H11: Hydro-ecological and hydrogeomorphic impacts of forest disturbance and management

Conveners: Jim Buttle[1], Irena Creed[2] and Brett Eaton[3] and Dan Moore[4]

Co-chairs: Jim Buttle[1], Irena Creed[2] and Brett Eaton[3] and Dan Moore[4]

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Session Description

Changes in forest cover associated with forest management and natural disturbance can have profound influences on hydrologic processes, nutrient cycling, sediment transport, channel morphology, water quality and aquatic habitat. It is important for managers and decision-makers to understand the nature of these changes in order to anticipate how they will influence ecosystem services. However, it is difficult to isolate the effects of forest cover change from background climatic variability, especially in the context of ongoing climate change and legacy effects of historic harvesting practices and past disturbances.This session aims to provide a platform for presenting research that provides new insights into the hydrologic, hydro-ecological and hydrogeomorphic consequences of forest cover changes at all spatial scales, from small plots to large regions, based on field research, empirical analysis of hydroclimatic data sets and simulation modelling. In addition to fundamental research on topics such as the effects of forest succession on water and nutrient budgets, we welcome presentations based on applied research, such as experimental studies of alternative riparian management impacts on water quality and aquatic habitat, or the effects of roads on runoff generation or sediment budgets.

Primary Affiliation: Hydrology, Biogeosciences, Earth Surface Processes

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NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE MAY BE SUBJECT TO CHANGE.

ORAL SESSION H11a

Chairs: J. Buttle, I. Creed, B. Eaton, D. Moore **Room: EOSC 135**

Wednesday, May 31st

TIME	AUTHORS	TITLE
11:00	U. Silins, M.B. Emelko, K.D. Bladon, C.H.S. Williams, A.M. Martens, M.J. Wagner, M. Stone & S.A. Spencer	Ecohydrological drivers of watershed resilience: crystal balling nitrogen production a decade after wildfire and beyond (invited)
11:30	K.E. Bennett, N. McDowell, C. Xu & R. Middleton	The sensitivity of the Colorado River basin to temperature, precipitation and land cover change
11:45	M.A. Arain, B. Xu, M. Peichl, J.J. Brodeur, N. Restrepo-Coupé, M. Khomik, R. Thorne, E. Beamesderfer & S. McKenzie	Ecohydrological response of age-sequence of managed temperate pine forests to climate variability and extreme weather events from 2003 to 2015
12:00	Q. Li* & X. Wei	The cumulative effects of forest disturbance and climate variability on flow components in a large forested watershed
12:15	R. Winkler, D. Spittlehouse & S. Boon	A comparison of water yield response to extensive clearcut logging in two small watersheds at Upper Penticton Creek, BC

ORAL SESSION H11b

Chairs: J. Buttle, I. Creed, B. Eaton, D. Moore **Room: EOSC 135**

Wednesday, May 31st

TIME	AUTHORS	TITLE
16:45	A. Corrigan*, U. Silins & M. Stone	Impacts of rapid harvest and subsequent haul road decommissioning on sediment production and ingress
17:00	A. Goodbrand* & A. Anderson	Hydrological impact of forest harvest in a Foothills watershed
17:15	J.M. Buttle, F.D. Beall, P.W. Hazlett, K. Webster & I.F. Creed	Hydrologic response to and recovery from differing harvesting strategies in a deciduous forest: the Turkey Lakes Forest Harvesting Experiment

POSTER SESSION H11

Chairs: J. Buttle, I. Creed, B. Eaton, D. Moore **Room: ESB Atrium**

Tuesday, May 31st

Poster No.	AUTHORS	TITLE
P01-H11	K.D. Bladon & R.P. Cole	Soil hydraulic properties and subsurface flow pathways following wildfire in the Cascade Mountains, Oregon
P02- H11	A.M. Martens*, U. Silins, K.D. Bladon, C.H.S. Williams, M. Wagner & E. Luchkow	Stable isotope analysis of food web dynamics in aquatic ecosystems following severe wildfire in Alberta's Rocky Mountains
P04- H11	S. Spencer*, U. Silins & A. Anderson	Temporal variation in precipitation-runoff dynamics and implications for resilience in the eastern slopes of Alberta's Rocky Mountains
P05- H11	M. Howard*, U. Silins & A. Anderson	Quantifying and forecasting erosion from off highway vehicle trails in Front-Range Rocky Mountain watersheds
P06- H11	D. Greenacre*, U. Silins & M. Dyck	Influence of alternative forest harvesting strategies on coupled spatial patterns of snowpack accumulation/melt and soil moisture storage
P07- H11	S. Karpyshin*, U. Silins & M. Dyck	Transpiration response of residual Lodgepole pine after strip and partial-cut harvesting in Alberta's southern Rocky Mountains
P08- H11	C.H.S. Williams*, U. Silins, K.D. Bladon & A. Anderson	Muted rainfall-runoff response to increased net rainfall after wildfire in Alberta's mountain headwaters
P09- H11	K. Herlein, U. Silins, C.H.S. Williams, A.M. Martens, M.J. Wagner, K. Hawthorn, M. Stone & M.B. Emelko	Long-term suspended sediment yields in wildfire affected mountain streams in southwestern Alberta

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SUBMITTED ABSTRACTS

H11-01: Ecohydrological drivers of watershed resilience; Crystal balling nitrogen production a decade after wildfire and beyond

Uldis Silins[1], Monica B. Emelko[2], Kevin D. Bladon[3], Chris H.S. Williams[1], Amanda M. Martens[1], Michael J. Wagner[4], Micheal Stone[5] and Sheena A. Spencer[1].

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Abstract

Biogeochemical processes reflect the interaction of vegetation and hydrology to regulate export of nutrients over long, successional time scales. This is particularly true of ecosystem limiting nutrients such as nitrogen (N) where watershed exports reflect the balance between inputs and ecosystem uptake. Watershed "recovery" after disturbance is most often viewed through the lens of the timeline for disturbance effects returning back to baseline or reference conditions. However, a long-term study of post-disturbance N production more than a decade after severe wildfire in Alberta's Rocky Mountains provides important clues into ecohydrological drivers of potential decadal or successional trajectories of N export beyond the basic notion of watershed recovery. Large initial increases in stream total N (TN) and nitrate (NO_3^-) 1-3 yr. after wildfire in both burned and burned /salvage logged watersheds declined strongly to levels similar to, and later well below that of unburned reference watersheds 4-6, 7-9, and 10-11 yr. after the fire. These changes closely corresponded with the early post-fire trajectory of initial establishment, early and latter juvenile growth of upper Montane and sub-alpine forest vegetation in both burned subsequently salvage logged watersheds. These results provide strong clues into likely trajectories of watershed N exports in the coming decades and beyond. Results of this study also provides insights into potential long-term implications of management in post-disturbance watershed resilience, and highlights ambiguity in the concept of stationary "control" or "reference" catchments, particularly for ecosystem limiting nutrients such as N.

H11-02: The sensitivity of the Colorado River basin to temperature, precipitation and land cover change

Katrina E. Bennett[1], Nathan McDowell[2], Chonggang Xu[2], and Richard Middleton[1]

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Abstract
The Colorado River Basin (CRB) is a critical watershed in terms of vulnerability to climate change and supporting the food-energy-water nexus. Climate-driven disturbances in the CRB—including wildfire, drought, and pests—threaten the watershed's ability to reliably support a wide array of ecosystem services while meeting the interrelated demands of the food-energy-water nexus. Our work examines the sensitivity of the CRB to changing temperature, precipitation and land cover using an updated version of the Variable Infiltration Capacity hydrologic model, parameterized for arid Southwestern US river basins. Our scenario approach simulates changing temperature (+0.1, 1, 3, 6 and 8°C), precipitation (-10, -20%, +10%, +20%) and land use (forest cover, canopy structure, and stomatal resistance alterations) in an elasticity framework. We consider simulated streamflow and water balances (evapotranspiration, soil moisture and snow water equivalent) for the 23 sub-watersheds of the upper and lower CRB on monthly and annual time scales. Our work will assist water managers determine the spatial variability and sensitivity of joint changes in climate and climate-driven disturbances for improved mitigation of the impacts on food-energy-water nexus infrastructure and ecology in the CRB.

H11-03: Ecohydrological response of age-sequence of managed temperate pine forests to climate variability and extreme weather events from 2003 to 2015

M. Altaf Arain, Bing Xu, Matthias Peichl, Jason J. Brodeur, Natalia Restrepo-Coupé, Myroslava Khomik, Robin Thorne, Eric Beamesderfer, Shawn McKenzie

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Abstract

Canadian temperate forests are a critical component of the global carbon cycle and regional water resources. A large portion of these forests has traditionally been managed for timber production and other uses. The response of these forests, which are in different stages of development, to extreme weather events such as drought and heat stresses, climate variability and management regimes is not fully understood. In this study, flux measurements in an age sequence (76-, 41-, and 13-years old) of pine forests in southern Ontario are examined to determine the impact of heat and drought stresses and climate variability over 13 years (2003-2015). The mean net ecosystem productivity (NEP) values were 199, 506 and 115 g C m^{-2} $year^{-1}$ in 76-, 41- and 13-year-old forests, respectively. A large decrease in annual NEP was observed during years experiencing heat waves such as 2005 and 2012. Air temperature was a dominant control on carbon fluxes and heat stress reduced photosynthesis much more as compared to ecosystem respiration in the growing season. Drought stress as indicated by Palmer Drought Severity Index (PDSI) had the strongest impact on the middle age forest which had the largest carbon sink and water demand. In contrast, young forest was more sensitive to heat stress, than drought. Severity of heat and drought stress impacts was highly dependent on the timing of these events. Simultaneous occurrence of heat and drought stress in the early growing season such as in 2012 had a drastic negative impact on carbon balance in these forests due to plant-soil-atmosphere feedbacks. Future research should consider the timing of the extreme events, the interaction among heat and drought effects and the stage of forest development. This research helps to assess the vulnerability of managed forests and their ecohydrological responses to climate change and extreme weather events.

H11-04: The cumulative effects of forest disturbance and climate variability on flow components in a large forested watershed

Qiang Li* and Xiaohua Wei

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Abstract

Assessing how forest disturbance and climate variability affect flow components is critical for ecosystem protection and engineering design. Previous studies have mainly evaluated the effects of forest disturbance on total streamflow, rarely with attention given to its components (e.g., base flow, surface runoff), particularly in large watersheds (>1000 km^2). However, studying this topic is challenging as it requires the explicit inclusion of climate into the assessment due to their interactions in large watersheds. In this study, we used the Tulameen River watershed (1780 km^2), located in the southern interior of British Columbia, Canada, to examine how forest disturbance and climate variability interactively affect all flow components. The cumulative disturbance level has reached to 36.7% of the watershed area until 2011. Baseflow was separated using a combination of the recursive digital filter method and the conductivity mass balance method. Modified double mass curves were then employed to quantitatively separate the relative contributions of forest disturbance and climate variability to each flow component. Our results showed that average annual baseflow and baseflow index (baseflow/streamflow) were about 105 mm year^{-1} and 0.27 for the study period of 1954-2013, respectively. Forest disturbance increased the annual streamflow, baseflow, and surface runoff by 33.0 ± 25.3 mm, 9.0 ± 6.8 mm, and 24.8 ± 18.2 mm, respectively, while climate variability decreased each component of -30.3 ± 25.3 mm, -8.2 ± 6.8 mm, and -22.5 ± 18.1 mm, respectively. Clearly, the role of forest disturbance played in annual streamflow, baseflow, and surface runoff was equal to that caused by climate variability in the study watershed despite their opposite directions. In addition, our results show surface runoff responded quicker to forest disturbance than baseflow. The implications of our results are discussed in the context of future forest disturbance and climate change.

H11-05: A comparison of water yield response to extensive clearcut logging in two small watersheds at Upper Penticton Creek, BC

R. Winkler[1], D. Spittlehouse[2] and S. Boon[3]

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[2] Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC
[3] Creekside Communication, Cobble Hill, BC

Abstract

In south-central British Columbia, upland watersheds supply downstream communities with drinking water while also providing timber, cattle range, and recreational opportunities. A long-term paired watershed experiment was established at Upper Penticton Creek in 1985 to evaluate the effects of forest harvesting on downstream water supply. Streamflow has been monitored continuously from three ~5 km^2 forested watersheds typical of those found on the Okanagan Plateau. The 240 (control) and 241 Creek (treatment) watersheds are south-facing with forest cover dominated by lodgepole pine, while the 242 Creek (treatment) watershed is west-facing with forest cover dominated by Engelmann spruce and subalpine fir. Following a 10-year pre-development period, approximately 50% of the forest cover was removed in two watersheds (241 and 242), while the 240 Creek watershed remained unlogged. Compared to the adjacent 240 Creek watershed, the 241 Creek watershed saw only a small increase in annual yield, but a substantial shift in the timing of snowmelt generated flows, with statistically significant increases in April/May yields and decreased June/July yields. Building on this previous analysis, we summarize post-logging changes in water yield from the 242 Creek watershed and examine differences in hydrologic response between the two treatment watersheds as a function of LiDAR-derived ecophysiographic attributes, measured forest regrowth, year of harvest, and meteorological conditions.

H11-06: Impacts of rapid harvest and subsequent haul road decommissioning on sediment production and ingress

Amelia Corrigan*[1], Uldis Silins[1], Mike Stone[2]

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Abstract
While rapid road and road-stream crossing decommissioning after forestry operations may serve to limit broader impacts of sedimentation in high value headwater streams, few studies have evaluated the combined effects of accelerated harvest operations and rapid retirement of roads on stream sediment. The objectives of this study were to evaluate the initial impacts of these strategies on sediment production and fate during a short duration (10-month) harvesting operation in 3 headwater sub-catchments in the southwestern Rocky Mountains of Alberta, Canada. A multi-pronged sampling approach (automated ISCOs samplers, event focused grab sampling, continuous wash load sampling, and sediment intrusion measurements) was used to measure sediment production and ingress in streambeds. Sediment production from forestry roads was generally much lower than has been reported from other studies in similar settings with little, if any, consistent pattern of elevated sediment production during the snowmelt freshet or periodic summer rainstorms. Data upstream and downstream of road-stream bridge crossings show that the impact of the combined disturbance of rapid harvest (2015) and road decommissioning (2016) on total suspended solids ($p = 0.52$), wash load concentrations ($p = 0.601$), and sediment ingress ($p = 0.33$) was largely negligible. In fact, turbidity was often higher ($p < 0.0001$) at the upstream sample location across both years. Minimal in-stream sediment impacts from forest harvest and road-stream crossings was likely a reflection of combined factors including a) employment of secondary erosion control Best Management Practices to roads and bridge crossings, b) rapid decommissioning of roads and crossings to limit exposure of linear land disturbance features, and c) drier El Niño climatic conditions during the study.

H11-07: Hydrological impact of forest harvest in a Foothills watershed

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Abstract
Recent investigations of long-term hydrometeorological data from watersheds on the eastern slopes of the Rocky Mountains showed the streamflow regime was resilient to forest harvest. These watersheds had low levels of harvest relative to their size and a large area of sparsely vegetated alpine talus slopes and exposed bedrock; an area shown to generate the majority of runoff for streamflow. In contrast, Foothills watersheds typically have harvestable timber throughout due to lower relief; therefore, Foothills watersheds may be more sensitive to forest disturbance and have increased potential for streamflow response. This research assesses the hydrological response to forest harvest in the Foothills using a long-term dataset from the Tri-Creeks Experimental Watershed (Tri-Creeks) near Hinton, Alberta. Tri-Creeks is located in a setting with complex glacial deposits and tilted sandstone bedrock strata; a hydrogeological condition that suggests considerable potential for water storage. Detailed hydrometeorological observations were collected during a paired-watershed study from 1968 – 1990. During the early 1980s, forestry experiments were conducted to compare the impacts of timber harvest and riparian buffers within three sub-watersheds: Eunice (16.8 km^2; control); Deerlick (15.2 km^2; 36% streamside timber removal); and, Wampus (28.3 km^2; 37% clear-cut). Chronologically paired, frequency paired, and change-detection hydrological modelling analyses were used to assess the hydrological impact of forest harvest on peak flows. Preliminary results suggest that the streamflow regime of Tri-Creeks displayed resilience to forest harvest despite having a high percentage of harvested area. We hypothesize that climate variability and watershed storage are the dominant drivers of streamflow response.

H11-08: Hydrologic response to and recovery from differing harvesting strategies in a deciduous forest: the Turkey Lakes Forest Harvesting Experiment

J M Buttle[1], F D Beall[2], P W Hazlett[2], K Webster[2] and I F Creed[3]

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Abstract
Studies examining the hydrologic consequences of forest harvesting have focused on clearcutting, while few have examined alternative harvesting strategies such as selection or shelterwood cutting. Most harvesting experiments in landscapes with seasonal snow cover have been in coniferous forests, whose hydrologic responses to harvesting may differ from those of deciduous stands. We present results of a 31-year examination of hydrological recovery to a range of forest harvesting strategies in a northern deciduous forest landscape in central Ontario using a paired-catchment experimental approach. A quantitative means of assessing hydrologic impact and recovery to harvesting is also developed. Clearcutting led to increases in water year (WY) runoff largely due to greater late fall and early winter streamflow. However, increases in growing season streamflow were not seen, likely due to reduced post-harvest summer water availability. Annual peak streamflow did not respond to clearcutting, although baseflow increased. The clearcut catchment showed the strongest evidence of all treatments that harvesting enhanced the relative importance of surface and near-surface water pathways based on geochemical tracing. Hydrologic recovery was incomplete 14 years after clearcutting, although there was evidence of decreased WY runoff below pre-harvest values due to vegetation regrowth. Selection harvest results were confounded by a forest access road in the catchment that facilitated water delivery to the stream. Nevertheless, response to selection and shelterwood harvesting was similar to that for clearcutting but more muted, while recovery time following forest disturbance differed between hydrological metrics for these treatments. The merit of characterizing the range in regional hydrologic conditions via multiple control catchments when assessing responses to forest harvesting is highlighted, as is the benefit of explicit consideration of temporal climatic changes during the experiment. Finally, we show the value of using multiple approaches to assess hydrological responses to forest harvesting.

H11-09: Soil hydraulic properties and subsurface flow pathways following wildfire in the Cascade Mountains, Oregon

Kevin D. Bladon[1] and Ryan P. Cole[1]

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Abstract
The Stouts Creek wildfire burned ~10,700 ha of forestland in the Cascade Mountains in southwestern Oregon in 2015. Burn severity was spatially variable—17% of the landscape burned at high severity and 33% at medium severity. Soil hydraulic properties and runoff generation were investigated on hillslopes that were more severely impacted by the wildfire. Mean soil moisture in the surface soil layer (θ_{surf}; 0–5 cm) along unburned hillslopes was 20.4% ± 2.5%, while mean θ_{surf} on burned hillslopes was 13.9% ± 2.2% ($F = 11.8$; $p = .002$). Similarly, mean θ_{depth} (5–10 cm) on reference hillslopes was 22.0 ± 2.2%, and mean θ_{depth} on burned hillslopes was 17.6 ± 2.8% ($F = 4.54$; $p = .042$). Unsaturated hydraulic conductivity was approximately the same at the soil surface in the unburned (3.34 mm hr^{-1}) and burned catchments (2.76 mm hr^{-1})—however, unsaturated hydraulic conductivity at 10 cm depth in the soil was ~3-times greater along unburned hillslopes compared to the burned hillslopes ($\chi^2 = 6.5$; $p = .01$). A dye tracer experiment and soil profile image analysis showed high variability in infiltration and subsurface flow paths between reference and burned plots. Dye image analysis suggested that water infiltrated and moved vertically as a more uniform wetting front with little evidence of lateral movement of water downslope in the reference plots. Alternatively, the burned plots showed greater evidence of heterogeneous finger flow, as well as evidence of overland flow, which produced gullies (>4 m long, 0.5 m wide) below the bottom edges of the burned plots. Overall, results suggest the wildfire impacted soil structure with likely impacts on surface runoff and subsurface flow pathways—these hillslope changes can influence the timing and magnitude of streamflow and increase soil erosion, negatively affecting source water quality.

H11-10: Stable isotope analysis of food web dynamics in aquatic ecosystems following severe wildfire in Alberta's Rocky Mountains

Amanda M. Martens[1*], Uldis Silins[1], Kevin D. Bladon[2], Christopher H.S. Williams[1], Michael Wagner[3], Evan Luchkow[1]

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Abstract

Wildfire alters landscapes and can have significant impacts on stream ecosystems. The 2003 Lost Creek wildfire was one of the most severe on Alberta's eastern rocky mountain slopes. Elevated sediment production and nutrient (phosphorus, nitrogen, and carbon) export in impacted streams resulted in increased algal productivity and macroinvertebrate abundance and diversity. Due to increased productivity, fish in watersheds draining wildfire-affected catchments were larger than those in the same age class from reference (unburned) watersheds. In the present investigation, stable isotope analysis of carbon and nitrogen was utilized to evaluate ecosystem energy dynamics and describe trophic relationships in those watersheds. Macroinvertebrates were collected and identified to family and sorted into functional feeding groups (scrapers, shredders, filterers, and predators). Primary food sources (algae and terrestrial vegetation) were collected and analyzed to identify important sources of energy. Macroinvertebrates that feed on algae (scrapers) were more abundant in burned streams compared to unburned streams (58.8% vs 43.0%), suggesting a reliance on algae (autochthony) as a primary source of energy. Invertebrates that consume terrestrial detritus were more abundant in unburned streams compared to burned streams (33.1% vs 19.0%), indicating reliance on allochthonous or terrestrial energy sources. Preliminary analysis of $\delta^{15}N$ in aquatic invertebrates from burned catchments showed slight enrichment, suggesting a trophic shift. Isotopic analysis of primary consumers and possible food sources, coupled with careful consideration of community structure, will provide greater resolution of how wildfire affects specific invertebrate families within feeding guilds. This will allow more robust insights into how wildfires may impact stream ecology in mountain environments.

H11-11: Temporal variation in precipitation-runoff dynamics and implications for resilience in the eastern slopes of Alberta's Rocky Mountains

Sheena Spencer[1*], Uldis Silins[1], and Axel Anderson[1, 2]

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Abstract
Forest disturbance (harvesting, wildfire, and disease) is known to impact water quality, water quantity, and hydrological regimes, but severity of these impacts varies greatly because of variation in soil, geology, climate, and the dominant hydrological processes that govern catchment response across regions. Some studies have suggested that these factors may also be responsible for watershed resiliency but the combination of factors that create resilient watersheds are not well understood. This study examines the influence of climate and basin structure on precipitation-runoff responses to shed light on how forest harvest may influence streamflow in the post-glacial, eastern slopes of Alberta's Rocky Mountains. Climatic and hydrometric data (2005-2014) from 5 nested watersheds in Star Creek were used to evaluate spatial patterns in gaining/losing reaches within a larger drainage network, long-term storage estimates, flow recession analyses, and event-based precipitation-runoff responses. Multi-year precipitation patterns of dry and wet periods were shown to influence sub-basin annual runoff contributions. However, no difference was found for event-based comparisons between dry and wet periods. Seasonal analyses of snowfall and runoff showed wet antecedent conditions (fall precipitation) increased summer runoff compared to dry antecedent conditions. Improved relationships for snowfall and annual runoff ratios for wet (compared to dry) hillslope conditions were observed for Star East sub-basin but not for Star West sub-basin. A conceptual model of runoff generation in Star Creek and the eastern slopes of Alberta's Rocky Mountains was developed and suggests that streamflow in this region may be highly resilient to disturbance. We hypothesize that hydrological resilience in this watershed is due to 1) permeable bedrock and deep heterogeneous surficial deposits that result in high storage capacity and 2) dominant subsurface flow pathways that are linked to this large storage capacity, but climatic patterns and inter-annual variation in precipitation further impact how the stream responds to disturbance.

H11-12: Quantifying and forecasting erosion from off highway vehicle trails in Front-Range Rocky Mountain watersheds

Melissa Howard[1*], Uldis Silins[2], and Axel Anderson[2]

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Abstract
Off highway vehicle (OHV) trails have the potential to transport sediment to sensitive headwater streams and increased OHV use is a growing watershed management concern in many Rocky Mountain regions. Tools for estimating erosion and sediment inputs are required to support assessment and management of erosion from OHV trail networks to identify potential problem areas needing remediation or other management actions such as trail decommissioning. The objective of this study was to a) assess erodibility (K factor) and total erosion from OHV trail networks in Rocky Mountain watersheds in south-west Alberta, Canada, and to b) evaluate the applicability of the Universal Soil Loss Equation (USLE) for predicting OHV trail erosion to support management strategies. Measured erosion rates and erodibility (K) from rainfall simulation plots on OHV trails during the summers of 2014 and 2015 were compared to USLE predicted erosion from these same trails. Erodibility (K) from 23 rainfall simulation plots was highly variable (0.001-0.273 Mg*ha*hr/ha*MJ*mm) as was total seasonal erosion from 17 large trail sections (0.0483-43.3 Mg/ha) across trail segments of variable slope, stoniness, and trail use intensity. In particular, intensity of trail use had a significant effect on both erodibility and total erosion that is not presently captured by erodibility indices (K) derived from soil characteristics. Results of this study suggest that while application of USLE for predicting erosion from OHV trail networks may be useful for initial broader erosion assessment, a better understanding of the effect of factors such as road/trail use intensity on erodibility is needed to support use of USLE or associated erosion prediction tools for road/trail erosion management.

H11-13: Influence of alternative forest harvesting strategies on coupled spatial patterns of snowpack accumulation/melt and soil moisture storage

Daniel Greenacre[1*], Uldis Silins[1], and Miles Dyck[1]

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Abstract

Snowpack accumulation, melt dynamics, and soil water storage play a critical role in regulating stressed regional water supplies in the southern Alberta Rockies. However these processes are sensitive to impacts from forest cover losses by logging and associated land disturbance. Few previous studies have explicitly linked altered postharvest spatial patterns in snowpack accumulation-melt processes to subsequent growing season soil moisture dynamics that regulate runoff. Moreover, early studies largely focus on clearcut harvesting practices that are not representative of current strategies resulting in a knowledge gap about how current practices or new/novel practices affect these hydrological processes. In 2015, three sub-catchments located in the Crowsnest Pass, Alberta were logged using three different harvesting strategies (clear-cut with tree retention, strip-shelterwood, and partial cut harvesting). This ongoing project aims to investigate how these alternative harvesting strategies affect snowpack accumulation and melt processes and seasonal soil moisture legacy. Spatial patterns in snowpack depth, snow water equivalent (SWE), and subsequent growing season soil moisture storage are being evaluated in three sub-catchments (clear-cut, strip-cut, partial-cut harvested) and an undisturbed reference using linear survey transects, with snow depth and SWE measurements conducted every 14-21 days from peak SWE through to disappearance. Correspondence between the legacy of spatial patterns in snowmelt on subsequent patterns of growing season soil water storage (0-20, 20-60 cm depth) is being evaluated using time domain reflectometry (TDR) at same sampling frequency. Differences in spatial/temporal patterns of coupled snowmelt/soil moisture are being evaluated in the context of differing solar radiation and air/ground temperature forcing among the three harvesting strategies. Results from this study will provide new information on how alternative logging strategies affect linked snowpack-soil moisture dynamics that regulate runoff from forested mountain watersheds in this critical water supply region.

H11-14: Transpiration response of residual Lodgepole pine after strip and partial-cut harvesting in Alberta's southern Rocky Mountains

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Abstract
Strip retention and partial-cuts are two harvesting strategies employed to address a variety of forest management objectives. The physiological response of residual trees following partial-cut harvesting has been previously studied, but little attention has been placed on altered microclimate conditions experienced by residual trees of retention harvesting. Moreover, tree water use responses following strip retention harvesting remain poorly understood. Understanding whole-tree water use responses to altered postharvest microclimates will provide further insight into linking soil-tree-atmosphere dynamics and their responses to contemporary harvesting strategies. Strip-retention and partial-cut harvest treatments were completed in 2015 in two subcatchments in the Rocky Mountains, Crowsnest Pass, Alberta. The objectives of this study are to evaluate short term acclimation of transpiration in residual Lodgepole pine (Pinus contorta) stands to changes in spatial patterns of soil and microclimatic conditions produced by differing forest harvesting patterns two years after harvesting. Whole-tree water use will be measured at a partial-cut, strip retention and a reference site using thermal dissipation sapflow sensors. Spatial patterns (edge effects; strip cutting, diffuse; partial cutting) in rooting soil moisture (below ground controls) and atmospheric moisture demand (air temperature, RH, VPD, wind) will be measured using time domain reflectometry (TDR) and canopy/ground level meteorological towers. This research will provide valuable information on short-term responses to altered above-/below-ground controls on transpiration. Further providing initial insights into potential longer-term physiological acclimation processes (tree hydraulic architecture) on the recovery/resilience of watershed scale evaporative fluxes.

H11-15: Muted rainfall-runoff response to increased net rainfall after wildfire in Alberta's mountain headwaters

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Abstract
The hydrologic effects of wildfire often include increased magnitude of stormflow runoff and peakflows, and quicker streamflow responses to precipitation. However, because of the complex sedimentary geologic setting of Alberta's Rocky Mountains, it is unclear if flow responses to severe wildfire are similar in this region to those often reported elsewhere. The present study focuses on changes to post-wildfire rainfall interception and event-based stormflows following severe wildfire in the Crowsnest Pass region of Alberta in 2003. Canopy rainfall interception was studied during three summers (2006-2008) in burned and unburned (reference) pine/fir stands and scaled over a ten year period using the measured distribution of rainfall events that occurred from 2005-2014. On average, annual net rainfall (R_N) was 40% greater (126 mm) in burned stands (annual R_N = 454 mm) than in unburned stands (annual R_N = 328 mm). Baseflow separation was performed on runoff data from 2005-2014 during snow-free periods to calculate event-based stormflow magnitudes in two burned and two reference catchments. Despite 40% greater mean R_N in burned watersheds, stormflow parameters did not group within disturbed/undisturbed watershed categories suggesting stormflow magnitudes were not different between burned and reference watersheds. Likewise, no difference in basin lag between burned and reference watersheds (burn $\bar{x}$=2.95 hr.; ref $\bar{x}$=2.60 hr.; p=0.32), or time-to-peak (burn $\bar{x}$=10.02 hr.; ref $\bar{x}$=9.75 hr.; p=0.78) was evident. Further, there did not appear to be any differences in these stormflow metrics between individual sites, regardless of the presence of the burn (p>>0.1). Despite relatively large increases in net storm rainfall, we found no clear evidence of post-wildfire changes to stormflow runoff magnitude or timing suggesting considerable watershed resistance to severe wildfire in this region.

H11-16: Long-term suspended sediment yields in wildfire affected mountain streams in southwestern Alberta

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Abstract
Wildfires can have a profound impact on sediment exports from forested mountain headwater streams and changes to instream sediment concentrations can substantially alter delicate aquatic ecosystems and downstream drinking water quality. Most published studies report increases in total suspended sediment yields and turbidities in streams immediately after the disturbance with some responses being more dramatic than others. These studies usually report on sediment production for 1-5 year periods after wildfire; during which observed sediment yields often return to baseline reference conditions. Far fewer studies exist that report elevated sediment yields more than 5 years post-fire and even fewer have a sediment data record that is greater than 10 years in length. This study is part of a long-term research project documenting the effects of the 2003 Lost Creek fire in the Rocky Mountains of southwestern Alberta on water quality and quantity since 2004. The study region has a geomorphological history that is dominated by the deposition of glacial moraine and the formation of fine-grained till blankets and veneers. Depth-integrated grab samples and automated daily composite water samples from seven study streams compose a total suspended sediment and turbidity data record for the years 2004 through 2014. Despite 11 years of recovery time after the wildfire, four disturbed watersheds show elevated suspended sediment yields and turbidities as compared to two reference watersheds. There are several well-documented driving factors that can determine the magnitude and longevity of post-fire sediment yield responses to wildfire which include: severity and extent of the burn, changes to pre-existing soil characteristics, vegetation recovery and hydroclimatic conditions. We propose that along with these drivers, there may be other dominant factors that govern watershed resilience to sediment production after wildfire disturbance.