

Proceedings of the IUFRO 2019 Joint Conference Genetics of Five-Needle Pines and Rusts of Forest Trees

2023



**Proceedings of the IUFRO 2019 Joint
Conference Genetics of Five-Needle
Pines and Rusts of Forest Trees**

Jodie Krakowski, Ward Strong, and
Richard A. Sniezko (compilers)



The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the Government of British Columbia of any product or service to the exclusion of any others that may also be suitable. Contents of this report are presented for discussion purposes only. Funding assistance does not imply endorsement of any statements or information contained herein by the Government of British Columbia. Uniform Resource Locators (URLs), addresses, and contact information contained in this document are current at the time of printing unless otherwise noted.

ISBN 978-1-0399-0017-2 – Print version

ISBN 978-1-0399-0018-9 – Digital version

Citation

Krakowski, J., W. Strong, and R.A. Sniezko (compilers). 2023. Proceedings of the IUFRO 2019 Joint Conference: genetics of five-needle pines and rusts of forest trees. Prov. B.C., Victoria, B.C. Tech. Rep. 142.

Jodie Krakowski
Independent consultant
Crowsnest Pass, Alta.

Ward Strong
B.C. Ministry of Forests
Vernon, B.C.

Richard A. Sniezko
United States Department of Agriculture Forest Service
Cottage Grove, Oreg.

Copies of this report may be obtained, depending upon supply, from:
Crown Publications, King's Printer
2nd Floor, 563 Superior Street
Victoria, BC V8W 9V7
1-800-663-6105
www.crownpub.bc.ca

© 2023 Province of British Columbia

When using information from this report, please cite fully and correctly.

Inside cover art credit: Svetlana Shkuratova

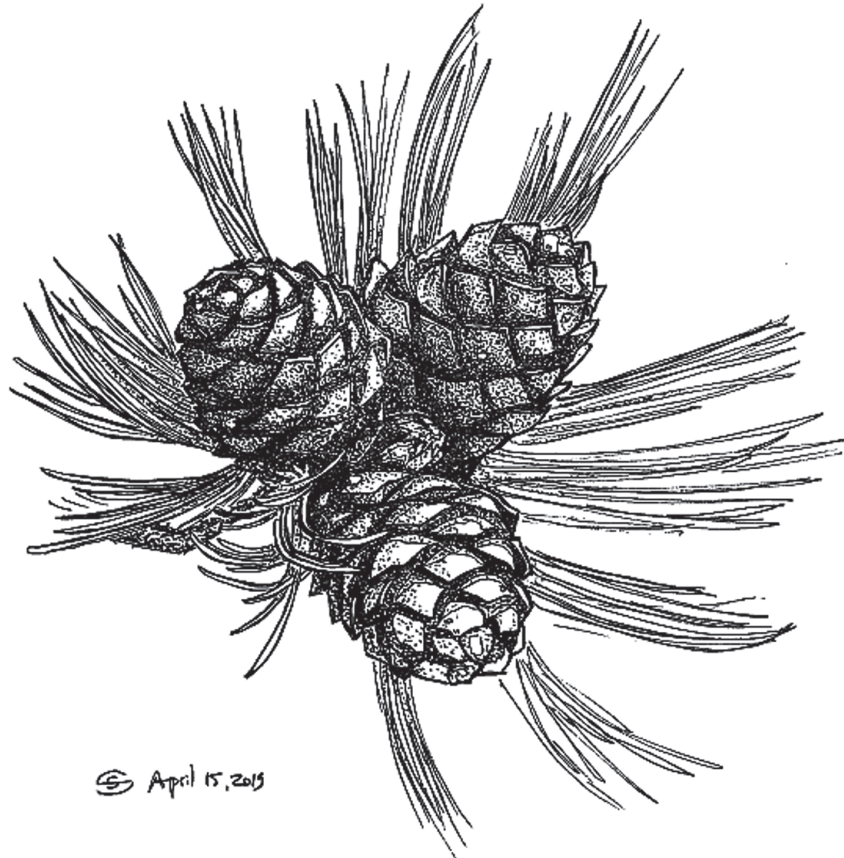


IUFRO 2019 Joint Conference

Genetics of Five-Needle Pines & Rusts of Forest Trees

July 22–26, 2019 • Invermere • British Columbia

Proceedings



© April 15, 2019

ACKNOWLEDGEMENTS

The organizers of the 2019 International Union of Forest Research Organizations (IUFRO) conference in Invermere, B.C. did an outstanding job developing an innovative and engaging program and field tours that highlighted current developments in research on and applications of genetics of five-needle pines and rusts of forest trees. The organizing committee was chaired by Ward Strong and supported by Nicholas Ukrainetz, Michael Murray, John King, Randy Moody, Charlie Cartwright, Don Pigott, Marnie Duthie-Holt, Richard Sniezko, and Anna Schoettle. Local arrangements were co-ordinated by Randy Moody and Marnie Duthie-Holt. Tours were organized by Don Pigott, Randy Moody, Barb Gass, Marnie Duthie-Holt, Michael Murray, and Charlie Chartwright. The program subcommittee was Nick Ukrainetz, Anna Schoettle, Richard Sniezko, Bruce Moltzan, Pascal Frey, and Philippe Tanguay. Richard Zabel, Western Forestry and Conservation Association, co-ordinated conference finances. The sponsorship subcommittee was Don Pigott, Charlie Cartwright, and Randy Moody. Pascal Frey was the IUFRO lead for Division 7.02.05, Rusts of Forest Trees. Bruce Moltzan secured additional U.S. Department of Agriculture sponsorship. Brigitte Burger provided support as IUFRO communications officer.

The generous support of many sponsors was integral to the success of this conference, and their contributions are listed in this report. Photos of the conference attendees were supplied by Richard Sniezko and Ward Strong. The beautiful original cover art was provided by Svetlana Shkuratova. The conference logo was developed and provided by Richard Zabel and the Western Forestry and Conservation Association, who also co-ordinated administration and registration. Our great thanks to the many volunteers who assisted with the local program and field trips. And lastly, our sincere appreciation to the registrants who contributed their time and expertise and generously shared their knowledge to build the community of practice.

CONTENTS

Acknowledgements	v
Introduction	1
Conference Organization and Sponsors	1
Program	4
Session 1: White Pine Blister Rust Resistance	7
1 Plenary: Breeding for White Pine Blister Rust Resistance— 50+ Years of Experience at Dorena Genetic Resource Center RICHARD A. SНИЕZKO AND ANGELIA KEGLEY	7
2 Blister Rust Distribution, Trends, and Resistance Screening in Southern British Columbia’s Endangered Whitebark Pine MICHAEL P. MURRAY AND RANDY MOODY	8
3 Results from Long-Term Field Trials in British Columbia: Resistance of Western White Pine to White Pine Blister Rust SARAH LEROUX, NICHOLAS UKRAINETZ, JOHN KING, DAVID PONSFORD, VICKY BERGER, AND MIKE CARLSON	13
4 Genomic Approaches to Dissecting Lodgepole and Jack Pine Interactions with <i>Cronartium harknessii</i> , the Causal Agent of Western Gall Rust CHANDRA MCALLISTER, MARION MAYERHOFER, JOSHUA MILLER, RHIANNON PEERY, TOD RAMSFIELD, ANDY BENOWICZ, DEOGRATIAS RWEYONGEZA, RONG-CAI YANG, PATRICK LENZ, AND JANICE COOKE	14
5 Screening Whitebark Pine for White Pine Blister Rust Resistance in British Columbia WARD STRONG AND MICHAEL MURRAY	15
6 Identifying Range-Wide Patterns of Genetic Resistance to Save a Species Threatened by a Non-Native Disease and Climate Change JEREMY JOHNSON, RICHARD SНИЕZKO, HUNTER MACKIN, EVAN HECK, MEGAN LEWIEN, DARREN BRONS, SHANNON MCCOY, SARA FRASER, ANGELIA KEGLEY, GERALD PAGE, MARJA HAAGSMA, CHRISTOPHER STILL, AND KRISTEN WARING . . .	16
7 The Influence of Genetics, Defensive Chemistry, and the Fungal Microbiome on Disease Outcome in White Pines LORINDA BULLINGTON, BEAU LARKIN, EMILY MARTIN, AND RICHARD SНИЕZKO . . .	17
8 Implementing a Bioinformatics-Based Targeted Sequencing Strategy for R-genes in the <i>Cronartium ribicola</i> –White Pine Pathosystem DAVID OLINE	18
Session 2: Genomics of Rust Resistance	19
9 Plenary: Genomics of Quantitative Resistance to White Pine Blister Rust in Sugar Pine AMANDA R. DE LA TORRE, MATTHEW WEISS, RICHARD SНИЕZKO, DANIELA PUIU, STEVEN L. SALZBERG, AND DAVID B. NEALE	19
10 Fusiform Rust Resistance Gene Discovery in <i>Pinus taeda</i> using RNAseq Bulked Segregant Analysis and Two-Way Testcross QTL Mapping EDDIE LAUER AND FIKRET ISIK	20

11	Uncovering the Natural Physiological Variation Driving Lodgepole Pine Resistance to Western Gall Rust NADIR ERBILGIN, HARLEEN KAUR, AND JENNIFER KLUTSCH	21
	Session 3: Hard Pine Stem Rusts	22
12	Age-Related Resistance to Hard Pine Stem Rusts in the Central Interior of British Columbia RICHARD W. REICH	22
13	Potential Trade-Offs in Growth and Environmental Resilience of Lodgepole Pine in Alberta EDEN MCPeAK AND BARB R. THOMAS	23
14	What Do We Know about Hemiparasitic Plant Hosts of Hard Pine Stem Rusts? SYBILLE HAEUSSLER	24
	Session 4: British Columbia Overview – White Pines	39
15	Five-Needle Pines in British Columbia – Status and Distribution RANDY MOODY	39
	Session 5: Rusts of Forest Trees	40
16	Plenary: Pine Rusts Never Sleep: Deciphering the Biology and Epidemiology of White Pine Blister Rust with Genomics RICHARD C. HAMELIN, KIAH ALLEN, ARNAUD CAPRON, NICOLAS FEAU, ERIKA DORT, AND PHILIPPE TANGUAY	40
17	Interspecific Hybridization in <i>Melampsora</i> Rusts of Poplars: A Mechanism of Emergence of New Species PASCAL FREY, MARIA MARLIN, HÉLOÏSE BASTIAANSE, AXELLE ANDRIEUX, ANDREW GROOVER, ISABELLE HENRY, LUCA COMAI, AND GEORGE NEWCOMBE	41
18	Evaluating the Presence and Introgression of the Hybrid Forest Pathogen <i>Cronartium</i> × <i>flexili</i> KIAH ALLEN, RICHARD HAMELIN, AND NICOLAS FEAU	43
19	Genotypic Diversity and Reproductive Biology of <i>Thekopsora areolata</i> , the Causal Agent of Cherry Spruce Rust in Norway Spruce Seed Orchards HERNÁN CAPADOR, BERIT SAMILS, JUHA KAITERA, AND ÅKE OLSON	44
20	Morpho-Anatomical Characteristics of <i>Eucalyptus urophylla</i> Leaves Inoculated and Not Inoculated with <i>Austropuccinia psidii</i> EDSON LUIZ FURTADO, CELSO LUIS MARINO, RENATA RUIZ SILVA-SOUZA, AND ROBERTO ANTONIO RODELLA	45
21	Alien Rust Fungi in Switzerland LUDWIG BEENKEN AND VALENTIN QUELOZ	58
22	The Effect of the Alien Rust Fungus <i>Melampsorium hiratsukanum</i> on Riparian Alder Formations in the Eastern Italian Alps SALVATORE MORICCA, CLAUDIA MARIA OLIVEIRA LONGA, ALESSANDRA BENIGNO, AND GIORGIO MARESI	59
23	<i>Pinus cembra</i> 's Last Stands? Small and Isolated Populations of Stone Pine in the Eastern Alps in Past and Current Climate Change BERTHOLD HEINZE, MARTIN GOLLOBICH, HANNAH HOCHSATTEL, AND LARA EIGNER	61

24	Evolution and Speciation of the Chinese White Pines XIAO-XIN WEI, YAN-YAN LIU, WEI-TAO JIN, AND XIAO-QUAN WANG	65
25	Whitebark Pine Restoration Strategy for the U.S. Forest Service, Pacific Northwest Region ANDREW BOWER.	66
26	Progress and Challenge in Tree Breeding of Korean Pine in South Korea KYU-SUK KANG AND YANG-GIL KIM	67
27	Clonal Variation of Strobilus and Seed Production in a 1.5-Generation Seed Orchard of <i>Pinus koraiensis</i> YANG-GIL KIM, DA-BIN YEOM, JI-MIN PARK, KI-WON KIM, HAE-IN KANG, SUNG-JOON NA, SOON-HO KWON, AND KYU-SUK KANG	68
28	Field Testing of Range-Wide Populations of Whitebark Pine in British Columbia CHARLIE CARTWRIGHT	69
29	Pines versus Spruce: Comparative Fitness in an Elevated CO ₂ × Soil Moisture Stress Factorial JOHN E. MAJOR AND ALEX MOSSELER.	70
30	Identification of <i>Phytophthora</i> Species Associated with Western White Pine Mortality in British Columbia Tree Seed Orchards NICOLAS FEAU, BERNI VAN DER MEER, WENDY VAN DER LINDEN, GEOFF BRADLEY, NICHOLAS UKRAINETZ, HARRY KOPE, AND RICHARD C. HAMELIN.	71
31	Chemical and Anatomical Defences of Lodgepole Pine Relate to Infection by Western Gall Rust, <i>Endocronartium harknessii</i> JENNIFER G. KLUTSCH, CHEN. X. KEE, AND NADIR ERBILGIN.	72
	Posters	73
1	Whitebark Pine Recovery: Testing Assisted Migration and Direct Seeding as Possible Restoration Methods IAIN R. REID, SIERRA C. MCLANE, AND SALLY N. AITKEN	73
2	Development and Application of Marker-Assisted Selection Tools for Breeding of Western White Pine Resistance to White Pine Blister Rust in British Columbia JUN-JUN LIU, HOLLY WILLIAMS, AREZOO ZAMANY, XIAO-RUI LI, SAVANNAH GELLNER, AND RICHARD A. SNEZKO	75
3	Monitoring of <i>Cronartium ribicola</i> in Québec Forest Tree Nurseries Using Genome-Enhanced DNA Detection Assays PHILIPPE TANGUAY, MARIE-JOSÉE BERGERON, NICOLAS FEAU, AND RICHARD C. HAMELIN	76
4	Whitebark Pine and Limber Pine Conservation in the Canadian Mountain National Parks NATALIE STAFEL, BRENDA SHEPHERD, ROBERT SISSONS, GREGG WALKER, AND JANE PARK	77
5	Investigating the Antagonistic Activity of Fungal and Bacterial Endophytes of Western White Pine against the Pathogen <i>Cronartium ribicola</i> EMILY MARTIN, BEAU LARKIN, AND LORINDA BULLINGTON.	80

6	Host Jump Drives Diversification of <i>Chrysomyxa</i> Species	
	CHONGJUAN YOU AND CHENGMING TIAN.	81
7	Returning Sugar Pine and Western White Pine to the Pacific Northwest Forests—A Collective Effort	
	RICHARD A. SNEZKO, ROBYN DARBYSHIRE, HOLLY KEARNS, ELLEN GOHEEN, BRENNAN FERGUSON, BRENT OBLINGER, BETSY GOODRICH, BLAKEY LOCKMAN, JOSH BRONSON, MICHAEL MCWILLIAMS, MIKE CRAWFORD, GEORGE MCFADDEN, JEFF DEBELL, DAN OMDAL, AMY RAMSEY, SCOTT KOLPAK, JIM HARGROVE, DOUG MANION, TIMOTHY LARKOSKI, GERALD BARNES, RICK KERN, DAN CRESS, BILL MARSHALL, DONALD J. KACZMAREK, JUN-JUN LIU, MARTIN NICHOLSON, SHAWN BARNES, NICHOLAS UKRAINETZ, LORINDA BULLINGTON, LISA WINN, ROBERT DANCHOK, EMILY BOES, AND ANGELIA KEGLEY	82
8	Ecology and Evolution of a Tree Species Challenged by Dual Threats	
	KRISTEN WARING, SAM CUSHMAN, ANDREW ECKERT, LLUVIA FLORES-RENTERIA, RICHARD SNEZKO, CHRISTOPHER STILL, CHRISTIAN WEHENKEL, AMY WHIPPLE, MICHAEL WING, JUSTIN BAGLEY, ETHAN BUCHOLZ, SOCORRO GONZALEZ-ELIZONDO, JESSICA HARTSELL, CORY GARMS, EVAN HECK, JEREMY JOHNSON, ERIN LANDGUTH, ALEJANDRO LEAL SÁENZ, MITRA MENON, EHREN MOLER, GERALD PAGE, JOHN SHAW, ANDREW SHIRK, AND JARED SWENSON	88
9	Finding and Using Genetic Resistance to White Pine Blister Rust in Alberta Populations of Limber Pine	
	RICHARD A. SNEZKO, JODIE KRAKOWSKI, ROBERT SISSONS, GENOA ALGER, JUN-JUN LIU, MEGAN LEWIEN, ROBERT DANCHOK, RACHEL ZITOMER, AND ANGELIA KEGLEY	90
10	The Search for White Pine Blister Rust Resistance in Foxtail Pine	
	RICHARD A. SNEZKO, JOHN GLEASON, BRIANNA McTEAGUE, ROBERT DANCHOK, MEGAN LEWIEN, AND ANGELIA KEGLEY.	95
11	Toward Evolutionary and Functional Characterization of an Avirulence Gene in the Poplar Rust Fungus <i>Melampsora larici-populina</i>	
	PASCAL FREY, CLÉMENTINE LOUET, AGATHE MAUPETIT, MÉLINE SAUBIN, ANTOINE PERSOONS, STÉPHANE DE MITA, SÉBASTIEN DUPLESSIS, AND FABIEN HALKETT.	99
12	Partnerships in the Pacific Northwest to Help Save an Endangered Species, Whitebark Pine—Research, Rust Resistance, and Restoration	
	RICHARD A. SNEZKO, KRISTEN CHADWICK, ROBYN DARBYSHIRE, JENNIFER HOOKE, CHRIS JENSEN, DAN OMDAL, AMY RAMSEY, BETSY GOODRICH, MICHAEL P. MURRAY, CHARLIE CARTWRIGHT, GEORGE MCFADDEN, MICHAEL CRAWFORD, DOUG MANION, WHITNEY MATTHES-FINLEY, JUN-JUN LIU, LORINDA BULLINGTON, ANNA CONRAD, ENRICO BONELLO, IAIN REID, EHREN MOLER, JENNIFER GRUHN, MARTIN NICHOLSON, ERIC SPRAGUE, SPUS WILDER, TYLER HALE, ROB MANGOLD, DIANA TOMBACK, ROBERT DANCHOK, KRISTIN SILVA, EMILY BOES, AND ANGELIA KEGLEY.	100
13	Reach for the Top: Implementing Whitebark Pine and Limber Pine Recovery in Alberta	
	JODIE KRAKOWSKI, ROBIN GUTSELL, AND BRAD JONES	111
	Attendees	115

INTRODUCTION

The IUFRO 2019 Joint Conference on Genetics of Five-Needle Pines and Rusts of Forest Trees was designed to highlight the synergies and alignment in current research and operational applications of two key divisions of the International Union of Forest Research Organizations (IUFRO). At this meeting, Division 2.02.15 focussed on screening and genetics programs for resistance to white pine blister rust (*Cronartium ribicola*); Division 7.02.05 updated the current state of knowledge of research on rusts (including blister rust) of forest trees.

The following describes the key focus of each division; additional information is available by accessing the URLs.

IUFRO Division 2.02.15 – Breeding and genetic resources of five-needle pines

<https://www.iufro.org/science/divisions/division-2/20000/20200/20215/>

The Working Party on Breeding and Genetic Resources of Five-Needle Pines is concerned with research co-operation and exchange of information on all aspects of genetic research on five-needle pines. This includes provenance testing and genetic resources, breeding, species hybridization, clonal propagation and testing, tissue or cell culture, cell and molecular genetics, and genetics of host–pathogen interactions. Increasingly, though, we are using this knowledge to address issues related to climate change, land use pressure, and conservation.

IUFRO Division 7.02.05 – Rusts of forest trees

<https://www.iufro.org/science/divisions/division-7/70000/70200/70205/>

Our Working Party aims to bring together scientists and investigators who are working on tree rusts. Our goal is to foster scientific discussion and exchanges related to tree rust epidemiology, biology, host–pathogen interactions, resistance, control and management, and genomics. Our Working Party meets approximately once every 4 years in Europe, North America, or Asia. We usually meet in locations that allow us to discuss our scientific findings and have field trips in a friendly and relaxed environment that is conducive to exchanges and debates. We want to place a strong emphasis on participation of young investigators and students, as these meetings provide unique experiences to meet and exchange information with the related community.

CONFERENCE ORGANIZATION AND SPONSORS

Conference Organization

Program	Richard Snieszko, Pascal Frey, Philippe Tanguay, Anna Schoettle, Bruce Moltzan
Registration, website, finances	Richard Zabel
Registration table	Barb Gass
Local arrangements	Randy Moody, Marnie Duthie-Holt, Barb Gass
Tours	Charlie Cartwright, Don Pigott, Randy Moody, Michael Murray
Sponsorship	Bruce Moltzan, Charlie Cartwright
Member-at-large	Nick Ukrainetz

22. The Effect of the Alien Rust Fungus *Melampsoridium hiratsukanum* on Riparian Alder Formations in the Eastern Italian Alps

SALVATORE MORICCA,^{1*} CLAUDIA MARIA OLIVEIRA LONGA,² ALESSANDRA BENIGNO,¹ AND GIORGIO MARESI³

1 Department of Agricultural, Food, Environmental and Forestry Science and Technology (DAGRI), Plant Pathology and Entomology Division, University of Florence, Florence, Italy

2 Department of Sustainable Agroecosystems and Bioresources, Research and Innovation Centre, Fondazione Edmund Mach., San Michele all'Adige, Trento, Italy

3 Centre for Technology Transfer, Fondazione Edmund Mach, San Michele all'Adige, Trento, Italy

*Presenting and corresponding author: salvatore.moricca@unifi.it

ABSTRACT

In approximately 20 years, the full-cyclic, alder rust pathogen *Melampsoridium hiratsukanum* has spread from the Baltics, where it was introduced from eastern Asia, through most of the European continent down to the Mediterranean countries. This exotic leaf parasite has now pervasively dispersed through several valleys of the eastern Italian Alps, where it causes yearly outbreaks on grey alder (*Alnus incana*). Owing to its high reproduction and dispersal capacity, conferred by its repeating uredinial stage, this rust has spawned repeated infection waves in valleys in the Alps for at least 10 years. The disease causes serious defoliation of grey alder during the summer, and has an infection rate that varies in relation to temperature and moisture trends but always remains quite high. *M. hiratsukanum* is damaging to grey alder stands, but the main concern is its possible effect on riparian alder formations due to the ecological processes it could trigger. Because of the high incidence and severity of the rust on grey alder, the tree species seems to be gradually declining in occurrence along mountain waterways and is being replaced by various non-native herbaceous and shrub species. The replacement of grey alder, a dominant riparian species in the Alps, by non-native invasive plants is causing a loss of stability in banks along mountain streams, which is leading to an increase in landslides. It seems, therefore, that we are witnessing a classic and all-too-common theme of invasion ecology: the arrival of a non-native organism into a new habitat, with negative effects on the native flora. *M. hiratsukanum* is altering the structure and dynamics of riparian ecosystems in the Alps by weakening grey alder and causing it to be driven out by invading competitors.

REFERENCES

- Hantula, J., T. Kurkela, S. Hendry, and T. Yamaguchi. 2009. Morphological measurements and ITS sequences show that the new alder rust in Europe is conspecific with *Melampsorium hiratsukanum* in eastern Asia. *Mycologia* 101:622–631.
- Moricca, S. and G. Maresi. 2010. *Melampsorium hiratsukanum* reported for the first time on grey alder in Italy. *New Disease Rep.* 21:17.