Zooey Diggory
Biol 862 Annotated Bibliography
Food Web Subsidies Across River-Floodplain Habitats

Ben-David, M., T.A. Hanley, and D.M. Schell. 1998. Fertilization of terrestrial vegetation by spawning Pacific salmon: the role of predator activity. Oikos 83(1): 47-55.

This study looked at how marine derived nutrients supplied from spawning salmon are transported into the terrestrial riparian environment and, once there, how they affect terrestrial food webs. Using stable isotope analysis, they found increased N in plants near spawning rivers, and near areas where piscivorous predators were known to occur. They also found evidence of marine-derived nitrogen and carbon in small mammals that were known to eat riparian vegetation fertilized by salmon. The descriptions of sampling methods and analysis procedures were clear and thorough and the inferences made from the results were discussed honestly. I thought this was a note-worthy study in that it demonstrated the affects of salmon carcass-derived nutrients not only on vegetation, but further up the terrestrial food chain. This is a frequently cited article; I found a reference to it in nearly every salmon-derived nutrient study I looked at.

Finlay, J.C., S.B. Khandwala, and M.E. Power. Spatial scales of carbon flow in a river food web. Ecology 83(7): 1845-1859.

This study, one of several I found on the South Fork Eel River, used stable isotope analysis to track carbon flow through aquatic food webs both spatially and seasonally. The study documented differences in invertebrate feeding types and predatory fish species associated with differences in supply and transport of algae in riffle vs. pool habitats. In response to varying supply of carbon from aquatic algae, the study found that terrestrial carbon input (in the form of leaf litter) could be important to the aquatic food web during certain parts of the year and for different trophic levels. The study appears to have quantified a process that was expected to be occurring here. Despite the discussion section, I was not convinced that the results demonstrated convincingly that riffle and pools have distinct food webs – the results suggest that they are very tightly coupled.

Gende, S.M., R.T. Edwards, M.F. Willson, and M.S. Wipfli. Pacific salmon in aquatic and terrestrial ecosystems. Bioscience 52(10) 917-928.

This is an extensive review article of salmon carcass-derived nutrient studies. It is a great introduction to ways in which salmon subsidize freshwater and terrestrial ecosystems but does not go into much detail for any particular study. The article reviews what nutrients, and of what magnitude, are delivered where and how as a result of spawning salmon. It also discusses at length the ecological ramifications of this nutrient subsidy, how restoration and management efforts could be impacted by the subsidy, and makes suggestions for additional research.

Helfield, J.M. and R.J. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. Ecology 82(9): 2403-2409.

This study evaluated the amount of marine-derived nitrogen supplied to riparian vegetation by spawning salmon and how that nitrogen affects the growth rates of riparian plants. Isotopic analyses revealed that riparian plants near spawning streams derive ~22-24% of their nitrogen from spawning salmon. Tree ring analysis indicated that this nitrogen supply significantly increases the growth rates of Sitka spruce. This study looked more specifically at some of the issues raised in Ben-David et al. (1998) and provides some sexy numbers regarding the amount of marine-derived nitrogen provided by spawning salmon in Alaska and increases in tree growth rates as a result. The

methods used to determine marine-derived nitrogen were a bit confusing, but might make sense to someone more familiar with stable isotope analysis.

Henschel, J.R., D. Mahsberg, and H. Strumpf. 2001. Allochthonous aquatic insects increase predation and decrease herbivory in river shore food webs. Oikos 93: 429-438.
Manipulative experiment along the Main River, Germany were conducted to evaluate whether and how emergent aquatic insects subsidize the diets of riparian spiders and how that subsidy affects the shore food web. In plots with subsidized spiders, herbivorous insects were depressed by predatory spiders and herbivory damage to riparian nettles was decreased. Results suggest connectivity between river and shore food webs and facilitative effect of the food web subsidy to improve spider predation effectiveness. The results of this study offer an interesting contrast to those of Sabo and Power (2002).

Naiman, R.J. and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics 28: 621-658.
This is a frequently cited review article that discusses many of the characteristics of riparian zones. The article is an excellent introduction to the watershed inputs and physical processes that drive the habitat and biological diversity seen adjacent to rivers. The article also discussion how the physical and ecological complexity of riparian areas should be considered and addressed when making management decisions and planning for restoration activities.

Power, M.E., W.E. Rainey, M.S. Parker, J.L. Sabo, A. Smyth, S. Khandwala, J.C. Finlay, F.C. McNeely, K. Marsee, and C. Anderson. 2004. River-to-watershed subsidies in an old-growth conifer forest. Pgs. 217 – 240 in G.A. Polis, M.E. Power, and G.R. Huxel, Eds. Food Webs at the Landscape Level. The University of Chicago Press, Chicago, Illinois.
This chapter is a review and synthesis of several studies that have been conducted in the South Fork Eel River, CA watershed that investigate river to watershed food web subsidies, primarily in the form of aquatic insects. The variation in aquatic insect emergence (seasonally and spatially) is discussed, as is the lateral extent that aquatic insects penetrate the riparian forest. Studies that are discussed investigated the effects of the aquatic insect subsidy on terrestrial spiders, riparian lizards, and bats. A significant discussion of the ecosystem-level effects of this subsidy is included. This is an excellent overview of this topic but did not discuss any impacts to vegetation in detail.

Power, M.E. 1990. Benthic turfs vs floating mats of algae in river food webs. Oikos 58(1): 67-79.
This is one of Mary Power's earlier studies looking at food web dynamics on the South Fork Eel River. This study looked at differences between benthic and floating algal mats in regards to: production, movement, food supply, and habitat for invertebrates. The study found higher invertebrate production and lower invertebrate predation by fishes in floating algae. She concluded that the seasonal abundance of different algae types could influence insect production in both river and terrestrial food webs. This study was excellent background material to many of the studies I reviewed that looked at how aquatic invertebrate production subsidizes terrestrial food webs. Study methods were interesting and described well, providing a strong framework for the results.

Power, M.E. 1992. Top-down and bottom-up forces in food webs: Do plants have primacy. Ecology 73(3): 733-746.
This is a review article that discusses top-down vs. bottom-up forces in food webs, with a focus on how plants control and/or respond to other trophic levels. The article also

speaks more generally about some of the constraints of studying food webs in the real world. A nice overview of the issues, but not entirely helpful in this particular instance.

Raffaelli D.G., S. Hull, and H. Milne. 1989. Long-term changes in nutrients, weed mats and shorebirds in an estuarine system. Cahiers Biologie Marine 30: 259-270.

This study on the Ythan estuary in northeastern Scotland investigated the effects of nutrient subsidies via agricultural runoff on the estuary food web. The study found that increasing concentration of nitrate from the runoff between 1950 and 1990's resulted in increases in the biomass and cover of green macroalgae. The spread on macroalgal mats resulted in a decline in invertebrates, and consequently shorebirds. They concluded that the changes in shorebird populations provided evidence for a bottom-up effect of the nutrient subsidy from agricultural runoff. I appreciated the straightforward discussion of data limitations and instances when their results were not significant.

Sabo, J.L. and M.E. Power. 2002. River-watershed exchange: effects of riverine subsidies on riparian lizards and their terrestrial prey. Ecology 83(7): 1860-1869.

This manipulative experiment investigated the effect of emergent aquatic insects in subsidizing the diet of riparian lizards along the river's edge. Lizard growth rates were positively correlated with the abundance of aquatic insects. Terrestrial insect abundance significantly decreased in plots where aquatic insects were blocked. Results suggest that aquatic insects provide an important seasonal subsidy to these lizards and reduce their predation on terrestrial insects. Study methods were unique and thorough, which gave me confidence in the abilities of the investigators and strength of the results! The results of this study offer an interesting contrast to those of Henschel et al. (2001), although impacts to plants were not measured in this study.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, C.E. Cushing. The river continuum concept. Can. J. Fish. Aquat. Sci. 37: 130-137.

This article synthesizes studies on river geomorphology to provide a framework for the river continuum concept. The concept begins with organic material input to rivers in the form of leaf litter and woody debris, and follows this input through progressively larger stream orders to shape the resulting invertebrate and predatory communities. The concept provided the framework for many river ecology studies and is frequently cited in both articles that support its premise and those that refute it. As one of the major concepts in river ecology it is definitely worth reading, and it does provide a good overview of some of the physical and chemical drivers for aquatic organism communities.

Wallace, J.B., S.L. Eggert, J.L. Meyer, and J.R. Webster. 1997. Multiple trophic levels of a forest stream linked to terrestrial litter inputs. Science 277: 102-104.

An impressively long-term and large-scale manipulative experiment that investigated terrestrial-aquatic linkages by excluding terrestrial leaf litter input to 180m of a headwater stream for three years. Results included major changes in invertebrate fauna compared with a nearby control steam, and changed between mixed-substrate and bedrock reaches. Provides evidence for importance of terrestrially derived leaf litter to the stream food web and existence of different food webs in nearby habitats of different geomorphology. This study was clearly developed to test and provides support for the river continuum concept (Vannote et al. 1980).

Willson, M.F., S.M. Gende, and P.A. Bisson. Anadromous fishes as ecological links between ocean, fresh water, and land. Pgs. 284 – 300 in G.A. Polis, M.E. Power, and G.R. Huxel, Eds. Food Webs at the Landscape Level. The University of Chicago Press, Chicago, Illinois.

This chapter was a good review of the distribution and life history of anadromous fish, the types and quantities of nutrients delivered from the ocean to riverine and terrestrial habitats via anadromous fish, the effects of the nutrients in riverine and terrestrial habitats, and how the importance of this nutrient transfer in restoring riparian and/or salmonid habitats. The effects of marine-derived nutrients on riparian plants in mentioned briefly, but primary literature is cited.