November 2011 - Fire Publications - Annotated Bibliography

Alexander, M. E. and M. G. Cruz (2011). **"Interdependencies between flame length and fireline intensity in predicting crown fire initiation and crown scorch height."** International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF11001

This state-of-knowledge review examines some of the underlying assumptions and limitations associated with the inter-relationships among four widely used descriptors of surface fire behaviour and post-fire impacts in wildland fire science and management, namely Byram's fireline intensity, flame length, stem-bark char height and crown scorch height. More specifically, the following topical areas are critically examined based on a comprehensive review of the pertinent literature: (i) estimating fireline intensity from flame length; (ii) substituting flame length for fireline intensity in Van Wagner's crown fire initiation model; (iii) the validity of linkages between the Rothermel surface fire behaviour and Van Wagner's crown scorch height models; (iv) estimating flame height from post-fire observations of stem-bark char height; and (v) estimating fireline intensity from post-fire observations of crown scorch height. There has been an overwhelming tendency within the wildland fire community to regard Byram's flame length–fireline intensity and Van Wagner's crown scorch height–fireline intensity models as universal in nature. However, research has subsequently shown that such linkages among fire behaviour and post-fire impact characteristics are in fact strongly influenced by fuelbed structure, thereby necessitating consideration of fuel complex specific-type models of such relationships.

Beck, P. S. A. and S. J. Goetz (2011). **"Satellite observations of high northern latitude vegetation productivity changes between 1982 and 2008: ecological variability and regional differences."** Environmental Research Letters 6(4): 045501. http://stacks.iop.org/1748-9326/6/i=4/a=045501

To assess ongoing changes in high latitude vegetation productivity we compared spatiotemporal patterns in remotely sensed vegetation productivity in the tundra and boreal zones of North America and Eurasia. We compared the long-term GIMMS (Global Inventory Modeling and Mapping Studies) NDVI (Normalized Difference Vegetation Index) to the more recent and advanced MODIS (Moderate Resolution Imaging Spectroradiometer) NDVI data set, and mapped circumpolar trends in a gross productivity metric derived from the former. We then analyzed how temporal changes in productivity differed along an evergreen–deciduous gradient in boreal Alaska, along a shrub cover gradient in Arctic Alaska, and during succession after fire in boreal North America and northern Eurasia. We find that the earlier reported contrast between trends of increasing tundra and decreasing boreal forest productivity has amplified in recent years, particularly in North America. Decreases in boreal forest productivity are most prominent in areas of denser tree cover and, particularly in Alaska, evergreen forest stands. On the North Slope of Alaska, however, increases in tundra productivity do not appear restricted to areas of higher shrub cover, which suggests enhanced productivity across functional vegetation types. Differences in the recovery of post-disturbance vegetation productivity between North America and Eurasia are described using burn chronosequences, and the potential factors driving regional differences are discussed.

Beverly, J. L., M. D. Flannigan, et al. (2011). **"The association between Northern Hemisphere climate patterns and interannual variability in Canadian wildfire activity."** Canadian Journal of Forest Research 41(11): 2193-2201. http://dx.doi.org/10.1139/x11-131

Wildfire impacts on ecological and socioeconomic systems are regulated, in part, by climate. Association between hemispheric-scale climate patterns and annual wildfire activity can be obscured by local factors that also control the initiation and spread of fires. Vegetation, topography, and fire suppression can be expected to influence conventional measures of annual wildfire activity such as area burned, effectively concealing evidence of broad-scale climate influences. This study investigates alternatives to area-burned statistics for quantifying annual wildfire activity in Canada in relation to Northern Hemisphere climate variability represented by the Atlantic Multidecadal Oscillation (AMO). We depart from conventional approaches by including socioeconomic measures of wildfire activity and by assessing spatially referenced wildfire data over units of observation chosen explicitly to diminish variability caused by factors unrelated to broad-scale climate. Our data-centred approach, combined with linear regression modelling, revealed that the AMO was positively correlated with national time series of very large fires (≥10 000 ha), wildfire-related evacuations, and fire suppression expenditures over the period 1975–2007. The AMO and wildfire activity were most closely coupled during a period of predominantly positive-phase Arctic Oscillation (AO) and Pacific Decadal Oscillation (PDO) between 1989 and 2001. Positive correlation between maximum evacuation wind speed and the AMO suggests that wind may be a causal factor in the AMO–wildfire relationship.

Boelman, N. T., A. V. Rocha, et al. (2011). **"Understanding burn severity sensing in Arctic tundra: exploring vegetation indices, suboptimal assessment timing and the impact of increasing pixel size."** International Journal of Remote Sensing 32(22): 7033-7056. http://dx.doi.org/10.1080/01431161.2011.611187

Little is known about how satellite imagery can be used to describe burn severity in tundra landscapes. The Anaktuvuk River Fire (ARF) in 2007 burned over 1000 km2 of tundra on the North Slope of Alaska, creating a mosaic of small (1 m2) to large (>100 m2) patches that differed in burn severity. The ARF scar provided us with an ideal landscape to determine if a single-date spectral vegetation index can be used once vegetation recovery began and to independently determine how pixel size influences burn severity assessment. We determine and explore the sensitivity of several commonly used vegetation indices to variation in burn severity across the ARF scar and the influence of pixel size on the assessment and classification of tundra burn severity. We conducted field surveys of spectral reflectance at the peak of the first growing season post-fire (extended assessment period) at 18 field sites that ranged from high to low burn severity. In comparing single-date indices, we found that the two-band enhanced vegetation index (EVI2) was highly correlated with normalized burn ratio (NBR) and better distinguished among three burn severity classes than both the NBR and the normalized difference vegetation index (NDVI). We also show clear evidence that shortwave infrared (SWIR) reflectivity does not vary as a function of burn severity. By comparing a Quickbird scene (2.4 m pixels) to simulated 30 and 250 m pixel scenes, we are able to confirm that while the moderate spatial resolution of the Landsat Thematic Mapper (TM) sensor (30 m) is sufficient for mapping tundra burn severity, the coarser resolution of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor (250 m) is not well matched to the fine scale of spatial heterogeneity in the ARF burn scar.

Brown, C. D. and J. F. Johnstone (2012). **"Once burned, twice shy: Repeat fires reduce seed availability and alter substrate constraints on Picea mariana regeneration."** Forest Ecology and Management 266(0): 34-41. http://www.sciencedirect.com/science/article/pii/S0378112711006827

Widespread climate change is expected to lead to altered patterns of disturbance, thereby driving future ecosystem change. This interaction, which is often poorly recognized or understood, may be particularly

important in the sub-arctic due to rapid climate change and frequent fire. Our objective was to investigate how an altered fire return interval can interrupt successional pathways in a serotinous boreal ecosystem. We conducted this research in black spruce (Picea mariana [Mill.] BSP.) forests on the northern margin of the species' distribution in Yukon Territory, Canada. We compared seed availability and seedling establishment of black spruce in stands of varying fire return interval using experimental manipulations within areas varying in their natural fire histories. Recruitment was drastically reduced following two closely timed fires, compared to stands burned under a typical fire return interval. However, recruitment was also limited in mature forest stands. On-site germination experiments demonstrated that black spruce recruitment was limited by seed availability after a short fire return interval, and by substrate quality in unburned stands. The vegetation of the boreal forest is thought to be highly resilient to climatic change, due in part to the adaptations that conifers have for post-fire regeneration. We show that shortened fire return intervals, through effects on seed availability, disrupt the normal sequence of post-fire recovery on seedbeds released by fire for colonisation. The results of this study provide strong empirical evidence that disturbance, although essential for stand renewal, may limit forest recovery or expansion when misaligned with reproductive cycles.

Gralewicz, N. J., T. A. Nelson, et al. (2012). "**Factors influencing national scale wildfire susceptibility in Canada."** Forest Ecology and Management 265(0): 20-29. http://www.sciencedirect.com/science/article/pii/S0378112711006542

Wildfires are expected to increase as a result of climate change. In order to effectively manage and monitor climate-induced changes in Canadian forests, a national-scale understanding of factors influencing wildfire susceptibility is necessary. The goal of this study is to better understand factors influencing large area wildfire susceptibility in Canada. Using year 2000 Canadian land cover data, we identify locations that burned before and after 2000. Pre- and post-fire landscape patterns were assessed and regression tree analyses were used to identify factors influencing national-scale fire susceptibility. Land cover composition, forest pattern, elevation, and anthropogenic influences were quantified for both pre- and post-fire environments. We examined recovery of forest pattern following wildfire events and derived a large-area fire susceptibility model using decision tree classification. Our results indicate that 11.88% of forested ecozones were impacted by large fires. The majority of large wildfires occur in coniferous forests characterized by high forest cover (greater than 45%), few forest patches, large mean forest patch area, and fragmentation-limited forest. Forests occurring at low to intermediate distances from populated places (50–150 km) and roads (12–72 km) experienced unexpectedly high amounts of fire, as did lower elevation forests. After fire, percentage forest cover, number of forest patches, forest patch size, and proportion forest patches regenerated to pre-fire forest pattern conditions within approximately 20 years. Anthropogenic influences on wildfire susceptibility indicate that human activity still dictates national fire regimes. Additionally, knowledge of space–time patterns of fire-landscape interaction and landscape pattern regeneration provides useful baselines for future comparisons with responses to climate change.

Iwata, H., M. Ueyama, et al. (2011). **"Quick Recovery of Carbon Exchanges in a Burned Black Spruce Forest in Interior Alaska."** Sola 7: 105-108. http://www.jstage.jst.go.jp/article/sola/7/0/7_105/_article

Observations of carbon dioxide (CO2) flux with the eddy covariance technique were conducted at a burned boreal forest site five years after a wildfire and at a mature forest site in Interior Alaska to investigate the effects of wildfire on CO2 exchange in a boreal forest. Both gross primary productivity and ecosystem respiration were lower at the burned site. The lower amount of vegetation explains the lower gross primary productivity and ecosystem respiration at the burned site. The reduced soil organic layer at the burned site further explains the lower respiration. On an annual basis, the five-year-old burned site was a CO2 sink, which indicated earlier recovery of CO2 exchange compared to other burned boreal forests in North America

reported in the literature. The quick recovery of net CO2 exchange is associated with constrained heterotrophic respiration, rather than recovery of vegetation. Burn severity can be a key variable in determining CO2 exchange during the early stage of succession after wildfire.

Kalamees, R., K. Püssa, et al. (2012). **"Adaptation to boreal forest wildfire in herbs: Responses to post-fire environmental cues in two Pulsatilla species."** Acta Oecologica 38(0): 1-7. http://www.sciencedirect.com/science/article/pii/S1146609X11001147

Although boreal forests are biomes which are characterized by periodical forest wildfires, very little is known about adaptations to fire in forest herbs. We investigated whether a putatively fire-dependent herbaceous species – Pulsatilla patens – demonstrated adaptive responses to environmental cues that reflect differences in pre-fire and post-fire environments (the presence of ericoid litter and charcoal, and light levels). For comparison, we included in the experiment a close congeneric species that is less bound to forest ecosystems (Pulsatilla pratensis) and a morphologically similar mesic grassland species from the same family (Ranunculus polyanthemos), as examples of species for which adaptations to fire should be of lower value, or of no value at all, respectively. The addition of ericoid litter to the soil generally enhanced plant growth, suggesting that its negative effect on plant germination and growth is not as widespread as previously thought. In both Pulsatilla species charcoal without forest litter retarded plant growth, but in combination with ericoid litter the negative effect disappeared or was even replaced by a slightly positive effect. Such an interactive effect was absent in the grassland species R. polyanthemos. The response of Pulsatilla species to different post-fire signals may be explained by adaptive down-regulation of growth after high-intensity fire – small plant size can be advantageous in sparse and well illuminated field-layer vegetation – and intense growth in the more competitive situation following weak fire. An additional experiment demonstrated that the effects of fire-related treatments were not mediated by differential AM infection.

Kasischke, E. S. and E. E. Hoy (2011). **"Controls on carbon consumption during Alaskan wildland fires."** Global Change Biology: n/a-n/a. http://dx.doi.org/10.1111/j.1365-2486.2011.02573.x

A method was developed to estimate carbon consumed during wildland fires in interior Alaska based on medium-spatial scale data (60 m cell size) generated on a daily basis. Carbon consumption estimates were developed for 41 fire events in the large fire year of 2004 and 34 fire events from the small fire years of 2006 to 2008. Total carbon consumed during the large fire year (2.72 x 106 ha burned) was 64.7 Tg C, and the average carbon consumption during the small fire years (0.09 x 106 ha burned) was 1.3 Tg C. Uncertainties for the annual carbon emissions ranged from 13 to 21%. Carbon consumed from burning of black spruce forests represented 76% of the total during large fire years and 57% during small fire years. This was the result of the widespread distribution of black spruce forests across the landscape and the deep burning of the surface organic layers common to these ecosystems. Average carbon consumed was 3.01 kg m−2 during the large fire year and 1.69 kg m−2 during the small fire years. Most of the carbon consumption was from burning of ground layer fuels (85% in the large fire year and 78% in small fire years). Most of the difference in average carbon consumption between large and small fire years was in the consumption of ground layer fuels (2.60 vs. 1.31 kg m−2 during large and small fire years, respectively). There was great variation in average fuel consumption between individual fire events (0.56 to 5.06 kg m−2) controlled by variations in fuel types and topography, timing of the fires during the fire season, and variations in fuel moisture at the time of burning.

Kitzberger, T., E. Aráoz, et al. "**Decreases in Fire Spread Probability with Forest Age Promotes Alternative Community States, Reduced Resilience to Climate Variability and Large Fire Regime Shifts."** Ecosystems: 1-16. http://dx.doi.org/10.1007/s10021-011-9494-y

The generalization that plant communities increase in flammability as they age and invariably lead to resilient self-organized landscape mosaics is being increasingly challenged. Plant communities often exhibit rapidly saturating or even hump-shaped age-flammability trajectories and landscapes often display strong non-linear behaviors, abrupt shifts, and self-reinforcing alternative community states. This plethora of fire-landscape interactions calls for a more general model that considers alternative age-flammability rules. We simulated landscape dynamics assuming communities that (1) increase in flammability with age and (2) gain flammability up to a certain age followed by a slight and moderate loss to a constant value. Simulations were run under combinations of ignition frequency and interannual climatic variability. Age-increasing fire probability promoted high resilience to changes in ignition frequency and climatic variability whereas humpbacked-shaped age-flammability led to strong non-linear behaviors. Moderate (20%) reductions in mature compared to peak flammability produced the least resilient behaviors. The relatively non-flammable mature forest matrix intersected by young flammable patches is prone to break up and disintegrate with slight increases in ignition/climate variability causing large-scale shifts in the fire regime because large fires were able to sweep through the more continuous young/flammable landscape. Contrary to the dominant perception, fire suppression in landscapes with positive feedbacks may effectively reduce fire occurrence by allowing less flammable later stage communities composed of longer lived, obligate seeders to replace earlier stages of light demanding, often more flammable resprouters. Conversely, increases in anthropogenic ignitions, a common global trend of many forested regions may, in synergism with increased climate variability, induce abrupt shifts, and large-scale forest degradation.

Kochtubajda, B., W. R. Burrows, et al. (2011). **"Exceptional cloud-to-ground lightning during an unusually warm summer in Yukon, Canada."** J. Geophys. Res. 116(D21): D21206. http://dx.doi.org/10.1029/2011JD016080

The 2004 lightning season and related wildfire activity in Yukon, Canada, was exceptional in many aspects. The synoptic environment during the summer was dominated by a persistent upper level ridge over Alaska and Yukon, bringing above-normal temperatures and below-normal precipitation to Yukon. The number of cloud-to-ground (CG) flashes, lightning-initiated forest fires, and extent of the area burned exceeded historic records. Forest fire smoke affected most of Yukon during the summer. Thunderstorms forming in this northern environment in July exhibited unusual lightning characteristics as detected by Canadian Lightning Detection Network. Changes in the frequency of extreme lightning days and in the fraction of nocturnal lightning occurrence were observed. Lightning properties in July differed from climatology in several ways. The central regions of Yukon experienced enhanced positive CG lightning activity. First-stroke positive peak currents were found to be stronger, while negative peak currents were weaker than climatology. Our observations are consistent with the previous findings reported in southerly climates. Although thunderstorms related to the diurnal heating and cooling cycle influenced positive lightning occurrences in Yukon, other possible sources, including pyrocumulonimbus clouds and inverted-polarity thunderstorms, cannot be overlooked. Evidence is presented suggesting that both atmospheric conditions and smoke from the fires may have influenced the electrification process of thunderstorms to enhance +CG production. The extreme summer of 2004 experienced in Yukon may provide a hint of future impacts due to climate change.

Krezek-Hanes, C. C., F. Ahern, et al. (2011). **Trends in large fires in Canada, 1959-2008.** Canadian Biodiversity: Ecosystem Status and Trends 2010. Ottawa, ON: 48. http://www.fire.uni-freiburg.de/inventory/database/Krezek-Hanes-2011-Large-Fires-Canada-1959-2007.pdf

Fire is an important disturbance in the forest ecosystems of Canada. On average, 18,471 km2 of forest burn annually, 92% of which burns within the boreal forest. Due to the long history of fire in the boreal forest, many boreal tree species have evolved to rely on fire to perform important ecological functions including:

nutrient cycling, influencing species composition and age structure, maintaining productivity and diversity of habitats, and regulating insects and disease (Weber and Flannigan, 1997; McCullough et al., 1998; Volney and Hirsch, 2005; Parker et al., 2006; Soja et al., 2007). The boreal forests of Canada are primarily contained within the Taiga Plains, Taiga Shield, Taiga Cordillera, Boreal Plains, Boreal Shield, Newfoundland Boreal, Boreal Cordillera, and Hudson Plains ecozones+. From an ecological standpoint fires can be an essential driver of ecosystem processes in these and other ecozones+.

Lafleur, B., D. Paré, et al. (2011). **"Growth of planted black spruce seedlings following mechanical site preparation in boreal forested peatlands with variable organic layer thickness: 5-year results."** Annals of Forest Science 68(8): 1291-1302. http://dx.doi.org/10.1007/s13595-011-0136-5

Context Following forest harvest, mechanical site preparation (MSP) is commonly used to regenerate harvested sites. In boreal forested peatlands, however, the effectiveness of MSP to regenerate harvested sites is likely to be hampered by thick organic layers. Aim We sought to determine the capability of different MSP techniques to improve growth conditions of planted black spruce seedlings in boreal forested peatlands where closed-crown productive forests could revert to unproductive forested peatlands in the absence of severe soil disturbance. Methods The effects of disc scarification, mounding and patch scarification on soil chemistry and seedling growth were contrasted. Results Seedlings of site-prepared plots were 15% taller than those of untreated ones, irrespective of the MSP technique used, likely owing to the greater abundance of exposed mineral soil and mesic substrates created. Mounding and patch scarification were able to expose mineral soil over a greater proportion (>25% vs. <10%) of the treated area compared with disc scarification and control, whereas the combined surface area of exposed mineral soil and mesic substrates was higher in every MSP treatments relative to the control (>57% vs. 41%, respectively). Individual seedling growth was influenced by substrate type and drainage. Seedlings planted in moderately and well-drained mesic substrates and mineral soil were 25% taller than those planted in poorly drained fibric substrates. Conclusion All three MSP techniques were effective because they succeeded in creating high-quality microsites despite thick organic layers.

Lu, X. and Q. Zhuang (2011). **"Areal changes of land ecosystems in the Alaska Yukon River Basin from 1984 to 2008."** Environmental Research Letters 6: 034012. http://www.eas.purdue.edu/ebdl/pdfs/2011-pub-3.pdf

Multivariate alteration detection (MAD) and Bayesian inference (BI) methods are used to analyze land cover changes with Landsat images for the Alaskan Yukon River Basin from 1984 to 2008. The US Geological Survey National Land Cover Database 2001 (NLCD 2001) is treated as reference information to detect the changes. It is found that the regional land cover change has three general trends with various potential causes during the study period: (1) forests decreased mainly due to wildfire, (2) the closed water bodies were shrinking possibly due to permafrost degradation if water drains well in discontinuous permafrost regions, (3) shrubs had expanded and a large portion of grassland was converted into shrubland likely due to forest fire and warming. The uncertainty of this analysis may mainly arise from image acquisition date differences and illumination angles and remaining cloud contamination to the images. This study provides a method to analyze land cover changes with Landsat data for other
regions. The developed land cover data should help future understanding of permafrost dynamics, biogeochemistry, hydrology and regional climate in the region.

Makoto, K., N. Kamata, et al. (2011). **"Bark-beetle-attacked trees produced more charcoal than unattacked trees during a forest fire on the Kenai Peninsula, Southern Alaska."** Scandinavian Journal of Forest Research: 1-6. http://dx.doi.org/10.1080/02827581.2011.619566

Alaskan boreal forests frequently suffer from outbreaks of bark beetles and fires, factors that appear to combine to alter charcoal production. Charcoal (black carbon) production in forest ecosystems is an important pathway to clarify for a more complete understanding of the effects of fire on carbon cycling in boreal forests. In this study, we aimed to clarify the effects of prevalent outbreaks of the spruce beetle, Dendroctonus rufipennis (Kirby), on charcoal production during forest fires in boreal forests. Snags with prefire damage by the spruce beetle (infested snags) have significantly more charcoal than those undamaged before fire (noninfested snags). This increased amount of charcoal in spruce beetle-damaged trees was probably the result of dried biomass in the canopies of these trees. The results of this study suggest that with changing environmental conditions, the proliferation of insect damage in the boreal forest can modify the effects of fire on carbon sink via a change in the amount of charcoal production.

Meigs, G. W., R. E. Kennedy, et al. (2011). **"A Landsat time series approach to characterize bark beetle and defoliator impacts on tree mortality and surface fuels in conifer forests."** Remote Sensing of Environment 115(12): 3707-3718. http://www.sciencedirect.com/science/article/pii/S0034425711003361

Insects are important forest disturbance agents, and mapping their effects on tree mortality and surface fuels represents a critical research challenge. Although various remote sensing approaches have been developed to monitor insect impacts, most studies have focused on single insect agents or single locations and have not related observed changes to ground-based measurements. This study presents a remote sensing framework to (1) characterize spectral trajectories associated with insect activity of varying duration and severity and (2) relate those trajectories to ground-based measurements of tree mortality and surface fuels in the Cascade Range, Oregon, USA. We leverage a Landsat time series change detection algorithm (LandTrendr), annual forest health aerial detection surveys (ADS), and field measurements to investigate two study landscapes broadly applicable to conifer forests and dominant insect agents of western North America. We distributed 38 plots across multiple forest types (ranging from mesic mixed-conifer to xeric lodgepole pine) and insect agents (defoliator [western spruce budworm] and bark beetle [mountain pine beetle]). Insect effects were evident in the Landsat time series as combinations of both short- and long-duration changes in the Normalized Burn Ratio spectral index. Western spruce budworm trajectories appeared to show a consistent temporal evolution of long-duration spectral decline (loss of vegetation) followed by recovery, whereas mountain pine beetle plots exhibited both short- and long-duration spectral declines and variable recovery rates. Although temporally variable, insect-affected stands generally conformed to four spectral trajectories: short-duration decline then recovery, short- then long-duration decline, long-duration decline, long-duration decline then recovery. When comparing remote sensing data with field measurements of insect impacts, we found that spectral changes were related to cover-based estimates (tree basal area mortality [R2adj = 0.40, F1,34 = 24.76, P < 0.0001] and down coarse woody detritus [R2adj = 0.29, F1,32 = 14.72, P = 0.0006]). In contrast, ADS changes were related to count-based estimates (e.g., ADS mortality from mountain pine beetle positively correlated with ground-based counts [R2adj = 0.37, F1,22 = 14.71, P = 0.0009]). Fine woody detritus and forest floor depth were not well correlated with Landsat- or aerial survey-based change metrics. By characterizing several distinct temporal manifestations of insect activity in conifer forests, this study demonstrates the utility of insect mapping methods that capture a wide range of spectral trajectories. This study also confirms the key role that satellite imagery can play in understanding the interactions among insects, fuels, and wildfire.

Moreno Ruiz, J. A., D. Riaño, et al. (2011). **"Burned area mapping time series in Canada (1984–1999) from NOAA-AVHRR LTDR: A comparison with other remote sensing products and fire perimeters."** Remote Sensing of Environment(0). http://www.sciencedirect.com/science/article/pii/S0034425711003749

A new algorithm for mapping burned areas in boreal forest using AVHRR archival data Long Term Data Record (LTDR) (0.05°, ca. 5 km, version 3) was developed in Canada using burn records for the period between 1984 and 1999 and evaluated against AVHRR 1 km and AVHRR-PAL 8 km burned area map products. The algorithm combined 1) absolute and relative radiometric thresholds, 2) a Bayesian network classifier, and 3) neighborhood analysis for spatial fire coherence. Fire event records from Canadian Forest Service National Fire Database (CFSNFD) for western Canada were used to train the algorithm. LTDR and AVHRR 1 km burned area mapping were similar for the same area, and correlated well to CFSNFD annual fire event records for western Canada, r2 = 0.72 and 0.77, respectively. In addition, the LTDR mapping correlated well with fires for all of Canada in the CFSNFD database (r2 = 0.65). This mapping product was a significant improvement over an 8 km AVHRR-PAL burned area map product. For mapping boreal forests burned areas globally, this study demonstrates the potential accuracy for where LTDR represents the highest spatial and temporal resolution of daily images available since the 1980s.

O'Donnell, J., M. Jorgenson, et al. (2011). **"The Effects of Permafrost Thaw on Soil Hydrologic, Thermal, and Carbon Dynamics in an Alaskan Peatland."** Ecosystems: 1-17. http://dx.doi.org/10.1007/s10021-011-9504-0

Recent warming at high-latitudes has accelerated permafrost thaw in northern peatlands, and thaw can have profound effects on local hydrology and ecosystem carbon balance. To assess the impact of permafrost thaw on soil organic carbon (OC) dynamics, we measured soil hydrologic and thermal dynamics and soil OC stocks across a collapse-scar bog chronosequence in interior Alaska. We observed dramatic changes in the distribution of soil water associated with thawing of ice-rich frozen peat. The impoundment of warm water in collapse-scar bogs initiated talik formation and the lateral expansion of bogs over time. On average, Permafrost Plateaus stored 137 ± 37 kg C m −2 , whereas OC storage in Young Bogs and Old Bogs averaged 84 ± 13 kg C m −2 . Based on our reconstructions, the accumulation of OC in near-surface bog peat continued for nearly 1,000 years following permafrost thaw, at which point accumulation rates slowed. Rapid decomposition of thawed forest peat reduced deep OC stocks by nearly half during the first 100 years following thaw. Using a simple mass-balance model, we show that accumulation rates at the bog surface were not sufficient to balance deep OC losses, resulting in a net loss of OC from the entire peat column. An uncertainty analysis also revealed that the magnitude and timing of soil OC loss from thawed forest peat depends substantially on variation in OC input rates to bog peat and variation in decay constants for shallow and deep OC stocks. These findings suggest that permafrost thaw and the subsequent release of OC from thawed peat will likely reduce the strength of northern permafrost-affected peatlands as a carbon dioxide sink, and consequently, will likely accelerate rates of atmospheric warming.

Ordóñez, C., A. Saavedra, et al. (2012). **"Using model-based geostatistics to predict lightning-caused wildfires."** Environmental Modelling & Software 29(1): 44-50.
http://www.sciencedirect.com/science/article/pii/S1364815211002155

The probability of fire in a particular area depends on a range of environmental and geographic variables. Fire prevention planning can be assisted by the construction of models to identify the variables that have a significant influence on the occurrence of fires and by building maps showing the spatial probability distribution for fires occurring in specific geographic areas. We used generalized spatial linear models to predict spatially distributed probabilities for fire occurrence in locations where storms featuring lightning occurred, on the basis of a set of variables related to climatology, orography, vegetation and lightning characteristics, and to assess the relative importance of these variables. A comparison of this model with simple logistic regression models used by other researchers to resolve similar problems demonstrates the importance of bearing in mind spatial correlation between variables.

Payeur-Poirier, J.-L., C. Coursolle, et al. **"CO2 fluxes of a boreal black spruce chronosequence in eastern North America."** Agricultural and Forest Meteorology(0). http://www.sciencedirect.com/science/article/pii/S0168192311002449

Forest harvest and subsequent stand development can have major effects on the carbon cycle of boreal stands. Carbon dioxide (CO2) fluxes of a three-point black spruce harvest chronosequence located in the boreal forest of eastern North America were measured over a one-year period at the ecosystem scale with the eddy covariance technique and CO2 efflux from soils was measured with a portable infrared gas analyzer. The three sites (pre-harvest, recently harvested, and juvenile) were 105-, 8- and 33-years old, respectively. On an annual basis, the pre-harvest site (EOBS) was a weak carbon sink (6 ± 4 g C m-2 yr−1), the recently harvested site (HBS00) a source (−87 ± 3 g C m−2 yr−1) and the juvenile site (HBS75) a moderate to strong sink (143 ± 35 g C m−2 yr−1). Annual gross ecosystem production (GEP) at the pre-harvest site was only 28% greater than at the recently harvested site (646 ± 6 versus 504 ± 5 g C m−2 yr−1), while GEP at the juvenile site (1107 ± 32 g C m−2 yr−1) was more than double that at the recently harvested site, suggesting significant physiological constraints to photosynthesis at the pre-harvest site. Annual ecosystem respiration (Re) followed the same pattern, but intersite differences were somewhat less (640 ± 8 to 591 ± 6 to 964 ± 50 g C m−2 yr−1). Annual soil respiration (Rs) decreased following harvest from 593 to 500 g C m−2 yr−1 and increased with further stand development to 644 g C m−2 yr−1, although the changes were less than for GEP and Re. Q10 and R10 of Rs for the snow-free period varied between sites, were lowest for the recently harvested site, and appeared to be related to GEP via substrate supply. The annual ratio of Rs to Re was lower for the juvenile site (67%) than for the pre-harvest and recently harvested sites (93 and 85%, respectively). These results quantify how some of the major physiological processes that influence the carbon cycle of boreal black spruce stands evolve following harvest and should be useful for better incorporating stand-age effects into regional and global scale models.

Raaflaub, L. D., C. Valeo, et al. (2011). **"Slope effects on the spatial variations in duff moisture."** Ecohydrology: n/a-n/a. http://dx.doi.org/10.1002/eco.272

Investigations were made on the influence of slope on the spatial variations in duff moisture, the decomposing organic matter of the forest floor. Relationships between duff and soil moisture along hillslopes were identified from field measurements over various moisture conditions. Results indicated that duff moisture is not related to soil moisture, nor is it controlled by a hydraulic gradient. The spatial pattern of duff moisture over a 2 week period was established along two 2 m by 60 m hillslope transects that were sampled every 3 m. Because of interception, tree proximity was found to be the primary factor that significantly influenced the spatial variation in duff moisture. As the duff dried, the influence of tree proximity decreased. The distance from the top of the hillslope was not found to be an important factor in duff moisture variability. The spatial variation in duff moisture is more prominent during periods of wetness because of the exponential nature of the duff drying curve.

Ray, L. (2011). **"Using Q-methodology to identify local perspectives on wildfires in two Koyukon Athabascan communities in rural Alaska."** Sustainability: Science, Practice, & Policy 7(2): 18-29. http://sspp.proquest.com/archives/vol7iss2/1011-061.ray.html

Sustainable resource management depends upon the participation of resource-dependent communities. Competing values between community members and government agencies and among groups within a community can make it difficult to find mutually acceptable management goals and can disadvantage certain resource users. This study uses Q-methodology to discover groups with shared perspectives on wildfire policy in the Koyukon Athabascan villages of Galena and Huslia, Alaska. Before the study, participants

appeared to disagree over the amount of wildfire suppression needed, but Q-method results showed three perspectives united around deeper, less oppositional concerns: Caucasian residents and resource managers who preferred natural processes; older Koyukon residents concerned about losing local control, small animals, and cultural places; and younger Koyukon residents who felt subsistence activities were resilient to social-ecological change. Additionally, both Koyukon groups suspected it was cheaper to suppress all wildfires while small. These results imply that community frustration with wildfire management may be reduced through collaborative research with Koyukon elders on locally important issues, cultural site mapping in order to extend some level of wildfire protection, and greater agency transparency about wildfire-suppression costs. The results also indicate that age may be an understudied driver of community resource-use preferences. This study proposes that without identifying resource user-interest groups and their main concerns, it is difficult to develop equitable environmental goals. It shows how Q-methodology provides a systematic approach for identifying the stakeholders and issues needed in resource management.

Reich, P. B., L. E. Frelich, et al. (2011). **"Understorey diversity in southern boreal forests is regulated by productivity and its indirect impacts on resource availability and heterogeneity."** Journal of Ecology: no-no. http://dx.doi.org/10.1111/j.1365-2745.2011.01922.x

1. Understanding the relationship between species diversity and productivity is central to linking compositional and functional aspects of terrestrial ecosystems, and little is known about such issues in boreal forests. We used structural equation modelling (SEM) to test several hypotheses about direct and indirect influences of productivity, its correlate basal area, and resources on understorey vascular plant diversity on 2025 plots in 81 southern boreal forests in Minnesota, USA. 2. We first examined the hypothesis that increasing basal area reduces plot-scale species richness due to competitive exclusion from the most limiting resource, light. As expected, light pre-emption increased with total basal area, which directly reduced understorey species richness. However, complex relations between basal area, dominant understorey species, and resource supply to the understorey can also influence understorey communities. Hence, we addressed whether plots with low light availability in the understorey were associated with low abundance of dominant understorey species and alleviation of competitive exclusion of other understorey species. SEM results showed that low light decreased total understorey cover, alleviating resource competition from this stratum and thus increasing understorey species richness. Furthermore, the cover of four dominant understorey species was positively correlated with light availability and negatively correlated with plot-scale species richness. 3. Aggregating data for the 25 plots at each stand, SEM showed that stand-scale species richness was positively influenced by light heterogeneity, which in turn increased with annual above-ground productivity. 4. Species richness was positively influenced by litter %N, considered an index of nitrogen availability at the plot and stand scale. 5. Synthesis. These results suggest that understorey species richness in boreal forests is regulated by productivity, but is primarily mediated by the indirect effects of productivity of the dominant producers on resource availability and heterogeneity.

Rykhus, R. and Z. Lu (2011). **"Monitoring a boreal wildfire using multi-temporal Radarsat-1 intensity and coherence images."** Geomatics, Natural Hazards and Risk 2(1): 15 - 32. http://www.informaworld.com/10.1080/19475705.2010.532971

Twenty-five C-band Radarsat-1 synthetic aperture radar (SAR) images acquired from the summer of 2002 to the summer of 2005 are used to map a 2003 boreal wildfire (B346) in the Yukon Flats National Wildlife Refuge, Alaska under conditions of near-persistent cloud cover. Our analysis is primarily based on the 15 SAR scenes acquired during arctic growing seasons. The Radarsat-1 intensity data are used to map the onset and progression of the fire, and interferometric coherence images are used to qualify burn severity and monitor post-fire recovery. We base our analysis of the fire on three test sites, two from within the fire and one

unburned site. The B346 fire increased backscattered intensity values for the two burn study sites by approximately 5–6 dB and substantially reduced coherence from background levels of approximately 0.8 in unburned background forested areas to approximately 0.2 in the burned area. Using ancillary vegetation information from the National Land Cover Database (NLCD) and information on burn severity from Normalized Burn Ratio (NBR) data, we conclude that burn site 2 was more severely burned than burn site 1 and that C-band interferometric coherence data are useful for mapping landscape changes due to fire. Differences in burn severity and topography are determined to be the likely reasons for the observed differences in post-fire intensity and coherence trends between burn sites.

Turetsky, M. R., W. F. Donahue, et al. (2011). **"Experimental drying intensifies burning and carbon losses in a northern peatland."** Nat Commun 2: 514. http://dx.doi.org/10.1038/ncomms1523

For millennia, peatlands have served as an important sink for atmospheric CO2 and today represent a large soil carbon reservoir. While recent land use and wildfires have reduced carbon sequestration in tropical peatlands, the influence of disturbance on boreal peatlands is uncertain, yet it is important for predicting the fate of northern high-latitude carbon reserves. Here we quantify rates of organic matter storage and combustion losses in a boreal peatland subjected to long-term experimental drainage, a portion of which subsequently burned during a wildfire. We show that drainage doubled rates of organic matter accumulation in the soils of unburned plots. However, drainage also increased carbon losses during wildfire ninefold to 16.8±0.2 kg C m−2, equivalent to a loss of more than 450 years of peat accumulation. Interactions between peatland drainage and fire are likely to cause long-term carbon emissions to far exceed rates of carbon uptake, diminishing the northern peatland carbon sink.

Waddington, J. M., D. K. Thompson, et al. (2011). "**Examining the utility of the Canadian Forest Fire Weather Index System in boreal peatlands."** Canadian Journal of Forest Research: 47-58. http://www.nrcresearchpress.com/doi/abs/10.1139/x11-162

The Duff Moisture Code (DMC) and Drought Code (DC) components of the Canadian Forest Fire Weather Index (FWI) System are used by fire managers to assess the vulnerability of organic soils to ignition and depth of burn despite being developed for upland soils. Given the need to assess wildfire risk in peatlands, we compared the DMC and DC in eight peatlands located in five regions in boreal Canada with water table position (WT) and surface volumetric moisture content (VMC). The slope of the change in WT and DC relationship ranged greatly (–0.01 to –0.11 cm) between sites and years likely due to differences in site-specific peat properties, catchment water supply, and presence of seasonal ice. A DC of 400, which has been associated with wildfire vulnerability in uplands, corresponded to a seasonal drop in WT in the range of 4–36 cm. The slopes of the relationships between DMC and DC with 5 and 15 cm VMC also varied greatly between sites. Our findings suggest that these FWI components are suitable for predicting the general moisture status and fire danger in boreal peatlands. However, there is a need for a modified DC for specific peat types to indicate when the WT has reached a critical depth upon which fire danger increases. We also present a suggested framework for the development of a new peat moisture code within the FWI.

Werth, P. A., B. E. Potter, et al. (2011). **Synthesis of knowledge of extreme fire behavior: volume I for fire managers**. Portland, OR: 144. http://www.nwccweb.us/content/products/fwx/pnw_gtr854.pdf

The National Wildfire Coordinating Group definition of extreme fire behavior (EFB) indicates a level of fire behavior characteristics that ordinarily precludes methods of direct control action. One or more of the following is usually involved: high rate of spread, prolific crowning/spotting, presence of fire whirls, and strong

convection column. Predictability is difficult because such fires often exercise some degree of influence on their environment and behave erratically, sometimes dangerously. Alternate terms include “blow up” and “fire storm.”

Fire managers examining fires over the last 100 years have come to understand many of the factors necessary for EFB development. This work produced guidelines included in current firefighter training, which presents the current methods of predicting EFB by using the crown fire model, which is based on the environmental influences of weather, fuels, and topography.

Current training does not include the full extent of scientific understanding. Material in current training programs is also not the most recent scientific knowledge. National Fire Plan funds have sponsored newer research related to wind profiles’ influence on fire behavior, plume growth, crown fires, fire dynamics in live fuels, and conditions associated with vortex development. Of significant concern is that characteristic features of EFB depend on conditions undetectable on the ground, relying fundamentally on invisible properties such as wind shear or atmospheric stability.

Obviously no one completely understands all the factors contributing to EFB because of gaps in our knowledge. These gaps, as well as the limitations as to when various models or indices apply should be noted to avoid application where they are not appropriate or warranted. This synthesis will serve as a summary of existing extreme fire behavior knowledge for use by fire managers, firefighters, and fire researchers.

The objective of this project is to synthesize existing EFB knowledge in a way that connects the weather, fuel, and topographic factors that contribute to development of EFB. This synthesis will focus on the state of the science, but will also consider how that science is currently presented to the fire management community, including incident commanders, fire behavior analysts, incident meteorologists, National Weather Service office forecasters, and firefighters. It will seek to clearly delineate the known, the unknown, and areas of research with the greatest potential impact on firefighter protection.

Williams, A. P., X. Chonggang, et al. (2011). **"Who is the new sheriff in town regulating boreal forest growth?"** Environmental Research Letters 6(4): 041004. http://stacks.iop.org/1748-9326/6/i=4/a=041004

Climate change appears to be altering boreal forests. One recently observed symptom of these changes has been an apparent weakening of the positive relationship between high-latitude boreal tree growth and temperature at some sites (D'Arrigo et al 2008). This phenomenon is referred to as the 'divergence problem' or 'divergence effect' and is thought to reflect a non-linear relationship between temperature and tree growth, where recent warming has allowed other factors besides growing-season temperature to emerge as dominant regulators of annual growth rates.

Wolken, J. M., T. N. Hollingsworth, et al. (2011). **"Evidence and implications of recent and projected climate change in Alaska's forest ecosystems."** Ecosphere 2(11): art124. http://dx.doi.org/10.1890/ES11-00288.1

The structure and function of Alaska's forests have changed significantly in response to a changing climate, including alterations in species composition and climate feedbacks (e.g., carbon, radiation budgets) that have important regional societal consequences and human feedbacks to forest ecosystems. In this paper we present the first comprehensive synthesis of climate-change impacts on all forested ecosystems of Alaska, highlighting changes in the most critical biophysical factors of each region. We developed a conceptual framework describing climate drivers, biophysical factors and types of change to illustrate how the biophysical and social subsystems of Alaskan forests interact and respond directly and indirectly to a changing climate. We

then identify the regional and global implications to the climate system and associated socio-economic impacts, as presented in the current literature. Projections of temperature and precipitation suggest wildfire will continue to be the dominant biophysical factor in the Interior-boreal forest, leading to shifts from conifer- to deciduous-dominated forests. Based on existing research, projected increases in temperature in the Southcentral- and Kenai-boreal forests will likely increase the frequency and severity of insect outbreaks and associated wildfires, and increase the probability of establishment by invasive plant species. In the Coastal-temperate forest region snow and ice is regarded as the dominant biophysical factor. With continued warming, hydrologic changes related to more rapidly melting glaciers and rising elevation of the winter snowline will alter discharge in many rivers, which will have important consequences for terrestrial and marine ecosystem productivity. These climate-related changes will affect plant species distribution and wildlife habitat, which have regional societal consequences, and trace-gas emissions and radiation budgets, which are globally important. Our conceptual framework facilitates assessment of current and future consequences of a changing climate, emphasizes regional differences in biophysical factors, and points to linkages that may exist but that currently lack supporting research. The framework also serves as a visual tool for resource managers and policy makers to develop regional and global management strategies and to inform policies related to climate mitigation and adaptation.