CFS Activities Relevant to ABoVE

(Maximum 2 page)

1. Project Title
Spruce resilience to abiotic stresses correlative of climate change
2. Investigators (include email). **a) Project Lead;** **b) CFS collaborators,** **c) external collaborators (individuals/institutions)**
a) Nathalie Isabel **b) Martin Girardin** **c) Martine Savard (GSC), Ingo Ensminger (U of Toronto), Jean Bousquet (ULaval), Joerg Bohlmann (UBC), Janice Cooke (U Alberta),** **Arthur Gessler (Swiss Federal Research Institute Forest, Snow and Landscape research)**
3. Project Description (200 words maximum)
Understanding climate change impacts and providing suitable mitigation responses are critical priorities for forest managers and policy makers. Predicting tree responses to changes in their local environment is a key to decision-making in tree breeding, forest resource management, carbon accounting models, and biodiversity conservation practices. Making genotype-phenotype-environment connections is central to these predictions. However, association between genotypes and environments using available genomic approaches neglects to evaluate phenotypic traits potentially under selection and suffers from confounding factors such as demographic history. The goal of this project is to 1) identify candidate genes and gene networks for traits related to resilience to abiotic stress, 2) use a novel retrospective approach to ascertain environmental factors that determine the ecological niche of white spruce, and 3) build genomic selection model systems for improvement of abiotic stress resilience. Connecting genotypes with phenotypes is also an additional challenge for precise estimation of genetic differentiation for quantitative traits in thousands of individuals. Phenotyping is a major bottleneck, and there is an urgent need to both refine and scale up phenotyping methods. We will develop high-throughput phenotyping methods by establishing quantitative relationships between **drought resistance** and **nutrient use efficiency (NUE)** traits and needle optical properties (spectral data). We will 1) develop algorithms for pattern recognition from spectral data, 2) estimate vegetation indices from spectral data, and 3) provide algorithms for multi-temporal analysis of spectral data to infer genotypic variation in foliage response to drought events. Also, we will use dendroclimatology to establish a relationship between tree growth performance and past weather- and climate-related environmental conditions to determine which conditions impact tree growth performance across its lifespan.

4. Timelines and current funding (level and source)

GRDI (2015-2019) : $800K
Genome Ontario (2016-2018): pending ($200K)
Genome Canada (2016-2020): pending ($ 2000 K)

5. Reference (1-2 key publication, website)

- Warren, R et al. 2015. Improved white spruce (*Picea glauca*) genome assemblies and annotation of large gene families of conifer defense metabolism. The Plant Journal. 83:189-212
- Pavy, N, B Pelgas, J Laroche, P Rigault, **N Isabel**, J Bousquet. (2012). A spruce gene map indicates ancient plant genome reshuffling and slow evolution in the gymnosperm lineage leading to extant conifers. BMC Biology 10(1):84

http://smartforests.ca/en-ca/home.aspx

6. ABoVE question being mainly addressed (please highlight)

1. How are environmental changes affecting critical ecosystem services - natural and cultural resources, human health, infrastructure, and climate regulation - and how ***are*** **human societies** responding?

2. What processes are contributing to changes in **disturbance** regimes and what are the impacts of these changes?

3. What processes are controlling changes in the distribution and properties of **permafrost** and what are the impacts of these changes?

4. What are the causes and consequences of changes in the **hydrologic system**, specifically the amount, temporal distribution, and discharge of surface and subsurface water?

5. How are **flora and fauna** responding to changes in biotic and abiotic conditions, and what are the impacts on ecosystem structure and function?

6. How are the magnitudes, fates, and land atmosphere exchanges of **carbon** pools responding to environmental change, and what are the biogeochemical mechanisms driving these changes?

7. Linkages with ABoVE:

- **a. Data being collected/generated**
- **b. Expected key benefits and potential challenges from collaborating with ABoVE**
- **c. Ongoing and / or interest in future involvement in ABoVE**

a. *Phenology* and in particular transition periods -leaf flush (spring), growing season peak, decline in photosynthetic activity (autumn) and other phenological events, and *Extreme events* -heat waves, drought, or abnormal precipitation.
Canopy multi- and hyperspectral characteristics, in situ measurements of individual seedlings spectral properties and fluorescence, laboratory analysis of leaf pigments and water content, and multi-variable regressions linking spectral, physiological and genotypic data for each individual trees.

b. Develop algorithms for pattern recognition from spectral data, 2) estimate vegetation indices from spectral data, and 3) provide algorithms for multi-temporal analysis of spectral data to infer genotypic variation in foliage response to extreme events.

c. Deliver new methods and tools to monitor and better predict resilience to abiotic stresses. Modern imaging and measurement technology will permit to measure complex phenotypes and rapidly phenotype large numbers of plots and field trials. Based on this innovative technology, we will develop precision phenotyping methods for boreal tree species.