



# Using Marine-Derived Nitrogen in Tree Rings to Assess Nutrient Flux and Salmon Escapement

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Based on the annual growth rate and stable nitrogen isotope composition of trees growing adjacent to salmon streams, we have developed a model which has reliably reconstructed historic salmon abundances and returns to a Northern California stream over a 20-year period. We are currently expanding the geographic extent of our investigations. Additionally, we are refining our nitrogen extraction technique to improve our model's accuracy.

Although it is generally accepted that anadromous Pacific salmon and trout populations have declined throughout California, trends for individual watersheds are largely based on anecdotal information and provide little basis for estimating the true extent of the decline. This is especially true in small coastal watersheds where continuous records of salmon escapement (i.e., the number of fish that return to freshwater to spawn) seldom exceed 10 years and stock-specific population trends are generally unknown.

Our research uses long-lived riparian trees to examine current and historic inputs of salmon transferred marine-derived nutrients to coastal watersheds. A fortunate result of feeding in the marine environment is that the bodies of adult anadromous salmon are uniquely enriched with heavier isotopic forms of many biologically important elements (e.g., nitrogen, carbon, and sulfur) relative to terrestrial or freshwater sources of these same elements. When salmon return to their natal streams and die after spawning, these heavy isotopes are liberated during carcass decomposition and incorporated into aquatic and terrestrial food web.

Our results to date indicate that trees growing adjacent to spawning streams readily sequester and incorporate marine-derived nitrogen ( $\delta^{15}\text{N}$ ) when available. In fact, annual tree growth,  $\delta^{15}\text{N}$ , and percent nitrogen content have all been found to positively correlate with the number of salmon returning to spawn in a given year. By determining the stable nitrogen isotope composition ( $\delta^{15}\text{N}$ ) of annual growth rings from extant riparian trees, we are able to infer changes in salmon abundance over time and model historic salmon returns for periods where no such information exists.

Over the past year we have expanded our project to field sites in the Salmon River (Siskiyou County) and

Waddell Creek (Santa Cruz County) watersheds. In addition to supporting important salmon runs, these California basins contain the requisite combination of mature trees and periods of known salmon escapement that permit us to validate our tree ring reconstructions.

In the laboratory, we continue to improve our ability to extract and quantify nitrogen isotopes from wood samples. Research has demonstrated that nitrogen



Salmon carcasses contain nearly all the nutrients essential for plant growth and often provide a large fraction of the nitrogen sequestered by riparian trees.

molecules can be highly mobile in the xylem of some tree species and such mobility can potentially cloud interpretation of nitrogen availability at the time of ring formation. To that end, we are investigating methods to remove soluble forms of nitrogen (primarily sap residues) prior to stable isotope analysis.

The ability to reliably measure marine-derived nitrogen in tree rings has tangible ecological significance for California's salmonid restoration efforts. Long-lived riparian tree species would serve as valuable records of past biological events such as salmon declines or extirpations. Moreover, if predictable relationships between tree ring  $\delta^{15}\text{N}$  and salmonid escapement can be routinely derived, it then becomes possible to reconstruct historic salmon returns for the many watersheds where mature streamside trees still exist and escapement records do not.

**Collaborative Efforts**

Dr. Mike Bradford, Fisheries and Oceans, Canada, and Simon Fraser University



**Collecting an increment core (tree ring) sample from a riparian coast redwood tree**

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