University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

CEDAR WELSH

MSc (University of Northern British Columbia, 2007)
BSc (Trent University, 2004)

"Multi-century records of hydroclimate dynamics and anadromous steelhead trout abundance from tree rings in Northern British Columbia, Canada"

Department of Geography

Monday, November 25, 2019
2:30 P.M.
Clearihue Building
Room B007

Supervisory Committee:
Dr. Dan Smith, Department of Geography, University of Victoria (Supervisor)
Dr. Tom Edwards, Department of Geography, UVic (Member)
Dr. Terry Prowse, Department of Geography, UVic (Member)
Dr. David Wilford, Ministry of Forests, Lands, and Natural Resource Operations (Outside Member)

External Examiner:
Dr. Trevor Porter, Department of Geography, University of Toronto Mississauga

Chair of Oral Examination:
Dr. Steve Evans, Department of Biochemistry and Microbiology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The impacts of climate variability and change on streamflow are of increasing concern, particularly as human demands on water supplies compete with the needs of natural ecosystems. The consequences on the hydrological cycle are predicted to be most severe for mid- to high-latitude regions. Of particular concern is the loss of mountain snow accumulation and related reductions in the snow- and glacier-derived water supply. In northern British Columbia (BC), recent snowpack declines have caused a unique water management challenge. Diminishing water security in a region considered water-abundant has intensified over the last decade. Characterizing the climate controls on hydrologic variability is a priority for developing baseline information required for water supply forecasting. This research focuses on developing multi-century, annually-resolved records of snow water equivalent (SWE) and streamflow records to provide a better understanding of long-term hydroclimate variability for the design and implementation of management strategies that balance riverine ecosystem services, such as recreation and fish habitat, with increasing economic and social demands.

Climate sensitive tree-ring chronologies provide the opportunity to extend instrumental records of hydroclimate by capitalizing on the influence of climate on both annual radial growth and seasonal runoff. Traditional dendrohydrology relies on moisture-limited tree species from dry, continental settings. This dissertation presents a new method by focusing on mid- to high-elevation conifers sensitive to snowpack variability. Ring-width and maximum latewood density records from mountain hemlock (*Tsuga mertensiana* (Bong.) Carriere), white spruce (*P. glauca* (Moench) Voss), and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) stands were collected at sites in northern BC. Dendrochronological techniques were used to develop a: 1) 222-year record of April 1 SWE for the Stikine River basin; 2) 416-, 715-, and 342-year record of summer streamflow for the Skeena, Nass and Stikine rivers, respectively; and, 3) a 192-year reconstruction of summer-run Skeena River steelhead abundance based on the influence of ocean-atmospheric forcings on both radial tree growth and steelhead escapement. The April 1 SWE record suggests that there has been considerable variability in snowpack levels in the Stikine basin and a distinct in-phase relationship with seasonalized PDO indices, not seen in basins to the south. The summer streamflow records also support a north-south “see-saw” effect, suggesting a unique association between moisture transport and atmospheric-ocean circulation in the region. In addition to the snow-sensitive tree-ring data, the streamflow models

incorporated paleo-hemispheric records to improve predictive skill. Finally, the steelhead model described alternating intervals of persistently above-average and below-average abundance that corresponded to oceanic Pacific Decadal Oscillation-like influences and describe links to “warm-warm” ENSO-PDO years associated with in-river low flow periods.

The reconstructions suggest that: 1) recent snowpack and streamflow declines are a rare event over a multi-century context; and, 2) existing instrumental records do not adequately represent the historic range of basin-specific hydroclimate variability necessary for new planning horizons. Mid- to high-elevation, snow-sensitive conifers have strong potential as paleohydrological proxies and for expanding the application of dendrohydrology to non-arid settings. Current conditions in northern BC, compounded by land use changes and climate change, are predicted to become more severe in the future. It is important that planning regimes incorporate long-term hydroclimate data to better understand and quantify how water supply and ecosystems will respond to future changes.