Development and assessment of freshwater mussel growth-increment chronologies in the Pacific Northwest

OWEB progress report

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Since the completion of our annual report to OWEB, we have made significant progress in developing freshwater mussel chronologies and indentifying the environmental variables that these chronologies reflect. Earlier we had developed chronologies from mussels collected at two localities in the Willamette River. One collection was made in the river near Albany, Oregon directly upstream of the confluence of the Calapooia River (the "Bryant Park" chronology). A second collection was taken in the Middle Fork of the Willamette River downstream of Dexter Reservoir at Elijah Bristow State Park (the "Middle Fork" chronology). The latter site was chosen for its proximity to USGS gage 14150000, which provided long-term data on stream discharge and temperature. A third chronology has now been completed for Steamboat Creek in the western Cascades at a sample site located below the Canton Creek confluence, directly downstream of USGS flow gage 14316700. Summer water temperatures are also available from this site, and have been recorded in most years since 1969 (Mikeal Jones, USFS, Umpqua National Forest, personal communication). The Steamboat Creek mussel chronology spans 1981 through 2005 and significantly ($p < 0.05$) and positively correlates with the other two mussel chronologies (Figure 1), indicating strong regional synchrony in growth patterns.

When related to climatic records, we found that the Middle Fork and Bryant Park chronologies were most sensitive to indices of drought or river discharge, particularly those for the spring months. The same was true for mussels at Steamboat Creek. This chronology related the most strongly with Palmer Drought Severity Index (PDSI), an indicator of soil moisture, and discharge records for the Willamette River (USGS gage 14150000). The chronology was not significantly related to any measures of air or water temperature, suggesting that flow is the dominant signal captured by growth increment width. Indeed, relationships with PDSI and flow were remarkably strong. Annual discharge for the Middle Fork of the Willamette was positively related to the Steamboat growth-increment chronology with an R^2 of 0.53, suggesting that high-flow events are detrimental to growth while low-flow favors robust growth (Figure 2A). This was also reflected by a strongly negative relationship with PDSI, and index in which negative values indicate drought conditions and positive values indicate abundant soil moisture (Figure 2B). Overall, western Oregon mussel chronologies have been consistently (and negatively) related to indices of discharge, precipitation, and moisture, underscoring their potential relevance for reconstructing river and stream flow.

The high quality of the Steamboat Creek chronology was made possible through recent and significant methodological advancements. All mussels had been thin-sectioned and viewed with reflected or transmitted light, though transmitted light often provided the greatest clarity. In addition, thin sections were stained in an attempt to increase contrast of the growth increments. Yet even with these treatments the growth increments in the Steamboat Creek samples were difficult to resolve. Individuals from this site were characterized by faint growth increment boundaries and a very large number of checks, or "false" growth increments. In an attempt to better resolve the increments, we experimented with "acetate peels," a procedure that has previously been used in the ageing of marine bivalves. First, the mussel thin section was highly polished and briefly immersed in weak acid to etch the surface. Then an impression (acetate peel) was made by pressing the etched surface of the hinge plate against a piece of acetate film softened with several drops of acetone. The peel was sandwiched between two glass slides and viewed with transmitted light. With the correct level of polishing, acid concentration, and immersion time, acetate peels greatly enhanced the clarity of the annual growth increments. We anticipate that this preparation technique will be useful at other sites in which the growth increments are difficult to resolve by traditional means.

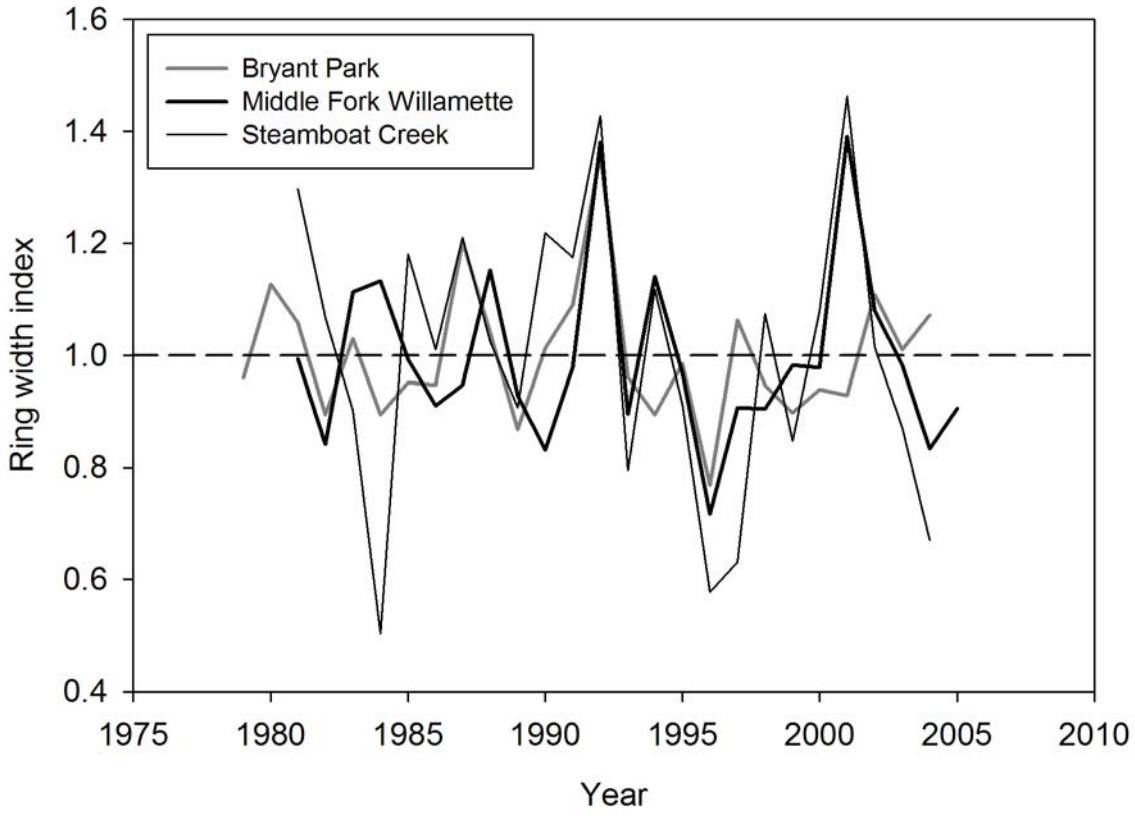

Figure 1. Middle Fork of the Willamette, Bryant Park, and Steamboat Creek freshwater mussel master chronologies. Minimum sample size is six individuals.

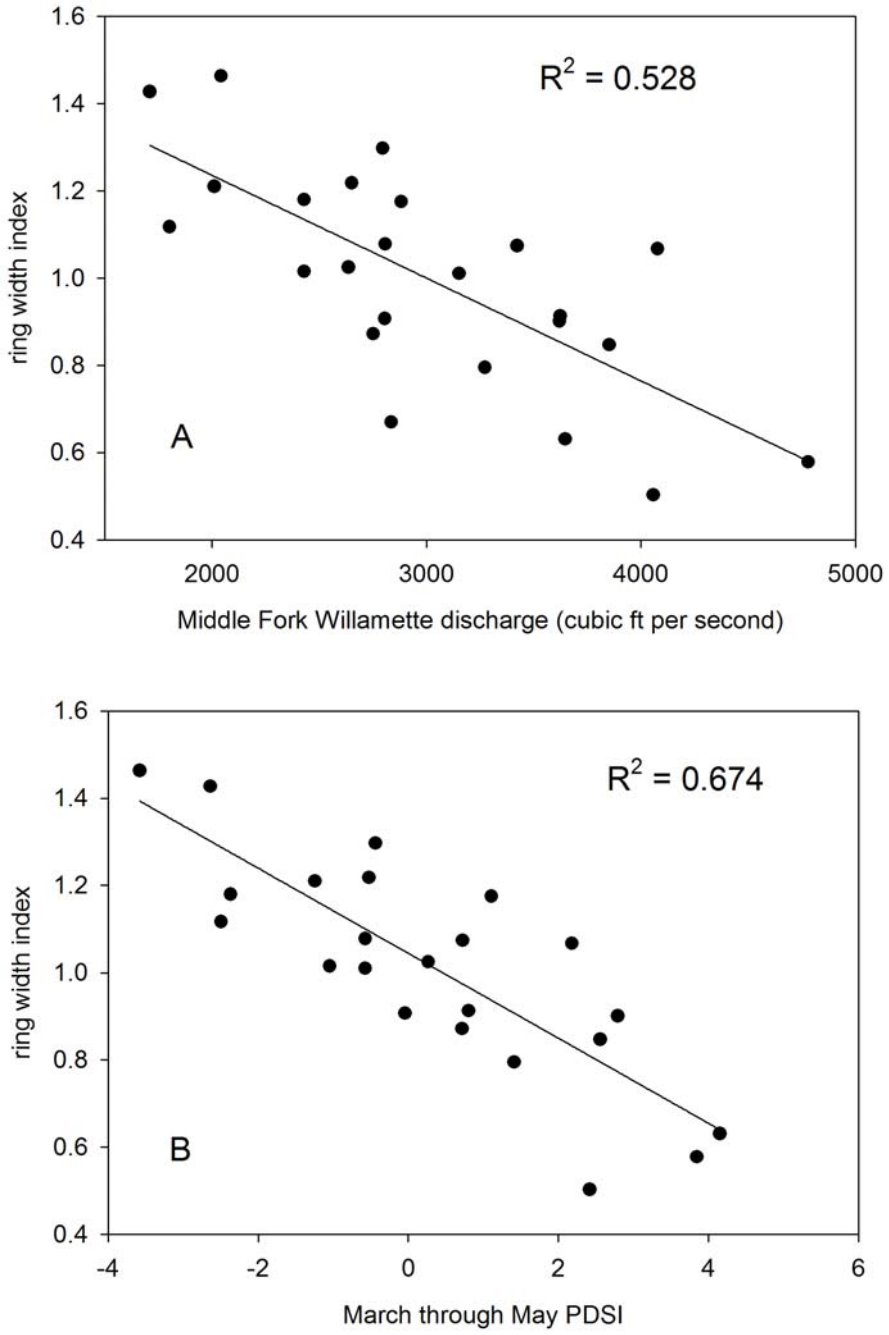

Figure 2. Relationships between the Steamboat Creek freshwater mussel chronology and A) river discharge at the Middle Fork of the Willamette, and B) regional Palmer Drought Severity Index