, on average, more than twice as much terrestrial invertebrate biomass during summer months than SL sites. Input of adult aquatic insects returning to the streams peaked in June in HDSD sites, which received 70 percent more biomass of these prey throughout the summer than SL sites. Even given high variability in inputs at HDSD sites, these effects were statistically significant.

Figure 3 Streams and their adjoining riparian areas managed for HDSD grazing received more than twice as much terrestrial invertebrate biomass as streams grazed season long

Figure 2 Biomass of riparian vegetation and input of both terrestrial invertebrates and adult aquatic invertebrates returning to streams were greater in streams with riparian zones under HDSD prescribed grazing (*left*) than those under SL grazing (*right*)

Trout in streams under HDSD grazing consumed more invertebrate biomass than those in streams under SL grazing

During August, when input of terrestrial invertebrates was highest, trout in streams with riparian zones under HDSD grazing had three to five times more biomass of terrestrial invertebrates in their afternoon diets than those in streams under SL grazing. On average, trout in HDSD sites consumed about twice as much terrestrial invertebrate biomass throughout summer as fish in SL sites. Moreover, for fish in both types of streams, terrestrial invertebrates made up 57 percent of prey biomass throughout the summer, indicating their importance for sustaining trout populations. When trout were sampled every 6 hours for a 24-hour period in August 2005, researchers found that those in sites under HDSD management also consumed nearly five times as much biomass of aquatic invertebrates as those in SL sites, but consumed these aquatic prey primarily at night. About 90 percent of this aquatic invertebrate prey biomass was larvae at HDSD sites, mainly of the shredder functional group that feed on vegetation that falls into the stream from the riparian zone. This suggests that HDSD grazing may also increase prey for trout by increasing the amount of plant detritus that enters streams and supports aquatic invertebrates.

Trout biomass was more than twice as high in streams under HDSD grazing compared to those under SL grazing

There was more than twice as much trout biomass in streams with riparian zones under HDSD grazing as those under SL grazing, although fish densities were similar (fig. 4). Data for individual trout showed that fish in HDSD sites were, on average, about 1.3 inches longer and had nearly twice the biomass as fish in SL sites.

Management implications

Research indicates that HDSD grazing management increases trout populations through several pathways in the food web that affect production and delivery of both terrestrial and aquatic invertebrate prey (fig. 5). Terrestrial invertebrates that fall into streams from riparian vegetation and aquatic invertebrates that feed on algae and inputs of plant detritus make up most of trout diets in western rangeland streams. HDSD grazing management, which promotes streamside vegetation, may increase terrestrial invertebrate prey production and transport to streams, while also increasing inputs of plant litter that supports production of aquatic prey.

In contrast, fish may emigrate from stream reaches with inadequate prey resources such as those under SL grazing, which received only half the terrestrial invertebrate inputs as sites managed for HDSD grazing. These results suggest that managers can manipulate the timing, intensity, and duration of grazing to increase riparian vegetation that supplies terrestrial invertebrates to trout directly, as well as increasing input of leaf litter that supports production of aquatic invertebrates that are also prey for trout.

Changes in vegetation associated with intensive grazing management may increase the amount of terrestrial invertebrates and adult aquatic insects entering streams by several mechanisms
Greater vegetative biomass at HDSD sites may provide more food and cover for terrestrial invertebrates, thereby supporting greater densities, and a greater variety of common plant species may also support a greater diversity of terrestrial invertebrates. Additionally, increased structural complexity of riparian vegetation may increase the chances that terrestrial invertebrates fall or blow into streams, as well as providing resting and staging areas for emerging adult aquatic insects, which may also fall back into the stream after they mate. Therefore, management of riparian vegetation that promotes insect development and concentrates invertebrates along streambanks may optimize inputs of this important prey resource for trout.

Figure 4 Trout biomass at sites managed for HDSD grazing was more than twice as high as at sites managed for SL grazing

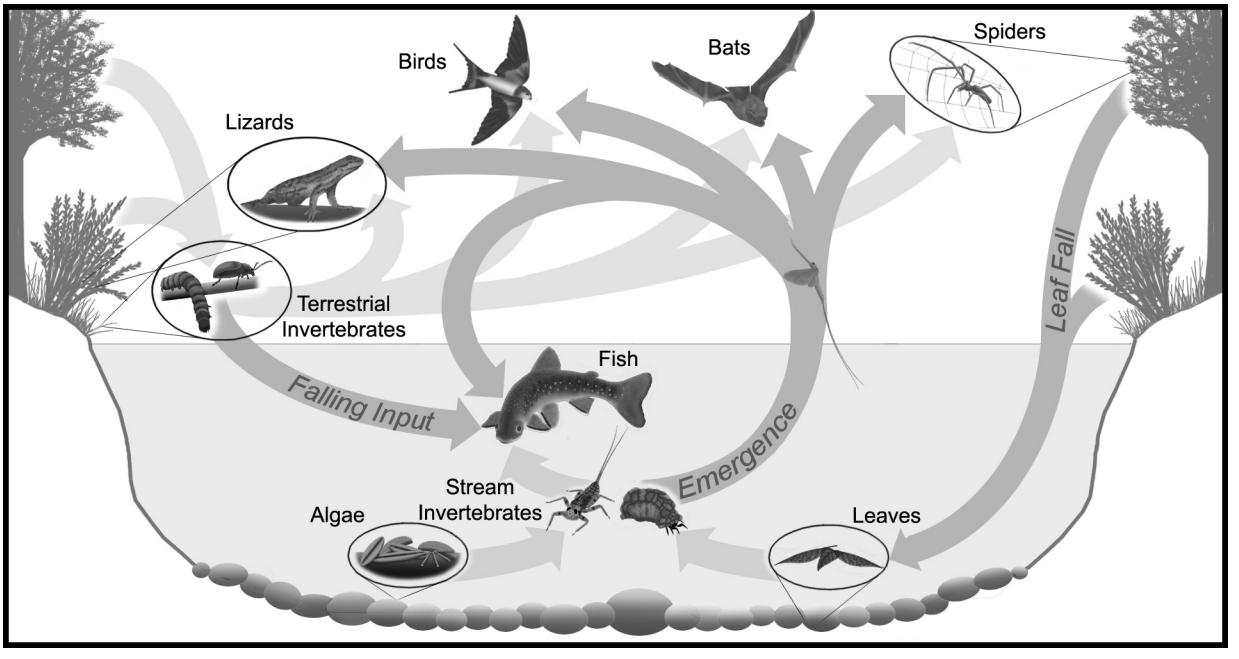
Riparian vegetation supports trout prey through multiple pathways

Fish at sites under HDSD management consumed greater amounts of both terrestrial and aquatic invertebrate prey. Many of the aquatic invertebrate larvae consumed by trout rely on plant detritus for food. Therefore, HDSD grazing management may increase prey resources not only by promoting the direct input of terrestrial invertebrates and increasing the return rate of adult aquatic insects but also by increasing inputs of plant detritus that support aquatic larvae.

What improved grazing management means for trout

The aboveground biomass and structural complexity of riparian vegetation that resulted from HDSD grazing appears to support greater invertebrate production and increases the transport of these invertebrates to streams where they are an important prey resource for trout. This direct input of terrestrial invertebrate prey to streams under HDSD grazing, along with increases in aquatic prey resources resulting from litter inputs and retention of adult aquatic insects after they emerge, means that these streams have the potential to support greater trout biomass. Higher trout biomass at sites managed for HDSD grazing may result from two possible mechanisms: fish at HDSD have higher growth rates due to greater invertebrate prey resources than fish at SL sites, or larger fish emigrated from SL sites. Two large-scale experiments in Japan showed that both mechanisms can occur when terrestrial invertebrate prey are reduced using a mesh greenhouse.

Figure 5 Generalized food web for linked stream-riparian ecosystems (Image from Baxter et al. 2005)



References

Baxter, C.V., K.D. Fausch, and W.C. Saunders. 2005. Tangled webs: reciprocal flows of invertebrate prey link streams and riparian zones. Freshwater Biology 50:201–220.

Baxter, C.V., K.D. Fausch, M. Murakami, and P.L. Chapman. 2007. Invading rainbow trout usurp a terrestrial prey subsidy from native charr and reduce their growth and abundance. Oecologia 153:461–470.

Cloe, W.W., III, and G.C. Garman. 1996. The energetic importance of terrestrial arthropod inputs to three warm-water streams. Freshwater Biology 36:105–114.

Edwards, E.D., and A.D. Huryn. 1995. Annual contribution of terrestrial invertebrates to a New Zealand trout stream. New Zealand Journal of Marine and Freshwater Research 29:467–447.

Kawaguchi, Y., and S. Nakano. 2001. Contribution of terrestrial invertebrates to the annual resource budget for salmonids in forest and grassland reaches of a headwater stream. Freshwater Biology 46:303–316.

Kawaguchi, Y., S. Nakano, and Y. Taniguchi. 2003. Terrestrial invertebrate inputs determine the local abundance of stream fishes in a forested stream. Ecology 84:701–708.

Merritt, R.W., and K.W. Cummins, eds. 1996. An introduction to the aquatic insects of North America, third edition. Kendall/Hunt Publishing Company, Dubuque, IA.

Nakano, S., H. Miyasaka, and N. Kuhara. 1999. Terrestrial-aquatic linkages: riparian arthropod inputs alter trophic cascades in a stream food web. Ecology 80:2435–2441.

Nakano, S., and M. Murakami. 2001. Reciprocal subsidies: dynamic interdependence between terrestrial and aquatic food webs. Proceedings of the National Academy of Science, U.S.A. 98:166–170.

Saunders, W.C. 2006. Improved grazing management increases terrestrial invertebrate inputs that feed trout in Wyoming rangeland streams. Master's Thesis, Colorado State University, Fort Collins, CO.

Saunders, W.C., and K.D. Fausch. 2007. Improved grazing management increases terrestrial invertebrate inputs that feed trout in Wyoming rangeland streams. Transactions American Fisheries Society 136:1216–1230.

Wipfli, M.S. 1997. Terrestrial invertebrates as salmonid prey and nitrogen sources in streams: contrasting old-growth and young-growth riparian forests in southeastern Alaska. Canadian Journal of Fisheries and Aquatic Sciences 54:1259–1269.