Environmental Case Study
Why Trees Need Salmon

Ecologists have long known that salmon need clean, fast-moving streams to breed, and that clear streams need healthy forests. Surprising new evidence now indicates that some forests themselves need salmon to remain healthy, and that bears play an important intermediary role in this dynamic relationship.

The yearly return of salmon from the open Pacific Ocean to coastal waters of western North America is one of nature's grand displays. Salmon (*Onchorhyncus* sp.) are anadromous: They hatch in freshwater lakes and streams, spend most of their lives at sea, then return to the stream where they were born, to breed and die. To reproduce successfully, these fish require clear, cold, shaded streams and clean gravel riverbeds. If forests are stripped from riverbanks and surrounding hillsides, sediment washes down into streams, clogging gravel beds and suffocating eggs. Open to the sunlight, the water warms, lowering its oxygen levels, and reducing survival rates of eggs and young fish.

Every year, as millions of fish return to spawn and die in rivers of the Pacific Northwest, they provide a bonanza for bears, eagles, and other species. Ecologist Tom Reimchen estimates that each bear fishing in British Columbia's rivers catches about 700 fish during the 45-day spawn, and that 70 percent of the bear's annual protein comes from salmon. After a quick bite on the head to kill the fish, the bears drag their prey back into the forest, where they can feed undisturbed. Some bears have been observed carrying fish as much as 800 m (0.5 mi) from the river before feeding on them.

Bears don't eat everything they catch. They leave about half of each carcass to be scavenged by eagles, martens, crows, ravens and gulls. A diversity of insects, including flies and beetles, also feed on the leftovers. Within a week, all the soft tissue is consumed, leaving only a bony skeleton. Reimchen calculates that between the nutrients leeching directly from decomposing carcasses and the excreta from bears and other scavengers, the fish provide about 120 kg of nitrogen per hectare of forest along salmon-spawning rivers. This is comparable to the rate of fertilizer applied by industry to commercial forest plantations. Altogether, British Columbia's 80,000 to 120,000 brown and black bears could be transferring 60 million kg of salmon tissue into the rainforest every year.

How do ecologists know that trees absorb nitrogen from salmon? Analyzing different kinds of nitrogen atoms, researchers can distinguish between marine-derived nitrogen (MDN) and that from terrestrial sources. Marine phytoplankton (tiny floating plant cells) have more of a rare, heavy form of nitrogen called 15N compared to most terrestrial vegetation, in which 14N, the more common, lighter form, predominates. Using a machine called a mass spectrometer, researchers can separate and measure the kinds and amounts of nitrogen in different tissues. We'll discuss different forms of atoms (called isotopes) later in this chapter. Because salmon spend most of their lives feeding on dense clouds of plankton far out to sea, they have higher ratio of 15N/14N in their bodies than do most freshwater or terrestrial organisms. When the fish die and decompose, they contribute their nitrogen to the ecosystem. Bears and other scavengers distribute this nitrogen throughout the forest where they drop fish carcasses or defecate in the woods.

Robert Naiman and James Helfield from the University of Washington found that foliage of spruce trees growing in bear-impacted areas is significantly enriched with MDN relative to similar trees growing at comparable distances from streams with and without spawning salmon. These results suggest that in feeding on salmon, bears play an important role in transferring MDN from the stream to the riparian (streamside) forest. Nitrogen is often a limiting nutrient for rainforest vegetation. Tree ring studies show that when salmon are abundant, trees grow up to three times as fast as when salmon are scarce. For some streamside trees, researchers estimate that between one-quarter to one-half of all their nitrogen is derived from salmon. Not only do salmon replenish the forest, but they also vitalize the streams and lakes

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

with carbon, nitrogen, phosphorous, and micronutrients. Nearly 50 percent of the nutrients that juvenile salmon consume comes from dead parents.

This research is important because salmon stocks are dwindling throughout the Pacific Northwest. In Washington, Oregon, and California, most salmon populations have fallen by 90 percent from their historic numbers, and some stocks are now extinct. Because of the close relationship of salmon and the trees, biologists argue, forest, wildlife, and fish management need to be integrated. Each population—rainforest trees, bears, hatchlings, and ocean-going fish—affects the stability of the others. Salmon need healthy forests and streams to reproduce successfully, and forests and bears need abundant salmon. Stream ecosystems need standing trees to retain soil and provide shade. So healthy streams depend on fish, just as the fish depend on the streams. As this case shows, the flow of nutrients and energy between organisms can be intricate and complex. Relationships between apparently separate environments, such as rivers and forests, can be equally complex and important.

For more information, see

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):2403–9.

Reimchen, T., et al. 2003. Isotopic evidence for enrichment of salmon-derived nutrients in vegetation, soil and insects in riparian zones in coastal British Columbia. *American Fisheries Society Symposium* 34:59–69.

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.