CLIMATE CHANGE, WILDFIRE, AND LANDSCAPE HOMOGENIZATION IN WESTERN CANADA

Research Update – July 2013

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Introduction

Wildfire is the most important mechanism of ecological disturbance in western North America, and so understanding the associations between wildfire and climatic variability, ecosystem dynamics, and land management is essential for conservation of forested environments. The combined effects of human land use, fire suppression and climate variation are hypothesized to have homogenized fire regimes in many regions of western Canada. This homogenization has reduced structural and compositional diversity of forests, increased average patch sizes, and increased vulnerability to environmental stressors such as climate change and invasive species. The cumulative impacts of these changes could have deleterious impacts on water quality in the Western Cordillera.

This research conducted in Alberta and British Columbia uses a hybrid fire history approach, combining tree-ring research on fire scars and tree ages with analyses of charcoal, pollen and diatoms, to reconstruct fire history and link it to climate, vegetation and water quality over the previous centuries to millennia. Within the scope of this project, we have five primary aims:

(1) To quantify the historical frequency, extent, and severity of wildfire along a gradient in climate and management intensities in the Western Canadian Cordillera.
(2) To evaluate the degree to which recent fire exclusion efforts have altered fire regimes, and homogenized forested landscapes.
(3) To characterize the climatic and landscape contexts in which mixed severity wildfire regimes were historically important.
(4) To quantify the association between fire occurrence, fire severity, and antecedent climate over interannual to interdecadal timescales in the context of the dominant vegetation characteristics.
(5) To evaluate the effects of climatic variability, wildfire activity, and land cover change on water quality.

Research Progress

Over the past 18 months, this project has involved 3 PhD students, 4 MSc students and numerous undergraduate field and lab assistants at four universities. Progress for student-lead projects is described below and will be presented during a workshop and field tour in the Alberta foothills and Jasper National Park on July 10 and 11, 2013. A second field tour in British Columbia will be held in August.

Research in Alberta

Vanessa Stretch (PhD candidate, University of Guelph) is using a multiproxy fire history approach to reconstruct wildfire history in the Alberta Foothills and to test the hypothesis that the landscape was historically characterized by a mixed-severity fire regime. Her pilot study was conducted in the summer of 2012, which involved the establishment of a sampling grid and the collection of fire scar and stand origin data from 16 plots. These records will be supplemented by further sampling in summer 2013. The fire records reconstructed from tree-rings will be extended using the macroscopic sedimentary charcoal sampled from small lakes to understand the spatial and temporal controls on changes to the wildfire regime in this area, as well as corroborating wildfire proxy records.

Raphael Chavardes (MSc student, University of British Columbia) sampled 29 plots in Jasper National Park (JNP), which superimpose on the network of sites sampled by the Foothills Research Institute (FRI) between 1996 and 2000. Raphael's objective was to reconstruct fire severity and better understand its effects on forest dynamics. He collected 550 increment cores and 80 fire scar samples to compliment the 100 fire-scar samples provided by FRI. His reconstructed fire record extends 457 years and includes 16 fires indicated by scars or cohorts. Abundant fire scars indicate low- to moderate-severity fires burned prior to 1904. Fire scars occurred in 19 plots, with up to 5 fire-scar years per plot. All sites had one or two even-aged cohorts, many of which originated after large fires in 1827, 1889 and 1904. Current forest canopies include a mix of white spruce, lodgepole pine and Douglas-fir, regardless of fire history. Subcanopies are dominated by white spruce at all sites, indicating a potential shift in species composition and decrease in forest diversity in absence of fire.

Two additional projects are underway in Jasper National Park. Theresa Dinh (MSc student, University of Guelph) is conducting new analyses on the fire-scar samples collected by Gerald Tande in the 1970s. Using improved technology and contemporary analytical methods, Theresa will crossdate each fire-scar sample to ensure the fire dates are annually resolved, refining fire metrics and yielding a dataset suitable for analyses of fire-climate relations. Updating our understanding of Tande's rich fire-history dataset will provide new information on fire severity and effects that will improve efforts to ensure forests are resilient to global environmental change.

Research by Emma Davis (MSc Candidate, Carleton University) will provide a long-term perspective on the historical relationships between climate and fires in Jasper. Emma is working on a 2000-year fire chronology to be created using tree-ring analysis and paleolimnology for the area surrounding Little Trefoil Lake, located near the Jasper town site. Using an existing 3-metre long sediment core, she is analyzing macroscopic charcoal. Changes in the amount and morphology of charcoal particles preserved in lake sediments provide evidence for fluctuations in the frequency and severity of wildfires over time. Emma will be conducting additional field work in summer 2013.

We are actively recruiting two additional MSc students to analyze interactions between land cover/land use, wildfire, climate, and water quality. These students will analyze data from sediment cores collected by Vanessa Stretch, Emma Davis, and possibly Colin Courtney Mustaphi (see below).

Research in British Columbia

Our research in British Columbia uses similar approaches to allow direct comparison with research conducted in Alberta. Several aspects of the fire history research in BC are well advanced as they started in 2008 and were supported by a previous grant from NSERC. In summary, we have developed crossdated, annually-resolved fire records for 121 sites and reconstructed stand dynamics at 47of these sites using high-quality increment cores. Combined, these records indicate mixed-severity fire regimes historically dominated the low and mid-elevation forests of the West and East Kootenays in British Columbia. Results from all study sites indicated low-to-moderate severity fires were common historically but have been effectively eliminated during the 20th century, with potentially important implications for fire and fuels management, sustainable forest management and timber supply, and conservation of biodiversity.

Three students are currently involved with this research and have made substantive progress on their respective projects in the past 18 months. Hélène Marcoux (MSc, UBC) completed her MSc degree in May 2013. Hélène's research, conducted near Cranbrook, BC, examined the prevalence of mixed-severity fire regimes, importance of underlying topographic drivers, and the influence of mixed- *versus* high-severity fires on forest composition and structure. She found evidence of mixed-severity fires at 55% of 20 study sites. At these sites, 73% of reconstructed fires were documented by fire scars, indicating many fires were of low-to-moderate severity. The remaining 27% of fires were severe enough to generate an even-aged cohort. Spatial patterns of fire severity were primarily controlled by elevation. Forest composition varied significantly with disturbance history; however, structural differences were subtle, except snag densities, which were greater in old forests where time-since-last-fire was >250 years. Hélène's research also highlighted errors in landscape-level fire regime classification and mapping systems that underlie current forest and fire management practices. Hélène attributed these errors to unsupported assumptions about disturbances combined with the limitations of the research methods used to estimate fire frequency. She concluded that understanding the ecological heterogeneity created by mixed-severity regimes is critical for sustainable forest management, wildfire and fuel mitigation and conservation of biodiversity in southeastern British Columbia.

Research by Colin Courtney Mustaphi (PhD Candidate, Carleton University) reconstructs long-term fire and vegetation histories in the West *versus* East Kootenay Mountains of British Columbia through the analysis of macroscopic charcoal, plant remains, and pollen in lake sediments. By examining multiple records across mountainous environments, Colin is examining the full variability of the fire regime and its drivers. His research shows that the warmer and wetter climate of the West Kootenays compared to the East Kootenays, explains differences in vegetation and fire regimes. His analysis of charcoal in the sediments from five lakes in the West Kootenays revealed important similarities and differences in fire history over the last 5000 years. Aspect was an important factor influencing fire frequency and synchrony among watersheds. North-facing sites burned less frequently, while south-facing sites burned more often. Sites sharing a similar aspect were more synchronous, while sites with different aspects were asynchronous at centennial time windows. Colin's ongoing work has generated full Holocene records from multiple lakes that he is using to investigate how vegetation evolved with changing fire regimes over the past 10,000 years.

Greg Greene's (PhD Student, UBC) research investigates the effects of fire exclusion on the dynamics of the grassland-forests ecotone in the valley bottom of the Rocky Mountain Trench in southeastern British Columbia. Fire scar records show that low- and moderate-intensity surface fires burned frequently prior to European settlement. However, land-management practices over the last 140 years have significantly reduced fire occurrence, contributing to ecosystem degradation. Greg's research is designed to improve understanding of the mechanism and rates of grassland-to-forest conversion and to supply baselines to guide ecological restoration aimed to reinforce forest and grassland resilience to future environmental change.

Student Accomplishments in 2012-2013

Vanessa Stretch, PhD Candidate, University of Guelph (supervised by Ze'ev Gedalof)
"Multiproxy Reconstructions of Mixed-severity Wildfire Dynamics in the Alberta Foothills"

- NSERC Industrial Postgraduate Scholarship (sponsored by Hinton Wood Products)
- Queen Elizabeth II Graduate Scholarship in Science & Technology in 2012
- University of Guelph Tri-Council Scholarship in 2012 and 2013
- Arthur D. Latornell Graduate Travel Scholarship to attend the Canadian Association of Geographers meeting in August 2013.

Colin Courtney Mustaphi, PhD Candidate, Carleton University (supervised by Mike Pisaric)
"An Assessment of Holocene Fire Regime Controls in Southeastern British Columbia"

- Dr. George A. Jeletzky Memorial Scholarship in Paleontology in 2012 and 2013
- Travel, Research, and Educational Experience travel grant, Association for Fire Ecology in 2012

Gregory Green, PhD Student, UBC (supervised by Lori Daniels)
"Fire-Resilience: History and Hazards in Ponderosa Pine and Douglas-fir Forests in the Rocky Mountain Trench of British Columbia"

- NSERC Industrial Postgraduate Scholarship (sponsored by the Rocky Mountain Trench Natural Resource Society)
- Travel, Research, and Educational Experience travel grant, Association for Fire Ecology in 2012

Raphael Chavardes, MSc Student, UBC (supervised by Lori Daniels)
"*Historical Fire Regimes in Montane Forests of Jasper National Park, Canada"*

- NSERC Industrial Postgraduate Scholarship (sponsored by Hinton Wood Products)
- UBC Travel Scholarship to attend the 2nd AmeriDendro Conference in May 2013
- NSERC Postgraduate Scholarship to pursue a PhD starting January 2014

Theresa Dihn, MSc Candidate, University of Guelph (supervised by Ze'ev Gedalof)
"*Wildfire Dynamics in Jasper National Park, Alberta*"

- University of Guelph Board of Graduate Studies Research Scholarship, 2013
- A.D. Latornell Graduate Travel Scholarship; Dean's Scholarship; NSERC USRA in 2012

Emma Davis, MSc Candidate, Carleton University (supervised by Michael Pisaric)
"Assessing the influence of climate on wildfire occurrences in Jasper National Park during the Late Holocene"

- NSERC CGS scholarship 2012-2013
- Ontario Graduate Scholarship (OGS) 2013-4

Dissemination of Results 2012-2013

Student Theses

Dyce, Braden A. 2013. A Paleolimnological Study of Two Lakes in Jasper National Park, Alberta. Undergraduate Thesis. Department of Geography, University of Western Ontario, London, Ontario.

Marcoux, Hélène. 2013. Towards Improved Understanding and Management of Mixed-Severity Fire Regimes in Mountain Forests. MSc Thesis. Department of Forest and Conservation Sciences, University of British Columbia, Vancouver, BC.

Journal Publications

Courtney Mustaphi, C.J. and M.F.J. Pisaric. *In press.* Varying influence of climate and aspect as controls of montane forest fire regimes during the late Holocene, south-eastern British Columbia, Canada. *Journal of Biogeography*

Marcoux, H.M., S.E. Gergel and L.D. Daniels. *In press.* Mixed-severity fire regimes: How well are they represented by existing fire-regime classification systems? *Canadian Journal of Forest Research.*

Submitted Manuscripts

Courtney Mustaphi, C.J. and M.F.J. Pisaric. Submitted. Holocene climate-fire-vegetation interactions at a subalpine watershed in southeastern British Columbia, Canada. Submitted to *Quaternary Research*

Courtney Mustaphi, C.J. and M.F.J. Pisaric Submitted. A classification for macroscopic charcoal morphologies found in Holocene lacustrine sediments. *Progress in Physical Geography*

Courtney Mustaphi, C.J. and M.F.J. Pisaric. Submitted. *A* 7500-year record of climate-fire-vegetation interactions at a mountain valley site, southeast British Columbia, Canada. Submitted to *International Journal of Wildland Fire*

Conference Presentations

Courtney Mustaphi, C.J. and M.F.J. Pisaric. An assessment of Holocene fire regime controls in southeastern British Columbia. 6th Ontario-Quebec Paleolimnology Symposium (PALS), May 15-17, 2013, Carleton University, Ottawa, ON, Canada.

Courtney Mustaphi, C.J. and M.F.J. Pisaric. Multiple lake sediment records of Holocene forest fire histories from southeastern British Columbia, Canada. 5th International Fire Ecology and Management Congress. Dec 3-11, 2012. Portland, OR, USA.

Courtney Mustaphi, C.J., J.T. Perreault, M.F.J. Pisaric, L.D. Daniels and Z. Gedalof. Multiple lake sediment records of Holocene forest fire regimes from the Nelson area, southeastern British Columbia, Canada. 5th Ontario-Quebec Paleolimnology Symposium (PALS), May 23-25, 2012, Western University, London, ON, Canada.

Daniels, L.D., Z. Gedalof, M.F.J Pisaric, S.E. Gergel, G.A.Greene, J. Cochrane, J. Nesbitt, E. DaSilva, H.M. Marcoux, and C.J. Courtenay Mustaphi. 2013. Climate Variability and Altered Fire Regimes in the Mountain Forests of British Columbia, Canada. 2nd American Dendrochronology Conference, May 11-18, 2013, University of Arizona, Tucson, AZ, USA.

Greene, G.A. and L.D Daniels. 2013. Mixed-Severity Fire Regimes in Montane Forests: The Darkwoods of British Columbia. 5th International Fire Ecology and Management Congress. Dec 3-11, 2012. Portland, OR, USA.

Poster Presentations

Chavardes, R., L.D. Daniels and D.W. Andison. 2013. Historical Fire Regimes in Montane Forests of Jasper National Park, Canada. 2nd American Dendrochronology Conference, May 11-18, 2013, University of Arizona, Tucson, AZ, USA.

Courtney Mustaphi, C.J. and M.F.J. Pisaric. 2012. Holocene fire records from small subalpine lakes in southeast British Columbia, Canada. International Paleolimnology Symposium, August 21-24, 2012, Glasgow, UK.

Courtney Mustaphi, C.J. and M.F.J. Pisaric. 2012. A new classification for sedimentary macroscopic charcoal morphology. 5th Ontario-Quebec Paleolimnology Symposium (PALS), May 23-25, 2012, Western University, London, ON, Canada.

Greene, G.A. and L.D. Daniels. 2013. Fire-Scarred Edges and Pie-Slice Wedges: Examining the Success of the Partial Cross-Section Method in Obtaining Fire-Scar Information. 2nd American Dendrochronology Conference, May 11-18, 2013, University of Arizona, Tucson, AZ, USA.

Stretch, V., Z. Gedalof and L.D. Daniels. 2013. PDF | XML | Multiproxy reconstructions of mixed-severity wildfire dynamics in the Alberta Foothills, Canada. 2nd American Dendrochronology Conference, May 11-18, 2013, University of Arizona, Tucson, AZ, USA.

Public Presentations and Communications

Hot Topics in Jasper: Tree Rings and Forest Fires, Presentation by Lori Daniels, Campfire Talks, Whistlers Campground, Jasper National Park, July 2012

Hot Topics in Jasper: Tree Rings and Forest Fires, Presentation by Raphael Chavardes and Ashley Dobko, Interpretive Program, Whistlers Campground, Jasper National Park, July 2012

Forest Fires and Climate Change. Presentation by Lori Daniels, Campfire Talks, Kokanee Creek Provincial Park, BC Parks, Nelson, BC July and August 2012; July 2013.

Historic Wildfires in Western Canada – Interviews by Colin Courteny Mustaphi with the Cranbrook Townsman, Lori Daniels with CBC Radio, Raphael Chavardes with Radio Canada, August 2012