Notice of the Final Oral Examination
for the Degree of Master of Science
of

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B.S.F. (University of British Columbia, 2013)

“Cold hardiness and carotenoid variation in western redcedar (*Thuja plicata* Donn ex. D. Don.): Implications for assisted migration for future climates”

Department of Biology

Monday, December 14, 2020
9:00 A.M.
Conducted Remotely

**Supervisory Committee:**
Dr. Barbara Hawkins, Department of Biology, University of Victoria (Supervisor)
Dr. Jürgen Ehlting, Department of Biology, UVic (Member)
Dr. Alvin Yanchuk, Department of Biology, UVic (Outside Member)

**External Examiner:**
Dr. Keith Jayawickrama, Department of Forest Ecosystems and Society, Oregon State University

**Chair of Oral Examination:**
Dr. Adam Ritz, Department of Physics and Astronomy, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

Western redcedar (*Thuja plicata* Donn ex D. Don; redcedar), an indeterminate conifer in the Cupressaceae family, is vulnerable to maladaptation in the face of climate change. Assisted gene flow is one mitigation strategy and involves human-mediated migration of populations, where the projected climate of the area of deployment matches the source climate of the population. Despite the overall projections of warmer temperatures globally, in British Columbia (B.C.), the risk of frost events will remain and therefore the potential for cold damage and mortality to redcedar exists if the newly migrated populations cannot withstand these freezing events. Knowledge of redcedar's ability to withstand freezing temperatures (cold hardiness) is therefore crucial. Redcedar, like many Cupressaceae species, produces and accumulates the purple-coloured carotenoid rhodoxanthin during the winter. This was hypothesized to be correlated with cold hardiness.

Assessment of variation in overall cold hardiness and comparisons of fall and spring seasonal cold hardiness were done through repeated, seasonal freeze testing of 61 clonal grafts originating from across the range of redcedar, and 36 seedling controlled cross families from U.S.A and coastal B.C. parents. Cold hardiness was quantified using electrolyte leakage. Variation in rhodoxanthin levels was assessed using repeated, seasonal sampling of seedlings from eight provenances from northern coastal B.C. and interior B.C. and 23 controlled cross families from U.S.A. and coastal B.C. parents. The 61 clonal grafts from the cold hardiness study were also sampled. Rhodoxanthin concentrations were quantified using high performance liquid chromatography. Cold hardiness and rhodoxanthin were individually modelled using a univariate and bivariate mixed effect models with clone/family as a random effect. Best linear unbiased predictors (BLUPs) were predicted for the random effects for both traits and compared with climatic variables from the locations of clonal origin to assess climatic clines. A subset of seedlings for which both rhodoxanthin and cold hardiness data was collected were compared to assess correlation between the traits.

Overall heritability of cold hardiness was 0.17±0.03. Novel findings included the positive genetic correlation between fall and spring cold hardiness (0.55±0.33); lack of reciprocal or parental effect for overall cold hardiness; and weak climatic relationships between cold hardiness and
predominantly temperature, with the strongest correlation between number of frost-free days in January (0.38, p < 0.01) and cold hardiness.

Rhodoxanthin varied with family/provenance and season, with fall rhodoxanthin concentrations lower than winter and spring. All rhodoxanthin findings were novel, including determination of heritabilities of rhodoxanthin in fall (0.30±0.09), winter (0.42±0.09) and spring (0.28±0.09). Winter and spring rhodoxanthin concentrations were phenotypically correlated (0.50, p < 0.01) and genetically correlated (0.76±0.14). Surprisingly, rhodoxanthin was not detected in clonal grafts of redcedar in any season.

Cold hardiness in redcedar showed genetic variation but weak climatic clines. This indicates that assisted gene flow of redcedar should be done on a case-by-case basis, rather than using hard climatic or geographic restrictions. These results indicate that rhodoxanthin probably cannot be used to estimate cold hardiness. The absence of rhodoxanthin in the clonal grafts compared to the seedlings suggests that plant age impacts rhodoxanthin accumulation.