Future of Alberta's Forests:

Impacts of Climate and Landscape Change On Forest Resources

2011-2012 Summary Work Plan

Prepared and Submitted by:

Foothills Research Institute

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Future Forest Conditions – Base Models for Research Teams

Research Team:

Dr. Nicholas Coops	Integrated Remote Sensing Studio Department of Forest Resources Management, University of British Columbia
Dr. Michael Wulder	Canadian Forest Service, Pacific Forestry Centre Natural Resources Canada, Victoria, BC
Dr. Trisalyn Nelson	Spatial Pattern Analysis and Research (SPAR) Lab Department of Geography, University of Victoria

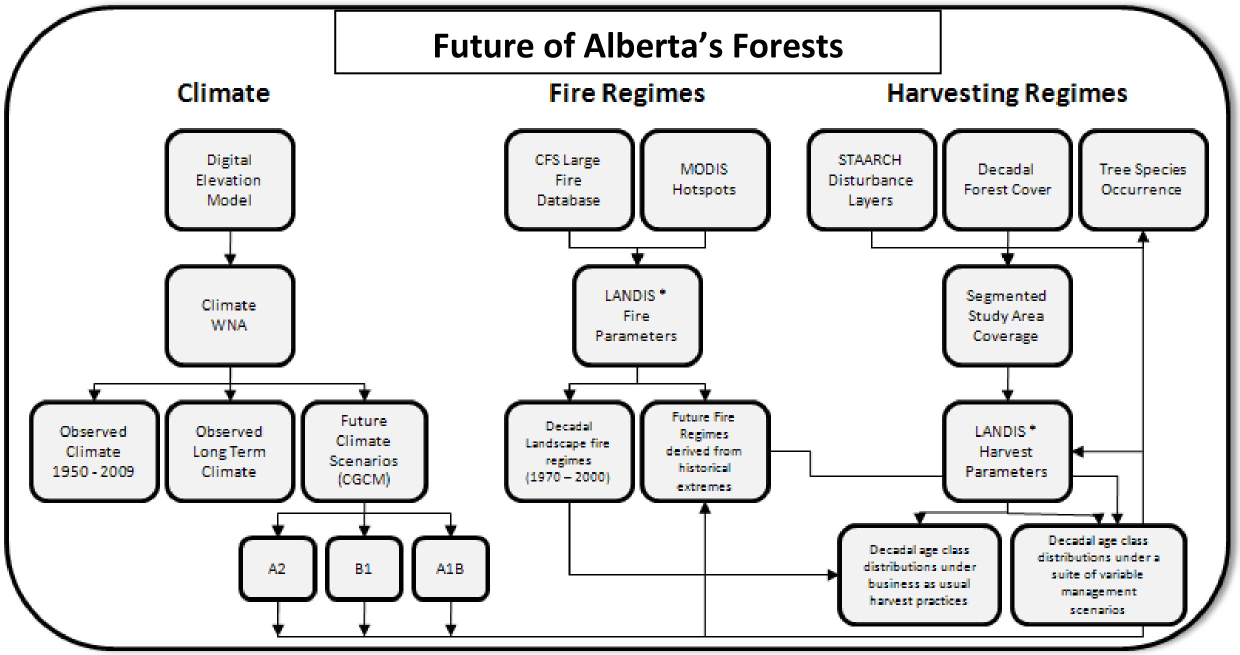
Introduction:

The Foothills Research Institute (FRI), through existing research initiatives will integrate results generated from an FRI research team focusing on future forest conditions, with current and new research data from three individual research programs. This integration will enable all three program research teams to utilize a common data set, with the same assumptions and methodological approaches, and then apply these base data sets with research data that directly link to water impacts, plant phenology for grizzly bear habitat supply, and mountain pine beetle predictions.

Long-term management of Alberta's forests and resources requires an understanding of potential future landscape conditions. There are many forest resources that will be affected by future conditions including but not limited to, water, vegetation and forest health parameters. Within the foothills region of Alberta a number of critical drivers exist which have the potential to have profound impacts on the future landscape condition and the forest resources of the region.

Capturing disturbance for ongoing characterization of the landscape is necessary as disturbances impact forest resources in both positive and negative manners. By mapping landscape disturbance we will gain insights on what changes, by type and location, are occurring over the study area and how forest resources are impacted by change. Characterization of habitat recovery post-disturbance is also important for this long-term monitoring and modeling program. These drivers of change include climate, modified fire regimes, and anthropogenic changes such as variable harvesting regimes, and exploration activities for oil and gas. The development of comprehensive management and conservation strategies therefore requires explicit modelling of these drivers, including various levels of spatial data integration to produce meaningful data layers from disturbance, phenology, and climate scenarios inputs. When combined these layers will enable the development of a range of scenarios each producing a future landscape from which three focal forest resources (water, plant phenology, and mountain pine beetle) will be evaluated.

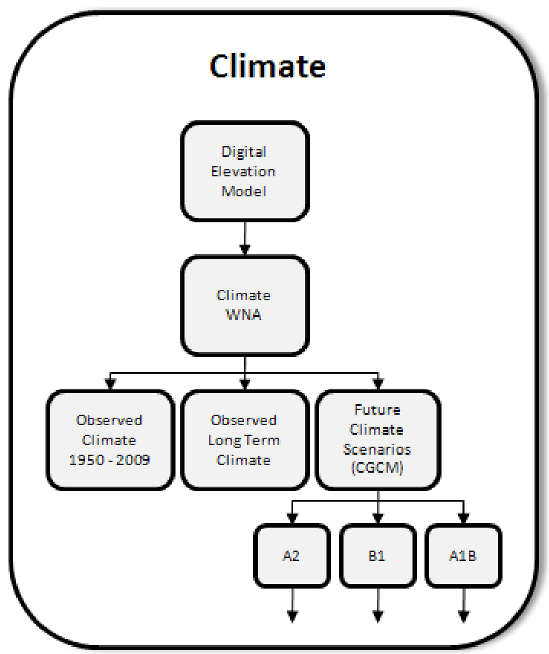
Our broad approach to modelling future landscape conditions is shown in the figure below and demonstrates the three main themes: climate, fire and harvesting.



Each of the themes will be described in detail below.

Climate:

Mean monthly climate spatial surfaces will be generated using ClimateWNA, which downscales precipitation and temperature data generated at 2 - 4 km by PRISM (Parameter-elevation Regressions on Independent Slopes Model, Daly et al. 2002) to 1 km. The downscaling is achieved through a combination of bilinear interpolation and elevation adjustment (see Wang et al. 2006).
To provide the required elevation data for ClimateWNA at 1 km a 90m Digital Elevation Model (DEM) will be resampled from the Shuttle Radar Topography Mission (SRTM). Mean monthly atmospheric vapor pressure deficits (VPD) for daylight periods will be estimated by assuming that the water vapor concentration throughout the day was equivalent to that held at saturation for the average monthly minimum temperature (Kimball et al. 1997).



The number of days per month with subfreezing temperatures (less than -2°C) was estimated from empirical equations with mean minimum temperature (Coops et al. 1998). Monthly climate data can be generated from past climate records from 1950 – 2009. Monthly estimates of total incoming short-wave radiation will be calculated following a modeling approach detailed by Coops et al. (2000) that first calculates the potential radiation at the top of the atmosphere then adjusts for slope, aspect, and elevation (Garnier & Ohmura 1968; Swift 1976), and finally for variation in water vapor and the effects of clouds on the fraction of diffuse to direct beam incoming radiation (Running et al. 1987) based on a previously published relationship with the difference between mean daily maximum and minimum temperatures and latitude (Coops et al. (2000)). The latter conversion takes advantage of a correlation between monthly mean temperature extremes and the transmissivity of the atmosphere (Bristow & Campbell 1984). The modeling approach, when compared with direct measurements, predicted both the direct and diffuse components of mean monthly incoming radiation with 93 - 99% accuracy on flat surfaces, and on sloping terrain accounted for >87% of the observed variation with a mean error less than 2 MJ m^{-2} day^{-1} (Coops et al. 2000).

To simulate conditions under a future projected climate, we will utilize the Special Report on Emission Scenarios (SRES) climate scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, AR4 (Nakicenovik and Swart 2000; IPCC 2007). Three climate scenarios will be produced: "a business as usual" scenario (A2), a scenario (B1) that assumes current emissions rates will remain steady until around 2040, and then slowly drop to about half of the current rate by the end of the century and a third in between scenario (A1B). Climate scenarios will be extracted from the Canadian Climate Centre's Modelling and Analysis (CCCma) third generation general circulation model (CGCM3), which includes improvements in the treatment of clouds, solar radiation, and land surface processes along with a simple ocean mixed-layer model with a thermodynamic sea ice component (McFarlane et al. 2005; Scinocca et al. 2008).

Monthly climate layers will be produced for three standard 30-year periods, the 2020`s (2011-2040), 2050`s (2041 – 2070) and the 2080`s (2071 – 2100).

Proposed Climate Data Characteristics	
Spatial Resolution	1 x 1 km
Geographic Region	Alberta
Software	Climate WNA (Wang et al 2009)
Time interval	Monthly
Date Range	1950 – 2009, 2020, 2050 and 2080
Climate Change Simulations	Assessment Report AR4
Circulation Model	Canadian Climate Centre's Modelling and Analysis (CCCma) 3rd generation GCM (CGCM3)
Climate Data Generated	Maximum Temperature (°C)
	Minimum Temperature (°C)
	Precipitation (mm)
Derived Climate Data	Vapour Pressure Deficit (Hpa)
	Total Incoming Radiation (MJ m^2 Day)
	Number of Frost Days (days)
Data Format	ARCINFO ESRI GRID FORMAT
	Export Float Format

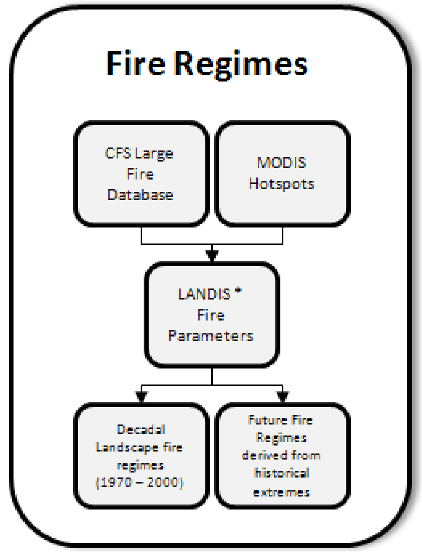
In order to obtain information on changes in forest species growth, and future species distribution we will apply the 3-PG simply physiological model (Landsberg and Waring 1997) which contains a number of simplifying assumptions that have emerged from studies conducted over a wide range of forests types and include the use of monthly climate data (rather than daily or annual) with little loss in the accuracy of model predictions. Each month, the most limiting climatic variable on photosynthesis is selected, based on departure from conditions that are defined as optimum (expressed as unity) or completely limited (expressed as zero) for a particular species or genotype. The ratio of actual/potential photosynthesis decreases in proportion to the reduction in the most limiting environmental factor. The fraction of production not allocated to roots is partitioned among foliage, stem and branches based on allometric relationships and knowledge of annual leaf turnover (Landsberg et al. 2003).

To date we have already predicted the distribution of lodgepole pine (Pinus contorta Dougl.) the major species in the region under current and future climate and addressed the question, how much might the current range of the species shift under a changing climate? To do so we first assessed the extent that suboptimal temperature, frost, drought, and humidity deficits affect photosynthesis and growth of the species across the Pacific Northwest with the 3PG process-based model. We then entered the same set of climatic variables into a decision- tree model, which creates a suite of rules that differentially rank the variables, to provide a basis for predicting presence or absence of the species under current climatic conditions. The derived decision-tree model successfully predicted weighted presence and absence recorded on field survey plots with an accuracy of ~70%. The analysis indicated that sites with significant spring frost, summer temperatures averaging <15^{o}C and soils that fully recharged from snowmelt were most likely to support lodgepole pine. Based on these criteria, we projected climatic conditions through the 21st century as they might develop without additional efforts to reduce carbon emissions using the Canadian Climate Centre model. In the 30-year period centered around 2020, the area suitable for lodgepole pine in the Pacific Northwest was projected to be reduced only slightly (8%). Thereafter, however, the projected climatic conditions appear to progressively favour other species, so that by the last 30 years of 21st century, lodgepole pine could be nearly absent from much of its current range.

Within this program we will continue this work. First based on discussions with the broader research team we will further the approach by modelling other key species in the area. This can only be done if field plot data of presence / absence of different species are provided to the research team within year 1. Secondly once developed we will run the species models annually using the data generated above for the period between 1976 and 2006, across the region. Using an approach described in Coops and Waring (2011) we will then establish which tree species are deemed resilient to recent changes in climate (assuming < 50% of years were designed as climatically inside the previously defined limits) and those species that are more vulnerable. Additional planning and discussion is required to determine if other species distribution maps need to be generated based on the future climate scenarios.

Fire:

In order to capture past and future landscape patterns due to fire and harvesting disturbance regimes we will use the LANDIS modelling framework (Mladenoff and He, 1999, Mladenoff et al., 1996). LANDIS is a landscape scale model which works across a range of spatial and temporal scales. Regions can be defined within the study area which have varying responses to a range of disturbances such as fire, harvesting, and wind as well as forest dynamics such as succession. LANDIS can be parameterised for a range of both overstory and understory species, and has a capacity to incorporate future climate with respect to fire fuel development and changes in future forest growth patterns. LANDIS is a spatially explicit, stochastic, raster-based model which each spatial cell is tracked with respect to presence / absence of species cohorts as well as fire and fuel characteristics.



The model has been applied to a large number of ecosystems around the world, and has active team of developers who are adding and refining modules based on individual model applications. The LANDIS fire module was developed by He and Mladenoff (1999) and predicts the mean fire return interval as a probabilistic function based on land cover, the number of years since a previous fire, and the fire return interval of the landscape. Fire size is defined by integrating random factors with the mean fire size and information on the smallest, mean and largest fire size expected. As a result fire disturbances are stochastic with smaller fires more likely to occur than larger ones as is typically observed. The severity of fire is based on fuel accumulation and time since previous fire as well as species fire resilience.

Our approach to using the LANDIS fire modules will be as follows:

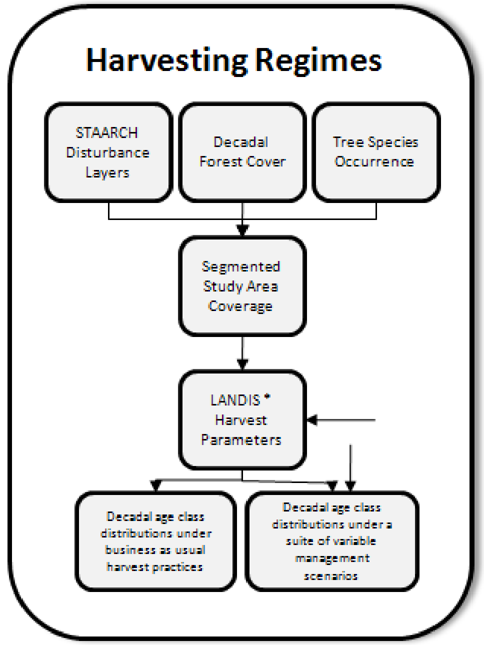
In order to parameterize the fire module within LANDIS we will utilise data from the August 20, 2008 release of the Canadian National Fire Database (NFDB). Locations of fire will be selected within increasing buffers centred over the study area and for each buffer distance fire events will be separated into three decades: 1977-1986; 1987-1996; and 1997-2006. The maximum, minimum, and mean fire size will then be calculated for each decade and the average decadal fire density determined by dividing the number of points within each decadal category by the total area. Fire returns frequency within the study area will be determined from the literature.

Once the predicted fire patterns match those patterns observed in the NFDB and by the MODIS hot spot datasets we will predict the future role of fire on the study area by developing a set of fire scenarios. A base level set of scenarios will be developed as part of this project including representing fire regimes over the 30 years, as well as an increasing and a decreasing scenario based on historical high and low patterns of fire in the region. Fire frequency will also vary based on future forest state, with available forest fuel also strongly linked to stand age. It is anticipated that an additional project may be needed in order that the basic fire module, once correctly calibrated, be linked to the climate change scenarios, where forest fuel will vary based on changes in temperature and precipitation regimes. This additional component of the project is under discussion by the research team..

Based on the species modelling described above under the climate theme, layers of tree species vulnerability and stress will also be, where possible, used in the LANDIS fire scenarios. For example, locations (spatially and temporally) where tree species are stressed will provide additional forest fuel through increased litter fall.

Proposed LANDIS Fire Output	
Spatial Resolution	250 x 250 m
Geographic Region	Defined Study area
Software	LANDIS-II
Time interval	Decade
Date Range	2000 – 2100
Output Variables	Fire pattern and severity under 3 scenarios
Data Format	ARCINFO ESRI GRID FORMAT
	Export Float Format

Harvesting:



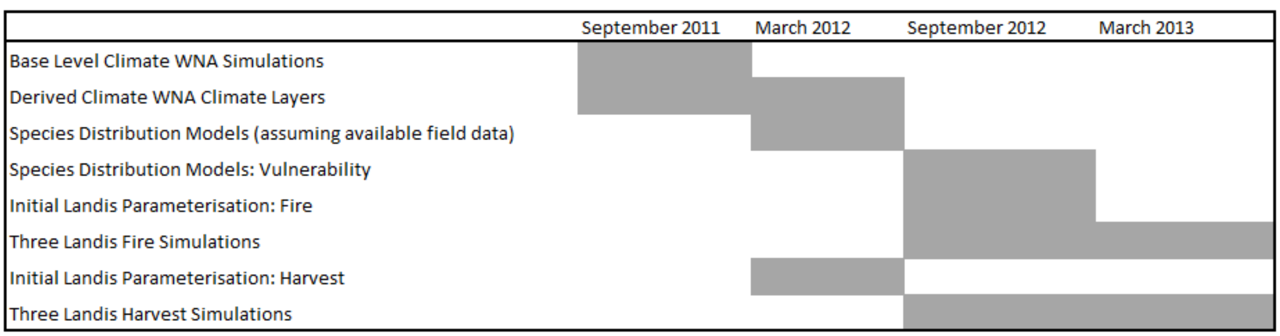
Habitat structure and the distribution of wildlife species, such as grizzly bears, can be strongly influenced by the spatial and temporal distribution of vegetation structure and by vegetation phenology. To date we have developed a new approach to predict landscape disturbances post 2000 using a fusion of high spatial resolution Landsat imagery with high temporal resolution imagery such as Moderate Resolution Imaging Spectroradiometer (MODIS). The algorithm, Spatial Temporal Adaptive Algortihm for mapping Reflectance Change (STAARCH) (Hilker *et al*. 2009), was developed as an extended version of STARFM to allow the detection of disturbance events at spatial scales smaller than that of a MODIS pixel, through the generation of a spatial change mask derived from Landsat and an image sequence recording the temporal evolution of disturbance events (based on MODIS). STAARCH was then applied over the entire grizzly bear study area (6 million ha) by Gaulton et al (2011) from 2001 to 2008 who found the majority of individual disturbance events were small in terms of area (mean patch size of 3.84 ha, standard deviation of 7.2 ha) with the most covering between 1 and 5 ha. A smaller number of larger disturbance events also occurred such as fire, with the largest covering an area of 1028 ha over the 8 year period.

The pattern of disturbances generated by STAARCH will be combined with decadal Landsat coverage since 1975 to produce an overall stand age map which will provide exceptionally detailed age information for stands less than 10 years old, decadal age estimates for stands between 10 and 40 and broad 30 – 50 year classes for stands older than 40 years. The generated STAARCH layers will also be used to map the spatial structure of the landscape using a segmentation approach which uses image homogeneity to map forest compartment size regions with which to base future landscape patterns. These polygons therefore provide the spatial basis for the future base harvesting units.

Once the forest age structure of the region and the compartment size map has been produced, the LANDIS harvesting module uses a range of parameters such as connectivity, age, species and the amount of wood extracted to simulate harvesting patterns over the region. As with the fire module we will vary the amount of wood extracted from the land base, based on future harvesting scenarios provided by the Province. It is anticipated that three harvesting scenarios will be provided as part of this project. Once confidence in the basic harvesting module has been obtained, and assuming additional funding, we will utilise more advanced harvesting modules which incorporate the impact of climate change by varying forest growth rates on a species by species basis depending on climate sensitivity, as well as incorporating information on forest stress (generated above) which can be linked to insect susceptibility.

Proposed LANDIS Harvest Output	
Spatial Resolution	250 x 250 m
Geographic Region	Study area
Software	LANDIS-II
Time interval	Decade
Date Range	2000 – 2100
Output Variables	Harvesting pattern and forest stand recovery under various scenarios
Data Format	ARCINFO ESRI GRID FORMAT
	Export Float Format

Timeline:



Deliverables (assuming April 1st 2011 start date):

Climate Data Deliverables. September 1st 2011	
Spatial Resolution	1 x 1 km
Geographic Region	Alberta
Software	Climate WNA (Wang et al 2009)
Time interval	Monthly
Date Range	1950 – 2009, 2020, 2050 and 2080 (60 + 3 years * 12 months = 756 layers per attribute
Climate Change Simulations	Assessment Report AR4
Circulation Model	Canadian Climate Centre's Modelling and Analysis (CCCma) 3rd generation GCM (CGCM3)
Climate Data Generated	Maximum Temperature (°C)
	Minimum Temperature (°C)
	Precipitation (mm)

Deliverables (assuming April 1st 2011 start date):

Climate Data Deliverables 2. March 1st 2012	
Spatial Resolution	1 x 1 km
Geographic Region	Alberta
Time interval	Monthly
Date Range	1950 – 2009, 2020, 2050 and 2080
	(60 + 3 years * 12 months = 756 layers per attribute except solar radiation which will be computed per decade rather than annually
Derived Climate Data	Vapour Pressure Deficit (Hpa)
	Total Incoming Radiation (MJ m^2 Day)
	Number of Frost Days (days)

Species Distribution Modelling. March 1st 2012	
Spatial Resolution	1 x 1 km
Geographic Region	Alberta (or within field plot range)
Date Range	Long Term distribution model based on long term climate using hybrid approach of Coops and Waring (2011)
Species:	Dependent on availability of presence / absence data provided by FMF. Maximum number of species models = 15.

Deliverables (assuming April 1st 2011 start date):

Species Distribution Vulnerability Modelling. September 1st 2012	
Spatial Resolution	1 x 1 km
Geographic Region	Alberta (or within field plot range)
Date Range	Annual distribution using developed models based on annual climate data using hybrid approach of Coops and Waring (2011)
Species:	Dependent on availability of presence / absence data provided by FMF. Maximum number of species models = 15.

LANDIS Fire Deliverables. Initial Output - 1st September 2012	
Spatial Resolution	250 x 250 m
Geographic Region	Study area
Software	LANDIS-II
Time interval	1980 – 2010
Simulation:	Long term fire pattern scenario based on calibration data from fire data base and MODIS.
Output Variables	Fire pattern and severity under scenario

LANDIS Harvest Deliverables – Initial Output - 1st September 2012	
Spatial Resolution	250 x 250 m
Geographic Region	Study area
Software	LANDIS-II
Simulation:	Long term harvesting scenario based on calibration using provincial harvesting data
Output Variables:	Simulated Harvesting patterns based on historical levels Segmented scene of harvest size compartments for modelling Map of forest stand age for LANDIS simulations

Deliverables (assuming April 1st 2011 start date):

LANDIS Fire Deliverables. Final Output - March 31st 2013	
Spatial Resolution	250 x 250 m
Geographic Region	Study area
Software	LANDIS-II
Simulation:	Scenarios of landscape pattern based on two fire scenarios of high and low fire frequencies
Output Variables	Fire pattern and severity under scenario

LANDIS Harvest Deliverables –Final Output - March 31st 2013	
Spatial Resolution	250 x 250 m
Geographic Region	Study area
Software	LANDIS-II
Simulation:	Simulated Harvesting patterns based on historical high and low harvesting levels
Output Variables:	Harvesting pattern under scenarios

Budget:

This work will be conducted under the supervision of Drs. Coops, Wulder and Nelson at the University of British Columbia and Victoria.

	Year 1 (2011)	Year 2 (2012)
Salaries	**$45,000.00**	**$45,000.00**
Equipment/Supplies	**$2,000.00**	**$2,000.00**
Travel for team members	**$3,000.00**	**$3,000.00**
TOTAL	**$50,000.00**	**$50,000.00**

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Subproject 1. Climate Change and Impacts to Water Supply.

1. **Project Title**: Potential impacts of climate change and vegetation dynamics on the monthly and annual water budget.
2. **Project Team**:
   Dr. Axel Anderson, Water Program Lead, FRI, Hinton
   Dr. Georg Jost, Research Associate, University of British Columbia

3. **Background**:
   Water from the eastern slopes and foothills of the Rocky Mountains makes up the majority of usable surface water supplies for of most of Alberta's rivers. Rivers with long records in Alberta, and similar regions, have shown a decline in annual flows. This decline has been attributed to many factors, including climate fluctuations and changing vegetation over the last century. These factors are likely to continue to impact the amount and timing of water we receive from these rivers. This may, in turn, have implications for economic and ecological well being of the regions. If vegetation changes have a large influence on the annual water budgets and timing of the flow for large river systems, there may be forest management options that could be used to mitigate expected negative impacts to the water supply and aquatic ecosystems. The first step is to link future climate and vegetation predictions with tools that can predict the amount of and timing of the flow. It is also important to understand the uncertainty of the predictions. There are many hydrological modeling tools that range from complex, detailed, physically based models, to simple, conceptual models. High numbers of parameters make more complex models relatively difficult to calibrate and to determine the uncertainty. Simpler models are often not physically based, so there can be limited confidence of model predictions outside of the calibration scope (when climate change is considered). The model selection will depend on data availability and outputs from the future forest condition, but this project will likely use a two level approach to predict the changes to the monthly water balance model and uncertainty:
   1) a well established conceptual model (e.g. HBV-EC) to investigate larger regional differences and uncertainty, but may poorly represent vegetation interactions with energy and water, and
   2) a flexible platform with more detailed algorithms (YAM - developed and used by Dr. Jost) to investigate the vegetation and topogoical differences.

4. **Project Objectives and Goals:**

   Objective 1: To understand how climate and vegetation changes may affect the components of the stand-scale water balance. To predict the changes to the monthly water balance for the river within the region and analysis the uncertainty.

   Goals:

   1. Determine available data and appropriate region for the analysis.
   2. Select and calibrate an appropriate model(s) given future forest and climate conditions, other factors (e.g. glaciers) and available data.
   3. Use the calibrated model, climate prediction and landscape inputs to compare current and likely future monthly and annual water budgets.
   4. Conduct a sensitivity analysis to investigate the uncertainty in the model predictions.

Objective 2: Understand the effect of the changing vegetation structure on the potential water balance.

Goals:

1. Link the changing vegetation with the likely changes to the potential changes in the monthly water balance.
2. Use this information to inform forest management options for water supply issues accounting for potential changes to the climate.

5. Project Deliverables:

A final report of this project will be prepared and contain the following results:

1. Understanding of the potential change to the water budget and sensitivity of results to vegetation and climate inputs for the study region.
2. Analysis of model uncertainty to help inform decision makers.
3. Considerations for forest management activities as they relate to water supply accounting for climate impacts on the future forest condition.

6. **Timelines:**

- This project will be completed within a two year period (April 2011- April 2013) with final reports being completed in March 2013.
- The first year of this project will focus on model selection and calibration and integration with climate predictions and future forest conditions (2011).
- Model uncertainty analysis and scenario testing will be done in the second year of the project.

7. Budget:

Work will be conducted with a part-time contract to Dr. Jost and Anderson (in-kind time seconded to FRI):

	Year 1 (2011)	**Year 2 (2012)**
Contractor (Jost)	**$25,000.00**	**$25,000.00**
Equipment/Supplies	**$2,000.00**	**$2,000.00**
Travel for team members	**$3,000.00**	**$3,000.00**
TOTAL	**$30,000.00**	**$30,000.00**

8. Other funding sources and contributions to project:

The FRI Water Program is currently under development so the Program structure is not yet determined. This work will informally build on work underway by a student supervised by Professor Valeo and Dr. Anderson at U of C, who is investigating the use of models to determine the possible MPB vegetation impacts to Water Supplies. Further opportunities for levering funding will be identified as the Water Program is developed in 2011.

Subproject 2. Climate Change and Plant Phenology Impacts in the Boreal Forest

5. **Project Title**: Potential Impacts of Climate Change on Key Grizzly Bear Foods and Energetics, in West-Central Alberta.
6. **Project Team**:
   Gordon Stenhouse, Research Scientist and FRI Grizzly Bear Program Leader, FRI, Hinton
   Dr. Greg McDermid, Associate Professor, Department of Geography, University of Calgary
   Dr. Scott Nielsen, Assistant Professor, Department of Renewable Resources, U of Alberta

7. **Background**:
   In general, bears may be more affected by climate change than other carnivore species, because they rely to a large extent on vegetative material for growth and especially the accumulation of fat reserves necessary for hibernation. Further work is needed to examine how environmental and climatic factors may influence plant phenology of key bear foods which impact variation on body weight and size in brown bears in different populations and different habitats if we are to understand the general pattern of life-history trait variations in relation to climate changes. Understanding the relationships between climate change and food, growth and reproduction will play an important role in the recovery and conservation of this species in Alberta.

   Contemporary approaches to wildlife habitat-assessment commonly rely on *resource selection functions* (RSFs): statistical models that explain observed patterns of animal location using environmental variables derived from remote sensing. While the approach is highly successful, RSFs have been recently criticized for relying too heavily on simplistic habitat surrogates (land cover, digital elevation models, vegetation indices, etc) that remain static through time, and provide an incomplete characterization of many complex environmental factors. For example, the distribution of food resources provides a *bottom-up* influence on animal populations that changes both spatially and temporally throughout the growing season, but is rarely accounted for explicitly in RSFs. In this manner, the use of coarse habitat surrogates in RSF models limits their capacity to describe key regulating factors of dynamic animal populations, and subsequently restricts our ability to use them to design appropriate management actions for a particular wildlife species. Grizzly bear recovery efforts in Alberta would be greatly enhanced with a more complete understanding of high quality food resources over time and how these may be affected by climate variation and change.

8. **Project Objectives and Goals:**

   Objective 1: To understand the linkages between climate (temperatures, moisture, and growing degree days), with the development and value of key grizzly bear foods.

   Goals:

   5. Gather data on phenophases along elevational gradient transects along the eastern slopes in core provincial grizzly bear conservation areas and relate data to climatic variables at a micro site scale. Collect seed stock for laboratory experiments identified in goal 3 below.
   6. Quantify how phenophase development impacts nutrient energy values of these species along elevational gradients.
   7. In controlled growth chambers at research facilities in Vegerville with Alberta Innovates Technology Futures, conduct experiments to determine the

threshold GDD temperatures required to achieve 8 basic phenophases (first leaf, all leaves unfolded, first flower, full flower, end of flowering, first ripe fruit, 50% colour, and 50% leaf fall) will be determined. These experiments will be based on seeds/stock collected along elevational gradients.

Objective 2: Using the base models and outputs for future forest conditions and climate scenarios provided by the remote sensing/forecasting group we will develop new predictive models based on identified relationships from objective 1 to forecast change in bear food abundance and value over time with different forest and climate conditions.

Goals:

3. Use newly established (research papers in press from FRI work) to perform radiometric noise-reduction and phenological metric extraction (start-of-season, length-of-season, NDVI amplitude, etc) from 8- and 16-day time series of MODIS vegetation index data.
4. Calibrate and validate empirical models designed to predict the key phenophases of all measured plant species using MODIS satellite data and other spatially explicit predictor variable
5. Prepare plant energy models that will link to observed phenology (NDVI) to understand landscape energy supply and availability.

5. Project Deliverables:

A final report of this project will be prepared and contain the following results, models and GIS applications:

1. Details of the established relationships between the phenophases of key bear foods in core conservation areas with both elevation and microclimate data variables.
2. Identification of the energy values of these key bear foods during the phenophases to establish plant value to grizzly bears in conjunction with climatic conditions.
3. Final models of the spatial and temporal distribution of key bear foods with the future forest conditions and climatic scenarios. (Spatial map products will form part of this report).
4. Models identify the spatial and temporal distribution of plant energy for grizzly bears with future forest and climatic scenarios will be prepared and new GIS applications will be developed to allow end users to vary forest management options to determine grizzly bear energy over the landscape.
5. It is the intent of the research team that all work associated with this project will be published in peer reviewed scientific journals.

6. **Timelines:**

- This project will be completed within a two year period (April 2011- April 2013) with final reports being completed in March 2013.
- The first year of this project will be focused on the collection of field data/samples and controlled growth chamber experiments (2011).
- Model development and analysis will form the major activity in the second year of the project.

7. Budget:

	Year 1 (2011)	Year 2 (2012)
Staff	**$6,000.00**	**$24,000.00**
Equipment/Supplies	**$14,000.00**	**$2,000.00**
Travel – Vehicles/Fuel	**$10,000.00**	**$4,000.00**
TOTAL	**$30,000.00**	**$30,000.00**

8. Other funding sources and contributions to project:

At this time our research team has applied for several grants to support this project. These include funding from an NSERC discovery grant (McDermid) of which $18,000.00 will be directed to this project. Applications have also been made to the STEP summer student employment program to offset some of the costs for field staff in 2011. In addition a PhD candidate at the UofC (David Laskin) will incorporate some of the work into his thesis program and he has received an Alberta Innovation scholarship to support his PhD program. Other research grants will be applied for in 2011 to support this undertaking.

Subproject 3. Climate Change and Mountain Pine Beetle Impacts in the Boreal Forest

9. Project Title:
The mountain pine beetle in novel pine forests: predicting impacts in a warming environment

10. Project Team:
Dr. Allan Carroll, Associate Professor, Department of Forest Sciences, UBC
Ms. Debra Wytrykush, Ph.D. Candidate, Department of Forest Sciences, UBC

11. Background:
Insect herbivory comprises one of the largest sources of disturbance in northern temperate and boreal forests (Dale et al. 2001). Given the sensitivity of herbivorous insects to variations in climate (Bale et al. 2002), combined with evidence of historical increases in herbivory associated with a warming environment (Currano et al. 2008), climate change is expected to have a significant impact on the dynamics of forest insect herbivores and the extent/severity of their impacts in northern forests (Logan et al. 2003). An increase in insect-caused forest disturbance beyond the long-term range of natural variability is also expected to significantly reduce forest carbon reservoirs, increase rates of heterotrophic respiration and cause feedback to future climate change (Kurz et al. 2008).

Recently, Carroll et al. (2004) showed that the mountain pine beetle (MPB) had significantly expanded its range in western Canada since 1970 as a result of a warming environment. These results, together with the extensive incursions across the Rocky Mountains into north-central Alberta by MPB since 2002, prompted Safranyik et al. (2010) to examine the potential distribution of climatically benign habitats in the boreal and eastern pine forests under climate change. Although they concluded that there was a significant probability of continued eastward expansion by MPB, they also concluded that confidence in their predictions was limited by lack of knowledge of (i) the productivity of MPB in novel pine forests, and (ii) the potential range of future climatic conditions derived from accepted greenhouse gas emissions scenarios. The proposed research will utilize recent quantifications of MPB productivity in naïve lodgepole pine forests (Cudmore et al. 2010; Clark et al. 2010; A.L. Carroll unpubl. data) to modify an empirical model of the role of climate in the beetle's outbreak potential (Carroll et al. 2004) and project distributions of climatically benign habitat under a range of future forest conditions based on accepted emissions scenarios (Coops et al., this proposal).

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Carroll AL., Taylor SW, Régnière J, Safranyik L. 2004. Effects of climate and climate change on the mountain pine beetle. Pages 223-232 in T.L. Shore, J.E. Brooks and J.E. Stone, eds. Proceedings of the mountain pine beetle symposium: challenges and solutions, October 30-31, 2003, Kelowna, British Columbia, Canada. Can. For. Serv., Pac. For. Cent., Inf. Rep. BC-X-399

Clark EL, Carroll AL, Huber DPW. 2010. Differences in lodgepole pine constitutive terpene profile across a geographic range in British Columbia and the correlation to historical attack by mountain pine beetle, Dendroctonus ponderosae Hopkins (Coleoptera: Curculionidae). Can. Entomol. 142: 557-573

Cudmore TJ, Björklund N, Carroll AL, Lindgren BS. 2010. Climate change and range expansion of an aggressive bark beetle: evidence of higher reproductive success in naïve host tree populations. J. Appl. Ecol. 47: 1036-1043

Currano ED, Wilf P, Wing SL, Labandeira CC, Lovelock EC, Royer DL. 2008. Sharply increased insect herbivory during the Paleocene-Eocene thermal maximum. PNAS 105: 1960-1964

Dale VH, Joyce LA, McNulty S, Neilson RP, Ayres MP, Flannigan MD, Hanson PJ, Irland LC, Lugo AE, Peterson CJ, Simberloff D, Swanson FJ, Stocks BJ, Wotton BM. 2001. Climate change and forest disturbances. BioScience 51: 723-734

Kurz WA, Dymond CC, Stinson G, Rampley GJ, Neilson ET, Carroll AL, Ebata T, Safranyik L. 2008. Mountain pine beetle and forest carbon: feedback to climate change. Nature 454: 987-990

Logan JA, Régnière J, Powell JA. 2003. Assessing the impacts of global warming on forest pest dynamics. Front. Ecol. Evol. 1: 130-137

Safranyik L, Carroll AL, Régnèire J, Langor DW, Riel WG, Shore TL, Peter B, Cooke BJ, Nealis VG, Taylor SW. 2010. Potential for range expansion of mountain pine beetle into the boreal forest of North America. Can. Entomol. 142: 415-442

12. Project Objectives and Goals:

Objective 1: Develop a model of the effects of climate on MPB populations that incorporates altered beetle productivity associated with novel pine habitats.

Goals:

1. Gather meta data from studies of MPB dynamics in novel pine habitats (Cudmore et al. 2010; Clark et al. 2010; A.L. Carroll, unpubl. data).
2. Establish relationships between host-tree characteristics and MPB productivity in novel pine habitats.
3. Modify existing model of MPB climatic suitability (Carroll et al. 2004) to incorporate new beetle productivity relationships
4. Calibrate and validate modified model outputs against Alberta Sustainable Resources Development annual MPB productivity (i.e. r-value) surveys.

Objective 2: Projections of MPB climatic suitability under climate change in novel pine habitats.

Goals:

1. Apply the modified model of MPB climatic suitability to the outputs of future climatic conditions under different emissions scenarios derived by Coops et al. (this proposal)
2. Overlay outputs of MPB climatic suitability derived from the climate change scenarios on projections of future forest conditions provided by Coops et al. (this proposal).

13. Project Deliverables: **A final report of this project will be prepared and contain the following results, models and outputs:**

6. Details of the relationship derived from meta data between host-tree characteristics and MPB productivity in novel pine habitats.
7. A final model of the role of climate on MPB dynamics in novel pine habitats.
8. Detailed maps of the risk of MPB outbreaks under a range of climate change scenarios, intersected with the distribution of susceptible lodgepole pine derived from projections of future forest conditions.
9. All work associated with this project will be published in peer reviewed scientific journals.

14. **Timelines:**

- This project will be completed within a two year period (April 2011- April 2013) with final reports being completed in March 2013.
- The first year of this project will be focused on the collation of data and the modification/parameterization of models.
- Projections of future conditions will form the major activity in the second year of the project.

15. **Budget:**

	Year 1 (2011)	**Year 2 (2012)**
Graduate student stipend	**$20,000.00**	**$20,000.00**
Equipment/Supplies	**$5,000.00**	**$5,000.00**
Travel – Vehicles/Fuel	**$5,000.00**	**$5,000.00**
TOTAL	**$30,000.00**	**$30,000.00**

16. **Other funding sources and contributions to the project:**

Several applications have been made to other funding agencies to support efforts that will complement and extend the proposed research through detailed studies of the ecological ramifications of range expansion by MPB. These include an application to NSERC for an Industrial Research Chair that will focus on elucidating the impacts of climate change on the dynamics of the major eruptive bark beetles in western North America. Funds from the proposed Chair directly related to this research amount to approximately $100,000 per year for 5 years to ascertain the biological basis for altered MPB productivity in novel pine habitats. In addition, an application has been submitted to the Pacific Institute for Climate Studies for funds to examine shifting climate envelopes for eruptive forest insect species in western North America. If successful, these funds will amount to approximately $30,000 per year for the next two years. Additional opportunities to support our research will also pursued in 2011.

Research Team CVs

1. **Future Forest Conditions – Team**

Research Team CV's (short versions)

NICHOLAS CHARLES COOPS

Title:

Professor and

Canada Research Chair in Remote Sensing

Department of Forest Resource Management

Forest Sciences Centre
2424 Main Mall, University of British Columbia
Vancouver, BC., Canada V6T 1Z4.

(W) 604 822 6452, Fax (604) 822-9106

Education:

1989 B. App. Sc. (Cartography) (with Distinction)
Royal Melbourne Institute of Technology

1996 Ph.D. Royal Melbourne Institute of Technology

Offices Held:

Director: Teaching and Learning Office, UBC University Sustainability Initiative

Adjunct Professor: Oregon State University

Editor-in-Chief: Canadian Journal of Remote Sensing

Scholarship:

Refereed Journal Papers (published or in press) (160 published, 25 in review):

Bater, C.W., Wulder, M.A., White, J.C., and Coops N.C. 2010. Integration of LIDAR and digital aerial imagery for detailed estimates of lodgepole pine (Pinus contorta) volume killed by mountain pine beetle (Dendroctonus ponderosae). Journal of Forestry, 108: 111-119.

Chen B., Black A., Coops N.C., Jassal R., Krishnan P., and Z. Nesic (2008), Seasonal controls on interannual variability in carbon dioxide exchange of a Pacific Northwest Douglas-fir forest, 1997 - 2006. Global Change Biology. 15: 1962–1981.

Coggins, S., Coops, N.C., Wulder, M.A. (2010) Cluster sampling to characterize mountain pine beetle populations Silvifenica. 44(23). 289-391.

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Gergel, S.E., Y. Stange, N.C. Coops, K. Johansen, and K.R. Kirby. (2007) What is the value of a good map? An example using high spatial resolution imagery to aid riparian restoration. Ecosystems. 10: 688-702.

Goodwin, N., Coops, N.C., Culvenor, D.C. (2007) Development of a simulation model to predict LiDAR interception in structurally different forests. Remote Sensing of Environment, 111: 481-492

Hember RA, Coops NC, Black TA, (2010) Simulating gross primary production across a chronosequence of coastal Douglas-fir forest stands with a production efficiency model. Agricultural & Forest Meteorology 150: 238-53

Hilker, T, Coops, N.C., Schwalm, C.R., Jassal, R., Black, A., Krishnan, P. (2008) Effects of mutual shading of tree crowns on prediction of photosynthetic light use efficiency in a Coastal Douglas-fir forest . Tree Physiology. 28:825–834

Hilker, T., Coops, N.C., Hall, F.G., Wulder, M. Black, T.A. (2008) Separating physiologically and directionally induced changes in canopy reflectance using BRDF models. Remote Sensing of Environment 112: *2777-2788*

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Nightingale, J.M., Fan, W., Coops, N.C. and Waring, R.H. (2008) Predicting tree diversity across the USA as a function of modeled gross primary production, Ecological Applications 18: 93-108

Schroeder, T.A., Hamann, A., Coops, N.C., Wang, T (2010) Occurrence and dominance of six Pacific Northwest conifer species. Journal of Vegetation Science. 23(3): 586-596.

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Waring, R.H., Coops, N..C., Landsberg, J.J (2010) Improving predictions of forest growth using the 3-PGS model with observations made by remote sensing. Forest Ecology and Management 259, 1722:1729.

Wulder, M., Hall, R., Coops, N.C, and S. Franklin. (2004) High spatial resolution remotely-sensed data for the study of forest ecosystems. *Bioscience* 54(6): 511-521.

Wulder, M., J. White, B. Bentz, F. Alvarez, and N. Coops, 2006. Estimating the probability of mountain pine beetle red-attack damage, *Remote Sensing of Environment*, 101: 150-166

Wulder, M.A., J.C. White, N.C. Coops, T Nelson, and B. Boots, (2007) Using local spatial autocorrelation to compare outputs from a forest growth model, Ecological Modelling. 209: 264-276

Wulder, M.A., S Ortlepp, J. White, T. Nelson, N. Coops. (2010). A provincial and regional assessment of the mountain pine beetle epidemic in BC : 1999-2008. Journal Environmental Infomatics.15 : 1 – 13.

Varhola, A., Teti, P., Boon, S., Bater, C.W., Coops, N.C. Weiler, M (2010) The influence of ground and LiDAR-derived forest structure metrics on snow accumulation and ablation in disturbed forests. Canadian Journal of Forest Research. 40(4) 812-821.

van Leeuwen, M., N.C. Coops, M.A. Wulder (2010). Canopy Surface Reconstruction from a LiDAR point cloud Using Hough Transform. Remote Sensing Letters. 1 :125 - 132

Conference Proceedings papers (70)

Michael A. Wulder

Canadian Forest Service

506 West Burnside Road

Victoria, BC V8Z 1M5

Canada

Title

Senior Research Scientist, Research and Applications in Forest Geomatics

Educational and Professional

1998-present, Research Scientist, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada.

1998 Ph.D., Geography, University of Waterloo, Waterloo, Ontario.

1996 Master of Environmental Science, University of Waterloo, Waterloo, Ontario

1995 Bachelor of Science in Geography (Honours), University of Calgary, Calgary, Alberta.

Scholarship

Books

1. Wulder, M. and S. Franklin, (Editors), 2007; Understanding Forest Disturbance and Spatial Pattern: Remote Sensing and GIS Approaches, Taylor and Francis, Boca Raton, Florida, USA, 264p.
2. Wulder, M. and S. Franklin, (Editors), 2003; Remote Sensing of Forest Environments: Concepts and Case Studies, Kluwer Academic Publishers, Dordrecht / Boston / London, 519p.

Book Chapters (17)

Refereed Journals (In review: 18)

Refereed Journals (Published or In press [or Accepted]: 167). 2010 papers below:

1. Frazer, G.F., S. Magnussen, M.A. Wulder, and K.O. Niemann. (In press). Simulated impact of sample plot size and co-registration error on the accuracy and uncertainty of LiDAR-derived estimates of forest stand biomass. Remote Sensing of Environment. (Submitted May 7, 2010; Accepted Nov. 3, 2010).
2. Wulder, M.A., J.C. White, J.G. Masek, J. Dwyer, and D.P. Roy. (In press). Continuity of Landsat observations: Short term considerations. Remote Sensing of Environment. (Manuscript No. 10-00798 ; Submitted on August 26, 2010; Accepted Nov 2, 2010).
3. Bater, C.W., Coops, N.C., Wulder, M.A., Hilker, T., Nielsen, S.E., McDermid, G., and Stenhouse, G.B. 2010. Using digital time-lapse cameras to monitor species-specific understorey and overstorey phenology in support of wildlife habitat assessment. Environmental Monitoring and Assessment. (DOI: 10.1007/s10661-010-1768-x).
4. Coops, N.C., Michaud, J.S., Wulder, M.A., Andrew, M.E. (In press). Comparison of a regional-level habitat index derived from MERIS and MODIS estimates of canopy light absorbance. Remote Sensing Letters (Manuscript: TRES-LET-2010-0042; Submitted March 27, 2010; Revision returned June 8, 2010; Accepted August 13, 2010).

5. Coggins, S.B., Coops, N.C., Wulder, M.A., Bater, C.W., Ortlepp, S.M. 2010. Comparing the impacts of mitigation and non-mitigation on mountain pine beetle populations. Journal of Environmental Management. (DOI: http://dx.doi.org/10.1016/j.jenvman.2010.08.016)
6. Hilker, T., Hall, F.G., Coops, N.C., Lyapustin, A., Wang, Y., Nesic, Z., Grant, N., Black, T.A., Wulder, M.A., Kljun, N., Hopkinson, C., Chasmer, L. (2010). Remote sensing of photosynthetic light-use efficiency across two forested biomes: Spatial scaling. Remote Sensing of Environment. Vol. 114, No. 12, pp. 2863-2874. (DOI: http://dx.doi.org/10.1016/j.rse.2010.07.004).
7. Long, J.A., Nelson, T.A., and Wulder, M.A. (2010). Regionalization of landscape pattern indices using multivariate cluster analysis. Environmental Management. Environmental Management. Vol. 46, No. 1, pp. 134-142. (DOI http://dx.doi.org/10.1007/s00267-010-9510-6 ; Opentext: http://www.springerlink.com/content/r1m122xu28728v22/fulltext.pdf).
8. Mora, B., M.A. Wulder, J.C. White. (Accepted). Identifying leading species using tree crown metrics derived from very high spatial resolution imagery in a boreal forest environment. Canadian Journal of Remote Sensing. (Manuscript ID: CJRS-10-0085; Submitted May 17, 2010; Reviews received June 23, 2010; Accepted: July 15, 2010).
9. Wulder, M.A., J.C. White, and N.C. Coops. (In press). Fragmentation regimes of Canada's forests. The Canadian Geographer. (Submitted Feb 08, 2010; Accepted with minor revisions – returned on July 2010; Final Acceptance July 23, 2010).
10. Duncanson, L., K.O. Niemann, and M.A. Wulder (2010). Integration of GLAS and Landsat TM data for aboveground biomass estimation. Canadian Journal of Remote Sensing. Vol. 36, No. 2, pp. 129–141.
11. Mora, B., M.A. Wulder, and J.C. White (2010). Segment-constrained regression tree estimation of forest stand height from very high spatial resolution panchromatic imagery over a boreal environment. Remote Sensing of Environment. Vol. 114, pp. 2474–2484.
12. Coggins, S.B., N.C. Coops, M.A. Wulder. (2010). Estimates of mountain pine beetle infestation expansion factors with adaptive cluster sampling. International Journal of Pest Management. (DOI: http://dx.doi.org/10.1080/09670874.2010.505667).
13. Hilker, T., M. van Leeuwen, N.C. Coops, M.A. Wulder, G. Newnham, D.S. Culvenor, D.L.B. Jupp. 2010. Comparing canopy metrics derived from terrestrial and airborne laser scanning in a Douglas-fir dominated forest stand. TREES – Tree Structure and Function. (DOI: http://dx.doi.org/10.1007/s00468-010-0452-7).
14. Coggins, S.B., N.C. Coops, and M.A. Wulder. (2010). Improvement of low level bark beetle damage estimates with adaptive cluster sampling. Silva Fennica. Vol. 44, No. 2, pp. 289-301. http://www.metla.fi/silvafennica/full/sf44/sf442289.pdf
15. Coops, N.C., Gillanders, S., Wulder, M.A., Gergel, S.E., Nelson, T., Goodwin, N.R. (2010) Assessing changes in forest fragmentation following infestation using time-series Landsat imagery. Forest Ecology and Management. Vol. 259, No. 12, pp. 2355-2365. (DOI: 10.1016/j.foreco.2010.03.008).
16. White, J.C., C. Gómez, M.A. Wulder, N.C. Coops, 2010. Characterizing temperate forest structural and spectral diversity with Hyperion EO-1 data. Remote Sensing of Environment. Vol. 114, pp. 1576–1589 (DOI: http://dx.doi.org/10.1016/j.rse.2010.02.012)
17. Wulder, M.A., S.M. Ortlepp, J.C. White, T. Nelson, N.C. Coops. 2010. A provincial and regional assessment of the mountain pine beetle epidemic in British Columbia: 1999–2008. Journal of Environmental Informatics. Vol. 15, No. 1, pp. 1-13. (DOI: doi:10.3808/jei.201000161).
18. Long, J.A., Nelson, T.A., Wulder, M.A. 2010. Characterizing forest fragmentation: distinguishing change in composition from configuration. Applied Geography. Vol. 30, No. 3, pp. 426-435. (DOI: 10.1016/j.apgeog.2009.12.002)
19. van Leeuwen, M., N.C. Coops, M.A. Wulder (2010). Canopy Surface Reconstruction from a LiDAR point cloud Using Hough Transform. International Journal of Remote Sensing. (Submitted: November 16, 2009; Final acceptance Jan 25, 2010). Vol. 1, No. 3. (doi:10.1080/01431161003649339; http://dx.doi.org/10.1080/01431161003649339).

Conference Proceedings papers (122)

Dr. Trisalyn A. Nelson

Position: Associate Professor and Lansdowne Research Chair in Spatial Sciences

Spatial Pattern Analysis & Research (SPAR) Laboratory, Department of Geography, University of Victoria, Victoria, British Columbia, V8W 3R4.

Phone: 250 472 5620

Email: trisalyn@uvic.ca

Website: www.geog.uvic.ca/spar

Education:

2005 Ph.D, Geography and Environmental Studies
Wilfrid Laurier University, Waterloo, Ontario
Thesis: Spatial and spatial-temporal analysis of mountain pine beetle infestations at a landscape scale.

2001 M.Sc., Geography
University of Victoria, Victoria, British Columbia
Thesis: Spatial statistical techniques for aggregating point objects extracted from high spatial resolution imagery.

1998 B.Sc., Geography (Distinction/Honours/Co-op)
University of Victoria, Victoria, British Columbia

Scholarship

Selected Refereed Publications (48 published or in press; 7 in review):

Nelson, T.A., Gillanders, S., Harper, J., Morris, M. (Accepted). A monitoring system for nearshore aquatic habitats. *Journal of Coastal Research*. Submitted July 16, 2010. Accepted September 2010.

Nelson, T.A. (Accepted) Trends in spatial analysis. *The Professional Geographer*. Submitted November 2009. Accepted January 26, 2010.

Nelson, T.A., Laroque, C.P., Smith, D.J. (In Press) Detecting spatial connections within a dendrochronological network on Vancouver Island, British Columbia. *Dendrochronologia*. Submitted 2009. Accepted January 2010.

Coops, N.C., Gillanders, S., Wulder, M.A., Gergel, S.E., Nelson, T., Goodwin, N.R. (2010) Assessing changes in forest fragmentation following infestation using time-series Landsat imagery. *Forest Ecology and Management*. 259(12) 2355–2365.

Long, J.A., Nelson, T.A., Wulder, M.A. (2010) Characterizing forest fragmentation: distinguishing change in composition from configuration. *Applied Geography*. 30(3): 426–435.

Long, J.A., Nelson, T.A., Wulder, M.A. (2010) Regionalization of landscape pattern indices using multivariate cluster analysis. *Environmental Management*. 46(1): 134-142.

Smulders, M., Nelson, T.A., Jelinski, D.E., Nielsen, S.E., Stenhouse, G.B. (2010) A spatially explicit method for evaluating accuracy of species distribution models. *Diversity and Distributions*. 16: 996–1008.

Farmer, C.J.Q., Nelson, T.A., Wulder, M.A., Derksen, C. (2009) Temporal trends in the spatial association of satellite derived snow water equivalence: Relationships with land-cover and elevation. *The Canadian Geographer*. 53(4): 473–487.

Nelson, T.A., Duffus, D., Robertson, C., Laberee, K. and Feyrer, L.J. (2009). Spatial-temporal analysis of marine wildlife. *Journal of Coastal Research*. Special Issue 56: 1537–1541.

Robertson, C., Farmer, C.J., Nelson, T.A., Mackenzie, I., Wulder, M.A., White, J.C. (2009). Determination of the compositional change (1999–2006) in the pine forests of British Columbia due to mountain pine beetle infestation. *Environmental Monitoring and Assessment*. 158:593–608.

Robertson, C., Nelson, T.A., Jelinski, D.E., Wulder, M.A., Boots, B. (2009). Spatial-temporal analysis of species' range expansion: the case of the mountain pine beetle, *Dendroctonus ponderosae*. *Journal of Biogeography*. 36: 1446–1458.

Wulder, M.A., Stewart, B.P, Andrew, M.E., Smulders, M., Nelson, T.A., Coops, N.C., Stenhouse, G.B. (2009) Remote sensing derived edge location, magnitude, and class transitions for ecological studies. *Canadian Journal of Remote Sensing*. 35(6): 509–522.

Berland, A, Nelson, T.A., Stenhouse, G. Graham, K. and Cranston, J. (2008). The impact of landscape disturbance on grizzly bear habitat use in the Foothills Model Forest, Alberta, Canada. *Forest Ecology and Management.* 226: 1875–1883.

Gillanders, S.N., Coops, N.C., Wulder, M.A., Gergel, S.E., Nelson, T. (2008). Multitemporal remote sensing of landscape dynamics and pattern change: Describing natural and anthropogenic trends. *Progress in Physical Geography*. 32(5) 503–528.

Lightowlers, C. Nelson, T.A., Setton, E., Keller, P. (2008). Determining the spatial scale for analyzing mobile measurements of air pollution. *Atmospheric Environment*. 42(21) 5291–5303.

Nelson, T.A. and Boots, B. (2008). Detecting spatially explicit hot spots in landscape-scale ecology. *Ecography*. 31(5) 556–566.

Nelson, T.A., Duffus, D., Robertson, C., Feyrer, L.J. (2008). Spatial-temporal patterns in intra-annual gray whale foraging: Characterizing interactions between predators and prey. *Marine Mammal Science*. 24(2): 356–370.

Nelson, T., Boots, B., Wulder, M.A., Carroll, A.L. (2007). The environmental characteristics of mountain pine beetle infestation hot spots. *BC Journal of Ecosystems and Management*. 8(1): 91–108.

Robertson, C., Nelson, T.A., Boots, B., Wulder, M.A. (2007). STAMP: Spatial-temporal analysis of moving polygons. *Journal of Geographical Systems*. 9: 207–227.

Robertson, C., Nelson, T.A., and Boots, B. (2007). Mountain pine beetle dispersal: the spatial-temporal interactions of infestation. Forest Science. 53(3): 395–405.

Wulder, M.A., Nelson, T.A., Seemann, D. (2007). Using spatial pattern to quantify relationship between samples, surroundings, and populations. *Environmental Monitoring & Assessment*. 131:221–230.

Nelson, T., and Boots, B. (2005). Identifying insect infestation hot spots: an approach using conditional spatial randomization. *Journal of Geographical Systems* 7(3-4): 291–311.

Nelson, T., Boots, B., Wulder, M.A. (2005). Spatial and aspatial techniques for accuracy assessment of environmental point data extracted from remotely sensed imagery: An example using local maximum filtering. *Journal of Environmental Management* 74: 265–271.

Invited Speaking Engagements:

2010 University of Saskatchewan, School of Environment and Sustainability. *Environmental solutions: collaborative and interdisciplinary spatial science*. March 25, Saskatoon, SK.

2009 Texas A & M University, Department of Geography. *From Beetles to Bears: Understanding Patterns and Processes*. September 23, College Station, TX.

2007 San Diego State University, Department of Geography, *Mountain Pine Beetle Infested Landscapes: Understanding the Spatial Dynamics of Epidemics*. October 11, San Diego, CA.

Subproject Team : Water

AXEL ANDERSON

Water Program Lead
Foothills Research Institute
8660 Bearspaw Dam RD NW
Calgary, AB. T3L 1S4
403.297.8852

EDUCATION

PhD, Forest Hydrology, 2008, University of British Columbia, Vancouver, Canada
MSc, Forestry, 2003, University of British Columbia, Vancouver, Canada
BSc, Forest Operations, 2000, University of British Columbia, Vancouver, Canada

PROFESSIONAL REGISTRATION

Registered Professional Forester (R.P.F.)
    Association of British Columbia Forest Professionals (ABCFP)
    College of Alberta Professional Foresters (CAPF)
Professional Engineer (P.Eng.)
    Association of Professional Engineers and Geoscientists of BC (APEGBC)
    Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)

WORK EXPERIENCE

Water Program Lead, Secondment to Foothills Research Institute, 2011- present
Forestry Hydrology Specialist, Sustainable Resource Development, Calgary AB 2007 – 2011
Adjunct Assistant Professor, Civil Engineering, University of Calgary, Calgary AB, 2009 - present
Research Assistant, University of British Columbia, Vancouver BC 2000 – 2007
Consulting (Part time) Road Projection and integration with strategic planning tools, 2003 – 2007
Forest Engineer Assistant (part time/summer), Western Forest Products, Interfor, Campbell River BC and Tyhee Forest Consulting, Smithers BC, 1999-2002
Silviculture consultant, Supervisor, Foreman, Laborer, Backwoods Contracting, Smithers BC 1994 – 1998

RESEARCH PROJECTS

Assessment of Mountain Pine Beetle risks to the Elbow River Flow Regime and the potential effect to the City of Calgary's Water Supply, Co-Investigator, 2009 - 2011
Alberta Front Ranges LiDAR Snow Depth and Snow Water Equivalent Assessment, Collaborator, 2008
Southern Rockies Watershed Study – Enabling Source Water Supply and Protection in Alberta, Collaborator, 2006 – 2012
Effects of Mountain Pine Beetle on the Snow Processes of Southern Alberta, Collaborator 2009 – 2010
Marmot Creek Watershed Study: Mountain Pine Beetle Impacts to Water Supplies, Collaborator, 2009-2010

PUBLICATIONS
JOURNAL

Anderson, A., M. Weiler, Y. Alila, and R. O. Hudson. 2010. Piezometric response characteristics in hillslopes dominated by preferential flow. Hydrological Processes, 24(16): 2237-2247 doi:10.1002/hyp.7662

Anderson, A. E., M. Weiler, Y. Alila, and R. O. Hudson. 2009. Subsurface flow velocities in a hillslope with lateral preferential flow, Water Resources Research, 45, W11407, doi:10.1029/2008WR007121.

Beckers, J., B. Smerdon, T. Redding, A. Anderson, R. Pike, A. Werner. 2009. Hydrologic Models for Forest Management Applications: Part 1 – Model Selection, Streamline Watershed Management Bulletin 13(1): 45-54

Beckers, J., R. Pike, A. Werner, T. Redding, B. Smerdon, A. Anderson. 2009. Hydrologic Models for Forest Management Applications: Part 2 – Incorporating the Effects of Climate Change, Streamline Watershed Management Bulletin 13(1): 35-44

Silins U., Bladon K. D., Anderson A., Diiwu J., Emelko M. B., Stone M., Boon S. 2009. Alberta's Southern Rockies Watershed Project: How wildfire and salvage logging affect water quality and aquatic ecology. Streamline Watershed Management Bulletin 12(2): 1-7.

Anderson, A., Weiler, M., Alila, Y., and Hudson, R. O., 2009 Dye staining and excavation of a lateral preferential flow network, Hydrology and Earth Systems Science 13, 935-944. http://www.hydrol-earth-syst-sci.net/13/935/2009/hess-13-935-2009.html

Anderson, A. Nelson J. D., and R. D'Eon. 2006. Determining optimal forest road class and road deactivation strategies using dynamic programming, Canadian Journal of Forest Research 36: 1509–1518 (2006) doi:10.1139/X06-051

Anderson, A. and J. D. Nelson. 2004. Projecting Vector Based Road Networks with a Shortest Path Algorithm, Canadian Journal of Forest Research 34(7): 1444–1457. doi:10.1139/x04-030

Seely, B., J. Nelson , R. Wells, B. Peter, M. Meitner, A. Anderson, H. Harshaw, S. Sheppard, F. Bunnell, H. Kimmins, and D. Harrison. 2004 The application of a hierarchical, decision-support system to evaluate multi-objective forest management strategies: A case study in northeastern British Columbia, Canada. Forest Ecology and Management 199: 283–305. doi:10.1016/j.foreco.2004.05.048

PRESENTATIONS

Hopkinson, C., J. Pomeroy, C. DeBeer, C. Ellis, A. Anderson. 2010. Relationships Between Snowpack Depth and Primary Lidar Point Cloud Derivatives in a Mountainous Environment Remote Sensing and Hydrology Symposium, Jackson Hole, Wyoming

Anderson, A. 2009. Land, Forests and Water - Role of public perceptions in management of public resources. Western Canada Water education Conference, Banff, Alberta

Collins, T., C. Hopkinson, A. Anderson, I. Spooner. 2009. Estimating Snow Volume in the Elbow River Watershed Using Airborne Lidar. Eos Trans. AGU, 90(22), Jt. Assem. Suppl., Toronto Canada. Abstract H13C-07

Collins, T., C. Hopkinson, A. Anderson, I. Spooner. 2009. Simulating snow depth distribution in a high relief watershed using LiDAR and GIS. Canadian Symposium on Remote Sensing, Lethbridge, Canada.

Diiwu, J., U. Silins, B. Kevin, A. Anderson. 2008. Poster: Lessons learned from post-wildfire monitoring and implications for land management and regional drinking water treatability in Southern Rockies of Alberta. American Geophysical Union, San Francisco, USA.

Anderson, A. and M. Weiler 2008. Watertable response characteristics in hillslopes dominated by preferential flow. American Geophysical Union, San Francisco, USA.

Anderson, A. and M. Weiler 2008. Tracer based investigation of a hillslope subsurface flow network. European Geophysical Union, Vienna, Austria.

Hopkinson, C., A. Anderson, J. Diiwu 2008. Determining the snowpack depth in high relief densely forested areas using airborne LiDAR data. Canadian Geophysical Union. Banff Canada.

Anderson, A. and M. Weiler. 2005. How do preferential flow features connect? Combining tracers and excavation to examine hillslope flow pathways. American Geophysical Union, San Francisco, USA.

Anderson, A. and M. Weiler. 2005. Poster: How do preferential flow features connect? Combining tracers and excavation to examine hillslope flow pathways. SLope InterComparison Experiment (SLICE) workshop, HJ Andrews Experimental Forest, Oregon.

Anderson, A. and J. Nelson. 2004. Determining the optimal road class and deactivation strategies using dynamic programming. Canadian Operations Research Society Conference, Banff, Canada.

Anderson, A. 2003. Using a computerized road projection method to examine the strategic attributes of forest road networks in north eastern British Columbia. Canadian Operations Research Society Conference, Vancouver, BC, Canada.

Anderson, A. and J. Nelson. 2002. Projecting vector roads with a shortest path algorithm. Canadian Operations Research Society Conference, Toronto, ON, Canada.

GEORG JOST

41-40137 Government Road,
Squamish, B.C, V8B 0G6
(604) 389-9768

EDUCATION

2004: PhD (with Distinction) - University of Natural Resources and Applied Life Sciences, Vienna: "Quantification of water fluxes in a pure Norway spruce (Picea abies (L.) Karst.) stand and in a mixed Norway spruce - European beech (Fagus sylvatica L.) stand"

2001: MSc (with Distinction): University of Natural Resources and Applied Life Sciences, Vienna: "Spatio-temporal analyses of the soil water storage in a pure Norway spruce (Picea abies (L.) Karst.) stand and in a mixed Norway spruce - European beech (Fagus sylvatica L.) stand in Kreisbach (Lower Austria)"

1993-2001: University of Natural Resources and Applied Life Sciences, Vienna

1999: Undergraduate Exchange Student at the University of British Columbia, Vancouver, Canada

1988-1993: Higher Federal Institute of Forestry- Bruck./ Mur

WORK EXPERIENCE AND RESEARCH PROJECTS

2010 – ongoing: San Jose watershed - regional adaption to climate change study

2009 – ongoing: Glacier and Streamflow Response to Future Climate Scenarios, Mica Basin, British Columbia

2007 – ongoing: Research scientist in the: Integrated monitoring of Air Pollution Effects on Ecosystems (International Cooperative Programme on Effects of the UN-ECE , Convention on Long-Range Transboundary Air Pollution"). Field experiments, hydrological modeling, statistical and physical modeling of Nutrient fluxes (since 1998 also soil and botanical surveys, and studies on the impact of deer grazing).

2004 – ongoing: Research scientist in the Cotton Creek project: "Forest management in the interior of British Columbia: Moving beyond equivalent cut area". Field experiments, hydrological modeling, snow melt modeling, scenario analysis.

2008 – ongoing: Research Associate, University of British Columbia, Department of Geography, Sessional Lecturer

2004 – 2007: Post-doctoral Research Fellow, University of British Columbia, Department of Forest Resources Management

2001 – 2004: Assistant researcher at the Institute of Forest Ecology, BOKU University Vienna: research on the water cycle, stochastic and deterministic modelling, geostatistics

2004: Assistant researcher at the Institute of Forest Engineering, BOKU University Vienna: multivariate statistics, freelancer (soil classification, modeling)

2003: Visiting scientist at the University of Amsterdam (UVA)

2003: Visiting scientist at the Swiss Federal Institute of Technology (ETH Zürich) and at the University of Amsterdam (UVA)

2000 - 2001: Technician in the Special Research Program “Forest ecosystem restoration“: geostatistical analysis, responsible for measuring devices (Eddy Covariance, time domain reflectometry, climate stations, stem-flow).

1998-2004 (Summers): Soil and plant surveyor in the National Park ‘Kalkalpen’

1997: Botanical guide in Madeira and Algarve, Portugal

TEACHING EXPERIENCE

2008: Catchment Hydrology (Geog 403) at UBC Geography

2008-2009: Introduction to Hydrology (Geog 305) at UBC Geography

1998-2004: Teaching assistant at the Institute of Forest Engineering (road construction, forest harvesting)

PUBLICATIONS
JOURNAL

Jost, G., Schume, H, Markhart, G. The influence of tree species on soil moisture dynamics and lateral water flow during intense rainfall submitted, Journal of Hydrology

Jost, G., Dirnböck, T., Grabner, M.T., Mirtl, M. Nitrogen leaching of two forest ecosystems in a Karst watershed. Water, Air, & Soil Pollution, accepted

Jost, G., Dan Moore, R., Weiler, M., Gluns, D.R. and Alila, Y., 2009. Use of distributed snow measurements to test and improve a snowmelt model for predicting the effect of forest clear-cutting. Journal of Hydrology, 376(1-2): 94-106.

Berger, T.W., Untersteiner, H., Schume, H. and Jost, G., 2008. Throughfall fluxes in a secondary spruce (Picea abies), a beech (Fagus sylvatica) and a mixed spruce-beech stand. Forest Ecology and Management, 255(3-4): 605-618.

Jost, G., Weiler, M., Gluns, D.R. and Alila, Y., 2007. The influence of forest and topography on snow accumulation and melt at the watershed-scale. Journal of Hydrology, 347(1-2): 101-115.

Schume, H., Hager, H., Jost, G. (2005): Water and energy exchange above a mixed European beech – Norway spruce canopy: a comparison of eddy covariance against soil water depletion measurement. Theoretical and Applied Climatology, 2005, 1-2, 87-100.

Jost, G., Heuvelink, G. B.M., Papritz A. (2005): Analysing the space-time distribution of soil water storage in a mixed European beech (Fagus sylvatica) – Norway spruce stand using spatio-temporal kriging. Geoderma, 2005, 128, 3, 258-273.

Jost, G., Schume, H., Hager, H. (2004): Factors controlling soil water recharge in a mixed European beech (Fagus sylvatica L.) – Norway spruce (Picea abies (L.) Karst.) stand. European Journal of Forestry 123, 2, 93-104.

Schume, H., Hager, H., Jost, G. (2004): Soil water dynamics and evapotranspiration in a spruce monoculture and a mixed broadleaf-conifer stand. Ekológia 22, 3, 86-101.

Schume, H., Jost, G., Hager, H. (2004): Soil water depletion and recharge patterns in mixed and pure forest stands of European beech and Norway spruce. Journal of Hydrology 289, 258-274.

Schume, H., Jost, G., Katzensteiner, K. (2003): Spatio-temporal analysis of the soil water content in a mixed Norway spruce (Picea abies (L.) Karst.)–European beech (Fagus sylvatica L.) stand. Geoderma, 112, 3-4, 273-287.

Schume, H., Hager, H., Jost, G. (2003): Soil water dynamics and evapotranspiration in a spruce monoculture and a mixed broadleaf-conifer stand. Ekológia, 22, 3, 86-101; 1335-342X

OTHER

Johnson, M., Jost, G., Ecohydrology and biogeochemistry of the rhizosphere in forested ecosystems. Forest Hydrology and Biogeochemistry: Synthesis of Past Research and Future Directions (Book Chapter)

M. Weiler, R. Pike, D. Spittelhouse, R. Winkler, D. Carlyle-Moses, G. Jost, D. Hutchinson, S. Hamilton, P. Marquis, E. Quilty, R.D. Moore, J. Richardson, P. Jordan, D. Hogan, P. Teti, and N. Coops (in press). Chapter 15 – Watershed Measurement Methods and Data Limitations. In R.G. Pike et al. (editors). Compendium of Forest Hydrology and Geomorphology in British Columbia [In Prep.] B.C. Ministry of Forests and Range Research Branch, Victoria, B.C. and FORREX Forest Research Extension Partnership, Kamloops.

PRESENTATIONS

Jost, G.; How to trees influence runoff during intense rainfall? Invited Talk. CWRA/CSHS Discussion group. April 2010.

Jost, G.; A quick hydrological screening tool to assess the impact of landscape changes on streamflow regime. Invited Talk, Pacific Climate Impact Consortium (PCIC), January 2010.

Jost, G.; Schume, H., Hager, H. The influence of tree species on soil moisture dynamics and lateral water flow during intense rainfall, AGU Conference, 2009 (talk).

Jost, G.; Moore, D.; Weiler, M.; Gluns, d.R., Alila, Y. Distributed temperature index snow melt modeling for forested watersheds. Invited Talk. CWRA/CSHS Discussion group. October 2009.

Jost, G.; Moore, D.; Weiler, M.; Gluns, d.R., Alila, Y. Trees, Snow, and Hydrologic Modeling. Invited Talk. University of Washington. Invited Talk. June 2009.

Jost, G.; Moore, D.; Weiler, M.; Gluns, d.R., Alila, Y. A Combined Statistical and Mechanistic Modeling Approach to Study the Effect of Clear- cutting in a Snow Dominated Watershed, AGU Conference, 2008 (talk).

G. Jost and M. Weiler. Modeling the spatio-temporal process variability of throughfall and transpiration in a forest ecosystems. EGU Conference, 2007 (talk).

Jost G., Weiler, M., Gluns, d.R., Alila, Y. Vegetation and terrain effects on snow accumulation and snow melt. AGU Conference, 2006 (poster).

Swedish-Canadian Workshop on Hydrology and Biogeochemistry. Department of Forest Ecology, University of Umeå, Umeå, Sweden. May 10, 2006 (talk).

Weiler, M., Jost G., Gluns, d.R., Alila, Y. Designing Experimental Watersheds to Understand and Quantify the Influence of Land-Use Management and Natural Variability on the Hydrological Response at Multiple Scales. Headwater2005: International Conference on Headwater Control VI: Hydrology, Ecology and Water Resources in Headwaters in Bergen, Norway, June 20-23 2005. Abstracts. Bergen: University of Bergen (talk).

Weiler, M., Jost G., Gluns, d.R., Alila, Y. Micro Temperature Loggers: A Cost Effective Technology to Derive Input Data for Distributed Snow Melt Models. AGU Conference, 2005 (poster).

Jost, G., Schume, H., Hager, H. (2003): Dynamics of soil water recharge under forest. In: Conference of water and society needs, challenges, and restrictions, 19-21 November 2003, Vienna (Austria), 62-63 (talk).

Jost, G., Heuvelink, G. B.M., Papritz A. (2003): Analysing the space-time distribution of soil water storage in a mixed European beech (Fagus sylvatica) - Norway spruce stand using spatio-temporal kriging. . In: Working Group on Pedometrics, IUSS (Ed.): Book of Abstracts, 5th Conference, Pedometrics 2003, 11-12 September 2003, Reading (England) (talk)..

Jost, G., Heuvelink, G. B.M., Zlatic V. (2002): Comparing the space-time distribution of soil water storage for two forest ecosystems using spatio-temporal kriging. IAMG 2002; Annual Conference of the International Association for Mathematical Geology. Berlin, Germany (talk).

Jost, G., Katzensteiner, K., Schume, H., Hager, H. (2001): Spatio-temporal analysis of the soil water content in a mixed Norway spruce (Picea abies (L.) Karst.) - European beech (Fagus sylvatica L.) stand. In: Working Group on Pedometrics, IUSS (Ed.): Extended abstract papers, 4th Conference, Pedometrics 2001,

Subproject Team: Plant Phenology and Vegetation

Gordon B. Stenhouse

Research Scientist and Program Leader

Grizzly Bear Research Program

Foothills Research Institute

Hinton, Alberta

Research and Management positions

1998 –present:	Program Leader Foothills Research Institute Grizzly Bear Program, Hinton, Alberta
1995-1998	Senior Wildlife Biologist, Weldwood of Canada, Hinton, Alberta.
1980-1995	Wildlife Biologist, various locales, Northwest Territories.

Education

1980	MSc Animal Behaviour, University of Manitoba, Winnipeg, Manitoba.
1978	BSc. Department of Biology, University of Manitoba, Winnipeg, Manitoba.

Publications:

Berland, A., T.Nelson, G. Stenhouse, K.Graham, J.Cranston. 2008. The impact of landscape disturbance on grizzly bear habitat use in the Foothills Model Forest, Alberta Canada. Forest Ecology and Management 256:1875-1883.

Boulanger, J., G.C. White, M. Proctor, G. Stenhouse, G. Machutchon, S. Himmer. 2008. Use of occupancy models to estimate the influence of previous live captures on DNA-based detection probabilities on grizzly bears. Journal of Wildlife Management 72:589-595.

Boulanger, J., M. Proctor, S. Himmer, G. Stenhouse, D. Paetkau, J. Cranston. 2006. An empirical test of DNA mark-recapture sampling strategies for grizzly bears. Ursus 17:149-158.

Boulanger, J., G. Stenhouse, R. Munro. 2004. Sources of heterogeneity bias when DNA mark-recapture sampling methods are applied to grizzly bear (*Ursus arctos*) populations. Journal of Mammalogy 85:618-624.

Boyce, M.S., J. Pitt, J.M. Northrup, A. Morehouse, K. H. Knopff, B. Cristescu, G.B. Stenhouse. 2010. Temporal autocorrection functions for movement rates from global positioning system radiotelemetry data. Philosophical Transactions of the Royal Society B 00:1-7.

Boyce, M.S., S.E. Nielsen, G.B. Stenhouse. 2009. Grizzly Bears Benefit from Forestry - Except for the Roads. BC Forest Professional. January-February:19.

Cattet, M., G. Stenhouse, and T. Bollinger. 2008. Exertional myopathy in a grizzly bear (Ursus arctos) captured by leg-hold snare. Journal of Wildlife Diseases 44:973-978.

Cattet, M., J. Boulanger, G. Stenhouse, R.A. Powell, and M.J. Reynolds-Hogland. 2008. An evaluation of long-term capture effects in Ursids: Implications for wildlife welfare and research. Journal of Mammology 89:973-990.

Cattet, M.R.L., K. Christison, N.A. Caulkett and G.B. Stenhouse. 2003. Physiologic responses of grizzly bears to different methods of capture. Journal of Wildlife Diseases 39(3):649-654.

Cattet, M.R.L., N.A. Caulkett, and G.B. Stenhouse. 2003. Anesthesia of grizzly bears using xylazine-zolazepam-tiletamine or zolazepam-tiletamine. Ursus 14(1):88-93.

Cattet, M.R.L., N.A. Caulkett, M.E. Obbard and G.B. Stenhouse. 2002. A body-condition index for ursids. Canadian Journal of Zoology 80:1156-1161.

Chow, B.A., J.W. Hamilton, D. Alsop, M. Cattet, G. Stenhouse, and M.M. Vijayan. 2010. Grizzly bear corticosteroid binding globulin: cloning and serum protein expression. General and Comparative Endocrinology (in press)

Collingwood, A., S.E. Franklin, X. Guo, and G. Stenhouse. 2009. A medium-resolution remote sensing classification of agricultural areas in Alberta grizzly bear habitat. Canadian Journal of Remote Sensing 35:23-26..

Frair, J.L., S.E. Nielsen, E.H. Merrill, S. Lele, M.S. Boyce, R.H.M. Munro, G.B. Stenhouse, and H.L Beyer. 2004. Removing GPS-collar bias in habitat-selection studies. Journal of Applied Ecology 41, 201-212.

Franklin, S.E., Y.He, A.D. Pape, and G. J. McDermid. 2010. Landsat-comparable land cover maps using the ASTER and SPOT images; a case study for large-are mapping programs. International Journal of Remote Sensing (in press).

Franklin, S. E. 2009. Remote Sensing for Biodiversity and Wildlife Management: Synthesis and Applications. McGraw-Hill Professional, New York. 346p. (http://www.mhprofessional.com/product.php?isbn=0071622470)

Franklin, S. E., P. K. Montgomery, and G. B. Stenhouse. 2005. Interpretation of land cover using aerial photography and satellite imagery in the Foothills Model Forest of Alberta. Canadian Journal of Remote Sensing 31:304-313.

Franklin, S.E., D.R. Peddle, J.A. Dechka, G.B. Stenhouse. 2002. Evidential reasoning with Landsat TM, DEM and GIS data for landcover classification in support of grizzly bear habitat mapping. International Journal of Remote Sensing 23(21):4633-4652.

Franklin, S.E., M.B. Lavigne, M.A. Wulder, and G.B. Stenhouse. 2002. Change detection and landscape structure mapping using remote sensing. The Forestry Chronicle 78(5):618-625.

Franklin, S.E., M.J. Hansen, G.B. Stenhouse. 2002. Quantifying landscape structure with vegetation inventory maps and remote sensing. The Forestry Chronicle 78(6):866-875.

Franklin, S.E., G.B. Stenhouse, M.J. Hansen, C.C. Popplewell, J.A. Dechka, D.R. Peddle. 2001. An integrated decision tree approach (IDTA) to mapping land cover using satellite remote sensing in support of grizzly bear habitat analysis in the Alberta Yellowhead ecosystem. Canadian Journal of Remote Sensing 27(6):579-592.

Gau, R.J., R. Mulders, L.M. Ciarniello, D.C. Heard, C.B. Chetkiewicz, M. Boyce, R. Munro, G. Stenhouse, B. Chruszcz, M.L. Gibeau, B. Milakovic, K. Parker. 2004. Uncontrolled field performance of Televilt GPS-Simplex collars on grizzly bears in western and northern Canada. Wildlife Society Bulletin 32:693-701.

Graham, K., J. Boulanger, J. Duval, G. Stenhouse. Spatial and temporal use of roads by grizzly bears in west-central Alberta. Ursus 21:43-56.

Hamilton, J.W. 2007. Evaluation of indicators of stress in populations of polar bears (Ursus maritimus) and grizzly bears (Ursus arctos). M.Sc. Thesis. Department of Biology, University of Waterloo, Waterloo, Ontario.

He, Y., S.E. Franklin, X. Guo, and G.B. Stenhouse. 2010. Object-oriented classification of multi-resolution images for the extraction of narrow linear forest disturbance. Remote Sensing Letters, 2(2): 147-155.

He, Y., S. E. Franklin, X. Guo, and G. B. Stenhouse. 2009. Narrow-Linear and small-area forest disturbance detection and mapping from high spatial resolution imagery. Journal of Applied Remote Sensing 3: 033570

Hilker, T., Wulder, M.A., Coops, N.C., Linke, J., McDermid, G., Masek, J., Gao, F., & White, J.C. 2009. A new data fusion model for high spatial- and temporal- resolution mapping of forest disturbance based on Landsat and MODIS. Remote Sensing of Environment 113:1613–1627

Hilker, T., Wulder, M.A., Coops, N.C., Seitz, N., White, J.C., Gao, F., Masek, J., & Stenhouse, G.B. 2009. Generation of dense time series synthetic Landsat data through data blending with MODIS using the spatial and temporal adaptive reflectance fusion model (STARFM). Remote Sensing of Environment. 113:1988-1999.

Hird, J. and G.J. McDermid, 2009: Noise reduction of NDVI time series: An empirical comparison of selected techniques. Remote Sensing of Environment, 113(1): 248-258

Hird, J.N. 2008. Noise reduction for time series of the Normalized Difference Vegetation Index (NDVI): An empirical comparison of selected techniques. MSc Thesis, Department of Geography, University of Calgary

Huettmann, F., S.E. Franklin, G.B. Stenhouse. 2005. Predictive spatial modelling of landscape change in the Foothills Model Forest. Forestry Chronicle 81:525-537.

Hunter, A. 2007. Sensory Based Animal Tracking. PhD Thesis. Department of Geomatics Engineering, University of Calgary, Calgary, Alberta, Canada.

Lindsjo, H.J.A. 2009. Development and application of a health function score system for grizzly bears (Ursus arctos) in western Alberta. MSc. Thesis. Department of Veterinary Pathology, University of Saskatchewan, Saskatoon, Saskatchewan.

Linke, J. and G.J. McDermid. A conceptual model for multi-temporal landscape monitoring in an object-based environment. Journal of Selected Topics in Earth Observation and Remote Sensing (in press).

Linke, J., G.J. McDermid, D.N. Laskin, A.J. McLane, A.D. Pape, J. Cranston, M. Hall-Beyer, and S.E. Franklin. 2009. A disturbance-inventory framework for flexible and reliable landscape monitoring. Photogrammetric Engineering and Remote Sensing 75 (8): 981-996.

Linke, J., G.J. McDermid, A.D. Pape, A.J. McLane, D.N. Laskin, M. Hall-Beyer, and S.E. Franklin. 2009. The influence of patch delineation mismatches on multitemporal landscape pattern analysis. Landscape Ecology 24(2): 157-170.

Linke, J., M. Betts, M.B. Lavigne, and S.E. Franklin. 2007. Landcape structure, function and change. Chapter 1 in Understanding Forest Disturbance and Spatial Pattern: Remote Sensing and GIS Approaches. CRC Press (Taylor and Francis), Boca Raton, 1-30.

Linke, J., and S.E. Franklin. 2006. Interpretation of landscape structure gradients based on satellite image classification of land cover. Canadian Journal of Remote Sensing 32:367-379.

Linke, J., S.E. Franklin, F. Huettmann and G.B. Stenhouse. 2005. Seismic cutlines, changing landscape metrics and grizzly bear landscape use in Alberta. Landscape Ecology 20:811-826.

Linke, J. 2003. Using Landsat TM and IRS imagery to Detect Seismic Cutlines: Assessing their Effects on Landscape Structure and on Grizzly Bear (Ursus arctos) Landscape Use in Alberta. MSc. Thesis. Department of Geography, University of Calgary, Calgary, Alberta, Canada.

Macbeth, B.J. M.R.L. Cattet, G.B. Stenhouse, M.L. Gibeau and D.M. Janz. 2010. Hair cortisol concentration as a noninvasive measure of long-term stress in free-ranging grizzly bears (ursus arctos): considerations with implications for other wildlife. Canadian Journal of Zoology 88:935-943.

McDermid, G.J., N.C. Coops, M.A. Wulder, S.E. Franklin, and N. Seitz, 2009: Critical Remote Sensing Data Contributions to Spatial Wildlife Ecological Knowledge and Management, invited chapter in F. Huettmann and S. Cushman (Eds.), Spatial Complexity, Informatics, and Wildlife Conservation, pp 193-221, Springer, Tokyo ISBN: 978-4-431-87770-7.

McDermid, G.J., J. Linke, A.D. Pape, D.N. Laskin, A.J. McLane, and S.E. Franklin. 2008. Object-based approaches to change analysis and thematic map update: challenges and limitations. Canadian Journal of Remote Sensing 34(5): 462-466.

McDermid, G.J., R.J. Hall, G.A. Sanchez-Azofeifa, S.E. Franklin, G.B. Stenhouse, T. Kobliuk, E.F. LeDrew. 2009. Remote sensing and forest inventory for wildlife habitat assessment. Forest Ecology and Management 257:2262-2269.

McDermid, G. J., S. E. Franklin, and E. F. LeDrew (in press). Radiometric normalization and continuous-variable model extension for operational mapping of large areas with Landsat imagery. International Journal of Remote Sensing 00:000-000.

McDermid, G. J., S.E. Franklin and E.F. LeDrew. 2005. Remote sensing for large-area habitat mapping. Progress in Physical Geography 29:449-474.

McDermid, G.J. 2005. Remote Sensing for Large-Area, Mult-Jurisdictional Habitat Mapping. PhD. Thesis. Department of Geography, University of Waterloo, Waterloo, Ontario, Canada.

McLane, A.J., G.J. McDermid, and M.A. Wulder, 2009: Processing discrete-return profiling LiDAR data to estimate canopy closure for large-area forest mapping and management. Canadian Journal of Remote Sensing, 35(3): 217-229.

McLane, A.J. 2007. Processing discrete-return profiling LiDAR data to estimate canopy closure for the purpose of grizzly bear management in northern Alberta. MGIS Thesis, Department of Geography, University of Calgary.

Mowat, G., D.C. Heard, D.R. Seip, K.G. Poole, G.Stenhouse, D.W. Paetkau. 2005. Grizzly *Ursus arctos* and black bear *U. americanus* densities in the interior mountains of North America. Wildlife Biology 11: 31-48.

Munro, R.H.M, S.E. Nielsen, M.H. Price, G.B. Stenhouse, M.S. Boyce. 2006. Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. Journal of Mammology 87:1112-1121.

Nielsen, S.E., G. McDermid, G.B. Stenhouse, M.S. Boyce. 2010. Dynamic wildlife habitat models: seasonal foods and mortality risk predict occupancy-abundance and habitat selection in grizzly bears. Biological Conservation 143, 1623–1634.

Nielsen, S.E., G.B. Stenhouse, J. Cranston. 2009. Identification of priority areas for grizzly bear conservation and recovery in Alberta, Canada. Journal of Conservation Planning: 38-60.

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Nielsen, S.E., G.B. Stenhouse, M.S. Boyce. 2006. A habitat-based framework for grizzly bear conservation in Alberta. Biological Conservation 130:217-229.

Nielsen, S.E., M.S. Boyce, and G.B. Stenhouse. 2004a. Grizzly bears and forestry I: selection of clearcuts by grizzly bears in west-central Alberta. Canada.Forest Ecology and Management 199:51–65.

Nielsen, S.E., R.H.M. Munro, E. Bainbridge, M.S. Boyce, and G.B. Stenhouse. 2004b. Grizzly bears and forestry II: distribution of grizzly bear foods in clearcuts of west-central Alberta, Canada. Forest Ecology and Management 199:67–82.

Nielson, S.E., M.S. Boyce, G.B. Stenhouse, R.H.M. Munro. 2003. Development and testing of phenologically driven grizzly bear habitat models. Ecoscience 10(1):1-10.

Nielson, S.E., M.S. Boyce, G.B. Stenhouse, and R.H.M. Munro. 2002. Modeling grizzly bear habitats in the Yellowhead ecosystem of Alberta: taking autocorrelation seriously. Ursus 13:45-56.

Popplewell, C., S.E. Franklin, G.B. Stenhouse, and M. Hall-Beyer. 2003. Using landscape structure to classify grizzly bear density in Alberta Yellowhead Ecosystem bear management units. Ursus 14: 27-34.

Proctor, M., B. McLellan, J. Boulanger, C.Apps, G. Stenhouse, D. Paetkau, and G. Mowat. 2010. Ecological investigations of grizzly bears in Canada using DNA from hair, 1995-2005: a review of methods and progress. Ursus 21:169-188.

Roever, C.L., Boyce, M.S., and G.B. Stenhouse. 2010. Grizzly bear movements relative to roads: applicatoin of step selection functions. Ecography 33:1-10.

Roever, C.L., M.S. Boyce, G.B. Stenhouse. 2008. Grizzly bears and forestry I: Road vegetation and placement as an attractant to grizzly bears. Forest Ecology and Management 256:1253-1261.

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Schwab, C., B. Cristescu, M.S. Boyce, G.B. Stenhouse, M.Ganzle. 2009. Bacterial populations and metabolites in the feces of free roaming and captive grizzly bears. Canadian Journal of Microbiology 55:1335-1346.

Smulders, M., T.A. Nelson, D.E. Jelinski, S.E. Nielsen, G.B. Stenhouse. 2010. A spatially explicit method for evaluating accuracy of species distribution models. Diversity and Distributions 16:996-1008.

Stenhouse, G.B., J. Boulanger, M. Cattet, St.Franklin, D.Janz, G.McDermid, S.Nielsen, M.Vijayan. 2008. New Tools to Map, Understand, and Track Landscape Change and Animal Health for Effective Management and Conservation of Species at Risk. Final Report for Alberta Advanced Education and Technology and Alberta Sustainable Resource Development. 391 pp.

Stenhouse, G.B., J. Boulanger, J. Lee, K. Graham, J. Duval, J. Cranston. 2004. Grizzly bear associations along the eastern slopes of Alberta. Ursus 16:31-40.

Stenhouse, G.B., and K.Graham. (Eds.). 2010. Foothills Research Institute Grizzly Bear Program 2009 Annual Report. 144 pp.

Stenhouse, G.B., and K.Graham. (Eds.). 2009. Foothills Research Institute Grizzly Bear Program 2008 Annual Report. 166 pp.

Stenhouse, G.B., and K.Graham. (Eds.). 2008. Foothills Model Forest Grizzly Bear Research Program 2007 Annual Report. 206 pp.

Stenhouse, G.B., and K.Graham. (Eds.). 2007. Foothills Model Forest Grizzly Bear Research Program 2006 Annual Report. 67 pp.

Stenhouse, G.B. and K.Graham. (Eds.). 2005. Foothills Model Forest Grizzly Bear Research Program 1999-2003 Final Report. 289 pp.

Stenhouse, G.B., R. Munro and K.Graham. (Eds.). 2003. Foothills Model Forest Grizzly Bear Research Program 2002 Annual Report. 162 pp.

Stenhouse, G.B., R. Munro. (Eds.). 2002. Foothills Model Forest Grizzly Bear Research Program 2001 Annual Report. 126 pp.

Stenhouse, G. and R. Munro. (Eds.). 2001. Foothills Model Forest Grizzly Bear Research Program 2000 Annual Report. 87 pp.

Stenhouse, G. and R. Munro. (Eds.). 2000. Foothills Model Forest Grizzly Bear Research Program 1999 Annual Report. 98 pp.

Wang, K., S.E. Franklin, X. Guo, A.Collingwood, G.B. Stenhouse, S. Lowe.2010. Comparison of Landsat multispectral and IRS panchromatic imagery for landscape pattern analysis of grizzly bear habitat in agricultural areas of western Alberta. Can.J.Remote Sensing: 36:36-47.

Wasser, S.K., B. Davenport, E.R. Ramage, K.E. Hunt, M. Parker, C. Clarke, and G.B. Stenhouse. 2004. Scat detection dogs in wildlife research and management: Application to grizzly and black bears in the Yellowhead Ecosystem, Alberta, Canada. Canadian Journal of Zoology 82:475-492.

Gregory J. McDermid
Assistant Professor, Department of Geography,

University of Calgary

mcdermid@ucalgary.ca

403-220-4780

EDUCATION

University

PhD (Geography), Environmental Studies, University of Waterloo, 2006

Dissertation: *Remote Sensing for Large-area, Multi-jurisdictional Habitat Mapping*

MSc (Geography), Remote Sensing, University of Calgary, 1993

Thesis: *Remote Sensing of Slope Processes*

BSc (Honours Geography), University of Calgary, 1991

Focus: *Physical Geography*

ACADEMIC APPOINTMENTS

Associate Professor of Geography, University of Calgary, 2010-present

Assistant Professor of Geography, University of Calgary, 2005-2010

Sessional Lecturer, Department of Geography, University of Calgary, 2003-2005

SCHOLARSHIP

Journal Publications

Musiani, M., M. Anwar, G.J. McDermid, M. Hebblewhite, and D. Marceau, 2010: How humans shape wolf behavior in Banff and Kootenay National Parks, Canada. *Ecological Modelling*, 221: 2374-2387.

Stewart, B.P., M.A. Wulder, G.J. McDermid, and T. Nelson, 2010: Disturbance capture and attribution through the integration of Landsat and IRS-1C imagery. *Canadian Journal of Remote Sensing*, 35(6): 523-533.

Nielsen, S.E., G.J. McDermid, G.B. Stenhouse, and M.S. Boyce, 2010: Dynamic wildlife habitat models: Seasonal foods and mortality risk predict occupancy-abundance and habitat selection in grizzly bears. *Biological Conservation*, 143(7): 1623-1634.

Linke, J. and G. J. McDermid, 2010: A conceptual model for multi-temporal landscape monitoring in an object-based environment. *Journal of Selected Topics in Applied Earth Observation and Remote Sensing*, doi: 10.1109/JSTARS.2010.2045881.

Wang, K., S.E. Franklin, X. Guo, Y. He, and G.J. McDermid, 2009: Problems in remote sensing of landscapes and habitats. *Progress in Physical Geography*, 33(6): 747-768, doi:10.1177/0309133309350121.

McLane, A.J., G.J. McDermid, and M.A. Wulder, 2009: Processing discrete-return profiling LiDAR data to estimate canopy closure for large-area forest mapping and management. *Canadian Journal of Remote Sensing*, 35(3): 217-229.

Hilker, T., M.A. Wulder, N.C. Coops, J. Linke, G.J. McDermid, J.G. Masek, F. Gao, and J.C. White, 2009: A new data fusion model for high spatial- and temporal-resolution mapping of forest disturbance based on Landsat and MODIS. *Remote Sensing of Environment*, 113(8): 1613–1627, doi:10.1016/j.rse.2009.03.007.

Linke, J., G.J. McDermid, D.N. Laskin, A.J. McLane, A.D. Pape, J. Cranston, M. Hall-Beyer, and S.E. Franklin, 2009: A disturbance-inventory framework for flexible and reliable landscape monitoring. *Photogrammetric Engineering and Remote Sensing*, 75(8): 981-996.[1]

McDermid, G.J., R.J. Hall, G.A. Sanchez-Azofeifa, S.E. Franklin, G.B. Stenhouse, T. Kobliuk, and E.F. LeDrew, 2009: Remote sensing and forest inventory for wildlife habitat assessment. *Forest Ecology and Management*, 257(11): 2262-2269, doi:10.1016/j.foreco.2009.03.05.

Hird, J. and G.J. McDermid, 2009: Noise reduction of NDVI time series: An empirical comparison of selected techniques. *Remote Sensing of Environment*, 113(1): 248-258, doi:10.1016/j.rse.2008.09.003.

Linke, J., G.J. McDermid, A.D. Pape, A.J. McLane, D.N. Laskin, M. Hall-Beyer, and S.E. Franklin, 2009: The influence of patch delineation mismatches on multi-temporal landscape pattern analysis. *Landscape Ecology,* 24(2): 157-170, doi:10.1007/s10980-008-9290-z.

McDermid, G.J., J. Linke, A.D. Pape, D.N. Laskin, A.J. McLane, and S.E. Franklin, 2008: Object-based approaches to change analysis and thematic map update: challenges and limitations. *Canadian Journal of Remote Sensing*, 34(5): 462-466.

McDermid, G.J. and I.U. Smith, 2008: Mapping the distribution of whitebark pine (*Pinus albicaulis*) in Waterton Lakes National Park using logistic regression and classification tree analysis. *Canadian Journal of Remote Sensing*, 34(4): 356-366.

Hebblewhite, M., E. Merrill, and G.J. McDermid, 2008: A multi-scale test of the forage maturation hypothesis in a partially migratory ungulate population, *Ecological Monographs*, 78(2): 141-166, doi:10.1890/06-1708.1.

McDermid, G.J., S.E. Franklin, and E.F. LeDrew, 2005: Remote sensing for large-area habitat mapping. *Progress in Physical Geography*, 29(4): 449-474.

Harris, S.A. and G.J. McDermid, 1998: Frequency of debris flows on the sheep mountain fan, Kluane Lake, Yukon Territory. *Zeitchrift fur Geomorphologie*, 42: 159-175.

[1] Recipient of a 2010 ERDAS Award for Best Scientific Paper in Remote Sensing (3rd place)

Miller, J.R., H.P. White, J.M. Chen, G.J. McDermid, D.R. Peddle, R. Fournier, P. Sheperd, I. Rubenstein, J. Freemantle, R. Soffer, and E.F. LeDrew, 1997: Seasonal change in understory reflectance for boreal forests and influence on canopy vegetation indices. *Journal of Geophysical Research*, 102(29): 475-482.

McDermid, G.J. and S.E. Franklin, 1995: Remote sensing and geomorphometric discriminators of slope processes. *Zeitchrift fur Geomorphologie*, 101: 165-185.

Franklin, S.E., M.B. Lavigne, B.A. Wilson, E.R. Hunt, D.R. Peddle, G.J. McDermid, and P.T. Giles, 1995: Topographic dependence of synthetic aperture radar imagery. *Computers and Geoscience*, 21(4): 521-532.

McDermid, G.J. and S.E. Franklin, 1994: Spectral, spatial and geomorphometric variables for the remote sensing of slope processes. *Remote Sensing of Environment*, 24: 1-15.

Bowers, W., S.E. Franklin, J. Hudak, and G.J. McDermid, 1994: Separation of structural damage classes in balsam fir stands using SPOT satellite panchromatic and multispectral image patterns and semivariance. *Canadian Journal of Remote Sensing* 48(1): 28-36.

Franklin, S.E. and G.J. McDermid, 1993: Empirical relations between digital SPOT HRV and CASI imagery and lodgepole pine forest stand parameters. *International Journal of Remote Sensing* 14(12): 2331-2348.

Book Chapters

McDermid, G.J., N.C. Coops, M.A. Wulder, S.E. Franklin, and N. Seitz, 2009: Critical Remote Sensing Data Contributions to Spatial Wildlife Ecological Knowledge and Management, invited chapter in S. Cushman and F. Huettmann (Eds.), *Spatial Complexity, Informatics, and Wildlife Conservation*, pp 193-221, Springer, Tokyo ISBN: 978-4-431-87770-7.

Publications Pending

Franklin, S.E., Y. He, A.D. Pape, G.J. McDermid, and X. Guo: Landsat-comparable land cover maps using the ASTER and SPOT images: a case study for large-area mapping programs. *International Journal of Remote Sensing,* in press.

Bater, C.W., N.C. Coops, M.A. Wulder, T. Hilker, S.E. Nielsen, G.J. McDermid, and G.B. Stenhouse. Using digital time-lapse cameras to monitor species-specific understorey and overstorey phenology in support of wildlife habitat assessment. *Environmental Monitoring and Assessment,* in press.

Coops, N.C., T. Hilker, C.W. Bater, M.A. Wulder, S. Nielsen, G.J. McDermid, G. Stenhouse: Linking ground-based to satellite-derived phenological metrics in support of habitat assessment. *Remote Sensing Letters*, in press.

Castilla, G., J. Linke, A.J. McLane, and G.J. McDermid. The effect of landscape-sample displacement on pattern indices. *Canadian Journal of Forest Research*, in review.

Bater, C.W., N.C. Coops, M.A. Wulder, S, Nielsen, G.J. McDermid, and G.B. Stenhouse. Design and installation of a phenological camera network across an elevation gradient for habitat assessment. *Computers and Electronics in Agriculture*, in review.

McLane, A.J., C. Semeniuk, G.J. McDermid, and D. Marceau. The role of agent-based models in wildlife ecology and management: The importance of accommodating individual habitat-selection behaviours and spatially explicit movement for conservation planning. *Ecological Modelling*, in review.

Chen, G., K. Zhao, and G.J. McDermid. The influence of sampling density on geographically weighted regression: a case study using forest canopy height and optical data. *International Journal of Remote Sensing*, in review.

Polfus, J., A. J. McLane, G. J. McDermid, M. Hebblewhite, R. Tingey, and K. Heinemeyer: Remote sensing-based land cover classification to support northern woodland caribou conservation. *Canadian Journal of Forest Research*, in review.

Hird, J.N. and G.J. McDermid. NDVI time series and the remote sensing of vegetation phenology: Questioning the benefits of noise reduction. *Remote Sensing of Environment*, in review.

Curriculum Vitae

Scott Nielsen, PhD.

Department of Renewable Resources

University of Alberta

751 General Services Building

Edmonton, AB   T6G 2H1

Phone: 780.492.1656

E-mail: scott.nielsen@ales.ualberta.ca

Academic position

2008–present: Assistant Professor of Conservation Biology- Department of Renewable Resources, University of Alberta, Edmonton, Alberta.

Education

2000–2005 Ph.D. in Environmental Biology & Ecology, Department of Biological Sciences, University of Alberta.

1995–1997 M.Sc. in Natural Resources, College of Natural Resources, University of Wisconsin-Stevens Point.

1990–1995 B.Sc. in Biology (emphasis in ecology & botany), Univ. of Wisconsin-Stevens Point.

Teaching (University of Alberta)

Instructor for ENCS 364 (Principles of Managing Natural Diversity) and RenR 401 (Special topics: Conservation Planning).

Membership in scientific societies and organizations

The Wildlife Society (Executive member of the Alberta Chapter), Society for Conservation Biology, Sigma Xi, Alberta Native Plant Council, and Phi Kappa Phi Honor Society.

Research interests

My interests most broadly fit in the field of conservation biology and more specifically include: species habitat and species distribution modeling, biogeography, landscape ecology, wildlife ecology and management (particularly grizzly bears), restoration ecology, and conservation planning. My most significant contributions have been in the topics of: A. Grizzly bear habitat and population ecology; B. maladaptive habitat selection and habitat traps; C. resource selection functions and species distribution modeling; and D. restoration and ecology of oak and pine barrens.

Current graduate student projects

Claudia Lopez, Ph.D. candidate (2008-present). Individual-based models linking behaviour and impacts of development on grizzly bear (*Ursus arctos*) populations in Alberta.

Sean Coogan, M.Sc. candidate (2010-present). Grizzly bear (*Ursus arctos*) nutritional ecology of west-central Alberta.

Krista Fink, M.Sc. candidate (2009-present). Habitat and conservation ecology of greater short-horned lizards (*Phrynosoma hernandesi*) in Grasslands National Park. Co-supervised with Shelley Pruss.

James Glasier, M.Sc. candidate (2009-present). Community ecology of ants (Hymenoptera: Formicidae) on semi-forested sand hills of Alberta. Co-supervised with John Acorn.

Kim Ives, M.Sc. candidate (2009-present). Patterns of arrival and behavioural interactions within a community of scavengers in alpine and foothills environments.

Kristine Teichman, M.Sc. candidate (2009-present). Long-term cougar (*Puma concolor*) range contraction and expansion and its cascading effects on ground and shrub nesting birds in North America. Co-supervised with Jens Roland.

Carl Morrison, M.Sc. candidate (2010-present). Local and landscape factors affecting cougar (*Puma concolor*) distribution in the Cypress Hills of Saskatchewan. Co-supervised with Mark Boyce.

A selection of refereed publications (of 22 total)

Nielsen, S.E., McDermid G., Stenhouse, G.B. & Boyce, M.S. (2010) Dynamic wildlife habitat models: Seasonal foods and mortality risk predict occupancy-abundance and habitat selection in grizzly bears. *Biological Conservation*, 143, 1623–1634.

Nielsen, S.E., Cranston, J. & Stenhouse, G.S. (2009) Identification of priority areas for grizzly bear conservation and recovery in Alberta, Canada. *Journal of Conservation Planning,* 5, 38–60.

Nielsen, S.E., Boyce, M.S., Beyer, H., Huettmann, F. & Stenhouse, G.S. (2008) Can natural disturbance-based forestry rescue a declining population of grizzly bears? *Biological Conservation*, 141, 2193–2207.

Nielsen, S.E., Boyce, M.S. & Stenhouse, G.B. (2006) A habitat-based framework for grizzly bear conservation in Alberta. *Biological Conservation*, 130, 217–229.

Munro, R.H.M., Nielsen, S.E., Price, M.H., Stenhouse, G.B. & Boyce, M.S. (2006) Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. *Journal of Mammalogy,* 87, 1112–1121.

Gillies, C.S., Hebblewhite, M., Nielsen, S.E., Krawchuk, M.A., Aldridge, C.L., Frair, J.L., Saher, D.J., Stevens, C.E. & Jerde, C.L. (2006) Application of random effects to the study of resource selection by animals. *Journal of Animal Ecology*, 75, 887–898.

Johnson, C.J., Nielsen, S.E., McDonald, T.L., Merrill, E. & Boyce, M.S. (2006) Resource selection functions based on use-availability data: theoretical motivation and evaluation methods. *Journal of Wildlife Management*, 70, 347–357.

Nielsen, S.E., Johnson, C., Heard, D.C. & Boyce, M.S. (2005) Can models of presence-absence be used to scale abundances? Two case studies considering extremes in life history. *Ecography*, 28, 197–208. *High Impact Paper* in Ecography 2005.

Nielsen, S.E., Boyce, M.S. & Stenhouse, G.B. (2004) Grizzly bears and forestry I: selection of clearcuts by grizzly bears in west-central Alberta, Canada. *Forest Ecology and Management*, 199, 51–65.

Nielsen, S.E., Munro, R.H.M., Bainbridge, E., Boyce, M.S. & Stenhouse, G.B. (2004) Grizzly bears and forestry II: distribution of grizzly bear foods in clearcuts of west-central Alberta, Canada. *Forest Ecology and Management*, 199, 67–82.

Nielsen, S.E., Herrero, S., Boyce, M.S., Benn, B., Mace, R.D., Gibeau, M.L. & Jevons, S. (2004) Modelling the spatial distribution of human-caused grizzly bear mortalities in the Central Rockies Ecosystem of Canada. *Biological Conservation*, 120, 101–113.

Frair, J.L., Nielsen, S.E., Merrill, E.H., Lele, S., Boyce, M.S., Munro, R.H.M., Stenhouse, G.B. & Beyer, H.L. (2004) Approaches for removing GPS-collar bias in habitat-selection studies. *Journal of Applied Ecology*, 41, 201–212.

Nielsen, S.E., Kirschbaum, C.D. & Haney, A. (2003) Restoration of Midwest oak barrens: Structural manipulation or process-only? *Conservation Ecology* 7(2), 10.

Nielsen, S.E., Boyce, M.S., Stenhouse, G.B., & Munro, R.H.M., (2003) Development and testing of phenologically driven grizzly bear habitat models. *Ecoscience*, 10, 1–10.

Boyce, M.S., Vernier, P.R., Nielsen, S.E. & Schmiegelow, F.K.A. (2002) Evaluating resource selection functions. *Ecological Modelling,* 157, 281–300.

3. **CV's of Mountain Pine Beetle Research Team:**

ALLAN L. CARROLL, Associate Professor

University of British Columbia, Department of Forest Sciences

Faculty of Forestry, 2424 Main Mall, Vancouver, BC Canada V6T 1Z4

Education

Forest Entomology – Ph.D.	University of New Brunswick,	1993
Biological Science – B.Sc.	Simon Fraser University,	1988

Related Work Experience

Associate Professor	University of British Columbia	2009 – present
Research Scientist	Pacific Forestry Centre	1997 – 2009
Adjunct Professor	University of Victoria	2007 – present
Adjunct Professor	University of Northern British Columbia	2004 – present
Adjunct Professor	University of Alberta	2003 – 2007
Adjunct Professor	Memorial University of Newfoundland	1994 – 2001
Research Scientist	Atlantic Forestry Centre	1993 – 1997
Research Assistant	University of New Brunswick	1989 – 1993
Research Assistant	Simon Fraser University	1987 – 1989

Research:

Publications:		*Presentations:*		*Grants:*	
Refereed Journals:	35	Keynote/plenary:	15	External (26):	$4,786,675
Book Chapters:	9	Invited:	71	CFS Internal (5):	$405,000
Proceedings:	21	Contributed:	45	Total (29):	$5,191,675
Technical Reports:	12				

Teaching: Awards:

Mentoring/Training			
Postdoctoral Associates:	3	Chaire internationale, Université Libre de Bruxelles	2010
Completed Graduate Students:	6 (M.Sc.)	NRCan Award of Excellence	2008
Graduate Student Committees:	10	Canadian Forest Service Merit Award	2007, 2008
		NSERC Post-Doctoral Fellowship	1993
		Fraser Prize for Excellence in Forestry	1993
		NSERC Post-Graduate Scholarship	1991-1993
		CFS/NSERC Supplemental Award	1991, 1992, 1993
		Fraser Presentation Award	1989, 1990, 1991, 1992

Relevant Publications (last 5 years)

Scientific journals

Smith, G.D., Carroll, A.L. and Lindgren, B.S. 2011. Facilitation in bark beetles: endemic mountain pine beetle gets a helping hand. *Agric. For. Entomol.* 13: 37-43.

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