CIF/IFC e-Lecture Series: Innovative Solutions to Respond to the Challenges of a Changing Climate

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Presenters: Patrick Lenz, Tim Keddy, Natalie Isabel (absent), Jeff Fera, Mike Hoepting, Mike Cruikshank, Cosmin Filipescu, Janet Cooke, Michele Fullarton, and John Pedlar
Hello! Today’s e-lecture, will highlight the collaborative work being conducted in developing strategies for a sustainable fibre supply and bio-economy by the Canadian Wood Fibre Centre.

The CWFC’s mission is to provide collaborative scientific solutions supporting the forest sector as the cornerstone of an innovative, prosperous Canadian bio-economy. To get a better understanding of the forest sector’s perspective, CWFC met with the forest sector to identify what they perceive as CWFC’s supporting role. Some of the items that were identified include; develop tree improvement tools and techniques, supporting tomorrow’s bio-economy, and addressing the quantity and quality of the fibre supply.

Leading some of this work for CWFC and more importantly, leading today’s e-Lecture entitled “Connecting Future Fibre Supply to Genetics, Silviculture and a Changing Climate” is Patrick Lenz.

Slide 2: Patrick studied wood sciences in his hometown Hamburg (Germany) with a major in wood biology and cambial activity under cold temperatures. After graduation in 2006, he started his PhD in “Quantitative genetics of wood properties” at Laval University, Québec (supervisor John MacKay, co-supervised by Jean Beaulieu and Alain Cloutier). During graduate studies and postdocs he gained knowledge in genomics and its application to a tree breeding context. Since summer 2015, he is a research scientist at the CWFC in quantitative genetics and tree genomics. His research focusses on wood quality, its genetic control and developing approaches how to integrate wood traits into tree breeding programs. He is involved in the FastTRAC project and Co-PI of the Spruce-UP project, two large Genome Canada funded projects in the field of forest genomics.

Slide 3: Hello everybody thanks for tuning in today and thanks to Tim for the great introduction. It’s almost unfair to see my name on the presentation as we will hear from many different colleagues and their work. In the next 45 minutes or so we will hear about research spanning the entire country, on different species, ecosystems with a diversity of partners and stakeholders. They all share the aim to improve future fibre supply by finding appropriate stand establishment practices.

Slide 4: The work is part of the collaborative research project “Stand establishment practices for resilient forests” within the overall Fibre Center research program: Sustainable Fibre Solutions. Of course, there are more outputs such as you heard on silvicultural solutions by Jean-Martin Lussier a
couple of weeks ago. In our particular CRP, key research topics are around: genomic tools for tree breeding, assisted migration, but also work related to competition control, optimal stocking under future conditions or silvicultural tools to make stands more resilient to pest and disease.

Slide 5: Many of our deliverables are in close link with other CFS programs, such as Forest Climate Change, Sustainable Forest Management or Pest and Risk Management.

Slide 6: When I was first approached to lead this component in the CWFC, my first ideas how to achieve future fibre supply were related to my genetics background. (Need of tree improvement for production of planting stock to allow sufficient and good quality fibre). However, CC will force us to continuously alter our focus traits and also the way how we manage our plantations. To start off with superior stock we need flexible breeding approaches that allow for rapid selection of material with preferred traits. Genomic selection modelling and prediction will allow us to adapt quickly.

Slide 7: I presented about a year ago at the CIF on genomic tools for tree improvement and I do not want to go into much depth today. However, the Fibre Centre is very committed in supporting and in contributing to major largescale and applied genomic projects. Thus, I summarize the genomics activities in a couple of slides.

One of the main projects is the FastTRAC, co-lead by CWFC and Laval. It aims at implementing Genomic selection into spruce breeding programs in NB and QC. We are working very closely with breeders to perform genomic prediction in active breeding populations. The graph on the right hand side simply illustrates, that genomic prediction based on markers will cut the time needed to propagate new selected material in three.

Slide 8: The other very important project is the Spruce-Up project lead by Laval and UBC whereas Nathalie and I are co-applicants. The general goal is the improved characterization of spruce breeding populations and genomic selection of complex traits. Which traits are we looking at? Drought resistance and nutrient use efficiency which are traits that may help us to better understand resilience and select for trees that may be better off to cope with CC.
Besides traits for climate resilience we are also looking at wood property traits that will improve end-products: stiffness and uniformity, but also stem form and branching. Also bioprocess traits are on our radar, such as biomass estimates and bio-chemical composition. We most likely also want to select for growth, but a need for a diversification of the product basket is thought to present a

Slide 10: This presents a couple of major projects we are involved in but is by far not the entire picture of what we need for a resilient fibre supply in the future. Some key questions arise after we planted our high quality seedlings: how do we actually manage those plantations and forests optimally? What risks are brought to our stand through CC. How much will trees react to climate change? I think at least some of those questions my colleagues will be able to answer in the upcoming part.

So one of the questions that we are working to answer is “how can we identify what risks and potential opportunities may arise in the future associated with a changing climate”? I would like to ask Jeff Fera of CWFC to identify how we are moving forward on providing answers.

Jeff

This project is lead by CWFC forest research officers Jeff Fera and Mike Hoepting.

The Petawawa Research Forest (PRF) is located in Chalk River, ON, (2 hrs west of Ottawa). The PRF was established in 1918 and is the oldest continuously operated research forest in Canada.

The PRF is approximately 10,000 hectares in size and serves as a living laboratory for ongoing forest research focussing on silviculture, genetics, forest fire, growth and yield and enhanced forest inventory methods and modelling.

Slide 12: A Vulnerability Assessment for Climate Change is described by Parry et al. as “The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate vulnerability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity”
The objective of the project can be boiled down to “given a changing climate, how can we continue to sustainably manage the forest, given the dramatic climatic uncertainty”.

To guide us through the process we are using the CCFM’s Climate Change and Sustainable Forest Management in Canada guidebook.

Slide 13: A first step has been to work with Dr. Isabelle Aubin and Laura Boisvert-March, from the CFS to identify stands within the forest which are “sensitive” to a changed climate given CC model RCP 8.5.

Other climatic scenarios to be assessed, insect, fire, frost and all of the other horse men.

Slide 14: The vulnerability assessment for climate change at the PRF will provide information on how the various forest stand conditions found within the PRF area are able to cope with the change in climatic growing conditions; survival, growth and yield and migration. Novel silviculture treatments will developed and evaluated for their ability to adapt existing and new forest stand types to a changing climate. Silvicultural treatments will be explored through conceptual modelling exercises and targeted field trials. A conceptual framework being used by the USDA Forest Service ASCC project at several sites across the US and the Forets’adapter group in Southern Quebec will be used to guide the creation of adaptive treatments. This framework develops and tests silviculture treatment packages along an adaptation gradient that includes 1) no action, 2) resistance, 3) resilience, and 4) transition (Nagel et al. 2017). The objective will be that one or more of the adaptive silviculture treatments will be incorporated in operational forest management planning for each forest type through the next iteration of the SFMP for the PRF. (Partners Slide 15)

The work being completed by Mike Hoepting of CWFC and his team looking at enhancing forest productivity, value, and health through silviculture will help us ensure that we are keeping an eye on the past as we move forward!

Mike, can you give us an overview of the types of studies that you are looking at and what we have learned from this retrospective analysis?

Mike

Slide 16: My role within this larger project is to manage a portfolio of studies across a range of forest types, ages, and silviculture systems. While each is different they all have some common objectives. As a package they aim to help forest managers grow productive, healthy, and economically viable stands by
working to identify the optimal timing and intensity of vegetation management and density regulation. Vegetation management is used to influence early stand establishment and development. Density regulation either through initial spacing, pre-commercial thinning or commercial thinning is largely employed to reduce time to merchantability. Partial harvesting, such as used in the white pine uniform shelterwood system, is another approach to density regulation and for managing white pine regeneration. Study sites are located far and wide. The bigger star in the middle represents four studies at the Petawawa Research Forest.

Slide 17: Of course given the duration of these studies, I was not the one who set them all up, but I do certainly consider myself fortunate to have an ongoing role. Principle study design and installation credits go to folks like Gordon Baskerville, Will Stiell, Lorne Brace, Darwin Burgess, and the most recent retiree of the bunch, Doug Pitt, plus there would be a very long list of individuals who were or are significant collaborators. Also, as we all know, everything has a cost so the generous financial and in-kind support of these organizations and companies, among many others, has been greatly appreciated.

I was asked to present some preliminary results but rather than taking a study by study approach, I will provide a couple highlights of recent activities, areas where we are currently focusing on analyses, and where we’re looking at going in the near future.

Slide 18: To start, in conjunction with our University of Alberta collaborators, lead by Phil Comeau, we completed the 15th year assessments at the Whitecourt, AB installation of the Regenerating Boreal Mixedwoods study. Funding from the Forest Resource Improvement Association of Alberta supported this work and will also support analyses.

This past fall we reached another major milestone with a second study. In close co-operation with JD Irving, we conducted the final removal overstory harvest at the New Brunswick shelterwood installation of the White Pine Competition study. Immediately following the harvest, Isabelle Duchesne’s group collected wood samples to evaluate growth and climate relationships. The study’s 72 plots will get re-established in the coming year so monitoring can continue to document the growth of the regen and long-term effects of the early vegetation control treatments. We will also explore overlaying a PCT or cleaning study on the trial in the next couple years.

Slide 19: As for analyses the main focus right now is completing a summary of growth results from a 60 year old red pine initial spacing and commercial thinning trial. This study had eight initial spacings and since 1982 has had 4 commercial thinning entries completed to up to three target basal areas. Right
now, because of incomplete replication, we are focusing our analyses on the 1.2 to 3 m spacings that had thinned and unthinned pairs. As I mentioned before, a main function of thinning is to reduce time to merchantability which this trial has clearly demonstrated with larger trees in wider spacings and larger trees produced through thinning. For example if one had a target tree size of 25 cm, this was only achieved by 60 years in the unthinned 2.4 and 3 m spacings. With thinning this target is achieved in all spacings by age 60. Prior to the last thinning we also evaluated utility pole potential across all the studies PSPs and combined with predicted sawlog volumes this will help quantify product potential and therefore indicate value generated by the treatments.

Slide 20: The next piece I want to highlight is work by Isabelle Aubin and Kierann Santala, collaborators from the Great Lakes Forestry Centre. They are enhancing some of our core silviculture work by taking a functional traits approach to looking at the long-term effects of silviculture practices that are designed to enhance the success of tree regeneration on understory plant communities. This work is being done in two ways.

First, they analyzed the 10 years of vegetation cover data we had from the white pine competition study. A draft paper is nearly ready to send for review but briefly the results are showing that when both herbaceous and woody competitors are suppressed early, rather than one or the other, there is the greatest growth benefit to the target pine and the quickest non-pine community recovery.

For the second thrust, in 2016 and 2017 they assessed the structural and functional composition in two white pine shelterwood studies around 20 years after the initial site prep and veg management treatments. One study was the Meridian Rd shelterwood trial at the PRF, the other is the very closely related trial near Britt, ON. The assessment technique used provides a description of not just how much vegetation is there but also its vertical stratification. This will allow for a more comprehensive description of the vegetation community developments. Stay tuned for more results from this work.

Slide 21: Finally, I wanted to quickly share a new idea of where we may be going. We are having some ongoing discussions about establishing a Green River 2.0. For those not familiar, Green River 1, was a long-term trial set up to investigate PCT spacing in balsam fir dominated stands in New Brunswick. In 2008 through a large collaborative effort half of the study was harvested and the full value chain effects quantified (production, rot, harvesting, products, value). The regenerating stands are now 10 years old and provide an interesting opportunity to re-establish new treatments on these sites with a key factor being previous management history. Also because balsam fir
is expected to be sensitive to a changing climate, we want to explore spacing treatments that may improve resilience while also focusing on wood production. With the right set up this could serve as a platform for years to come upon which to look at these core questions but also conduct other research whether it be by us, academia or others.

Tim

Thanks guys! Very Interesting!

Keeping with the retrospective approach, I would like to ask Patrick to present his and Natalie Isabel’s work in determining relationships between tree growth performance and past weather- and climate-related environmental conditions.

Patrick for Nathalie

Slide 22: Yes, as mentioned, the goal is to establish a relationship between tree growth performance and past weather- and climate-related environmental conditions.

Slide 23: A pilot study was conducted on Eastern White Pine and we evaluated;

a) Basal area increment
b) Growth response to past extreme climatic events
c) Climate sensitivity: relationship between growth time-series and climate

Slide 24: The advantages of this is;

A) Identification of climatic constraints affecting growth
B) Retrospective analysis throughout the life span of trees
C) Analysis of intra-annual and seasonal climate sensitivity

Slide 25: One site we used is a Provenance progeny test established in 1979, that includes 214 open-pollinated families from 43 natural populations consisting 1,694 trees genotyped for 6,385 SNPs (existing Silviscan dataset)

Slide 26: The first step was to select provenances (among the 43 provenances) exhibiting contrasting response to drought events. This selection based on responses differences among provenances and families for wood density, resilient components.

Slide 27: 2017 sampling included 3 families per provenance; 6 provenances.

We are all aware that there is a lot of historical and active tree improvement information and research sites located
across Canada. I would like to ask Michele Fullarton of New Brunswick Department of Energy and Resource Development to provide an example of how this tree improvement information and ongoing research is being incorporated into industry operations.

Michele

Thank you!

Slide 28: New Brunswick has had a Tree Improvement program in place for over 40 years. We have been producing improved seedlings for reforestation on Crown land since the early 1990’s. ERD currently produces about ~20 million seedlings annually, about ⅔ of which are wS. The other species produced are black spruce, red spruce and Norway spruce.

Slide 29: The province is currently participating in a 3 year research project called FASTTRAC with industry, the Federal government and Laval University. This project is using genomic profiles of mature trees in a given population. Mathematical models are then built to link the genomic profile of each tree to their genetic trait values. These would be tree volumes, wood density, stem diameter or pest resistance. Research has already shown that the results from genomic selection are reliable and young trees from your population can be rapidly assessed without field testing over a 10-20 year period. For this project, Norway spruce and white spruce were the target species.

Slide 30: When the project started in 2015, foliar samples were taken from wS clonal tests which included some of the 1st generation wS selections. Subsequently, more sampling was completed in 2017 to include the entire 2nd generation plus tree population. This will augment the initial samples and provide the basis for a genomic sampling tool relevant to our future breeding and testing program. The results will be available in March 2018 and we plan to immediately apply them to our breeding and testing operations.

Slide 31: The goal of the project is to use the information generated from the models to apply to our field operations. By getting a ranking of wS orchard clones, we can:

1. Rogue the seed orchards
2. Collect only the top clones in the seed orchard
3. By using the genotyping results from the model, this eliminates establishing an OP test series of orchard clones and waiting 10 years for data. This saves both time and money.
Tim
Thanks Michele!

To show that we are not totally eastern biased, let’s go west ask Cosmin Filipescu of the CWFC to showcase some of the work that the CWFC and the Cedar Research Working Group have been involved in!

Cosmin

Slide 32: Cedar
High-value species, BC only
Importance;
  a) Indigenous People: social and cultural
  b) Ecological: wildlife habitat and ecological resilience
  c) Economic: Revenues (estimated at over $1B annually, 1900 jobs)

Slide 33: Cedar Research Working Group: platform for collaboration, research and practice, knowledge transfer, anchored in reality
  - Several pieces fitting together in the puzzle: projects are interconnected – goes down to stand establishment (what we plant, where we plant, in what growing conditions) – Management practices, Climate change and Genetics are all related

Slide 34: Management options: stump removal and species mixtures; wood density and physiological implications

Slide 35: Heartwood Extractives: important for durability, need a better understanding in second-growth – role of growth rate and site characteristics

Slide 36: Climate change: sensitivity to climate variables, signals for where to manage the species going forward

Slide 37: Decay dynamics: better understanding of what fungi are involved in decay and screen genetic families for resilience

Slide 38: Economic analysis: several recent products delivered, and some ongoing work

And staying in the west, I would like to ask Mike Cruickshank of CWFC to present on his work on douglas fir!

Mike

Slide 39: Control tree stress through:
1) Genetics and ecology
2) Modelling disease impact
3) Disease control - Sanitation – impact and economics

1) Genetics

Need to produce trees that maximize wood quality, survival, and yield. Particularly challenging is predicting trees that can handle several types of disturbance.

Slide 40: Project goals:

- identify half-sibling trees and traits that help cope with stress from common biotic abiotic agents (drought, two root diseases, Douglas-fir beetle fungus).
- determine wood quality and yield traits.
- investigate the relationship between tree resistance and tolerance to several stress agents and determine their frequency in a larger population
- determine the cost of resistance and tolerance to growth.
- understand all objectives from an ecological perspective.

Slide 41: Results:

- None of the families does well with all the stresses; however, host resistance maybe correlated with drought tolerance.
- Resistance alone was the least frequent strategy for one trial.
- Half siblings differ in growth response to some climate variables which affects wood quality.

- Strong resistance may be correlated with reduced wood quality of timber products.
- There was a cost to growth for tolerance and resistance; cost for tolerance before the stress and resistance cost after stress. Both strategies have costs and benefits.
- The choice of one or the other strategy (R or T) is complex and depends on the frequency and severity of the stress agent over time.

Slide 42: Users: Provincial tree breeders and licensees who do planting operations. Also supports communities by building
stands that have resilient trees to many agents and that are viable ecologically and economically.

2) Modelling

Project goals:

- Model the spread of Armillaria Root Disease belowground and integrate this with the BC Ministry of Forests stand simulator TASS which simulates the aboveground growth.

Slide 43: Results

- Simulator established using sampled data from about 13 sampled sites plus published data.
- Impacts have been used in at least 5 timber supply reviews so far.
- Impacts range from 32-67% by age 100 depending on the level of starting inoculum.

Users: Provincial government and consultants doing TSR.

Slide 44: 3) Sanitation

Goals: to control the largest disturbance problem for Douglas-fir using sanitation by root removal of diseased stumps.

Slide 45: Results:

- A long-term study provided stump removal data over 50 years, and then modelling was used to assess the impact and economics over 100 years.
- Productivity was 1.5 to 2 times greater by age 50 after stump removal for Douglas-fir and larch
- Stump removal is an economically viable option depending on the site index.
- Stump removal sites also store considerably more carbon.

Users: Provincial forest health personnel and licenses establishing new Douglas-fir stands.

Tim

Thanks guys!

So, you have heard today about research that we are conducting involving almost every commercial softwood species in Canada. And to continue on that theme, I would like to ask Janice Cooke of the University of Alberta to update us on her research on the genomics of western gall rust resistance in lodgepole and jack pine!
Thanks Tim/Patrick. Western gall rust is a disease of hard pines caused by the fungus Endocronartium harknessii, and is found across Canada. Two of the main hosts are lodgepole pine (pictured on the left) and jack pine (pictured on the right).

Our main goal is to develop genomic tools that can be used to select for western gall rust resistance in breeding programmes, and to do this we have three main objectives:

- Use association genetics to identify genetic architecture.
- Use genomic selection to calculate breeding values.
- Identify DNA markers that can be used in tree improvement programmes.

The partners on this project are Deogratias Rweyongeza and Andy Benowicz from the Alberta Tree Improvement and Seed Centre.

My collaborators are quantitative geneticists Rong-Cai Yang and Patrick Lenz, and pathologists Tod Ramsfield and Colin Myrholm.

A number of people in my lab have participated in this project. Chandra McAllister plays a lead role.

We started the project off by using microsatellite analysis to look at DNA variability in E. harknessii samples from across western and central Canada. These analyses showed that there are two very clear populations of E harknessii over this range. The western population correlates with the range of lodgepole pine, and the eastern population correlates with the jack pine range.

This suggests that there is a coevolutionary relationship between western gall rust populations and their pine hosts.
To look at this further we tested the relative pathogenicity of *E. harknessii* spores collected from western populations and eastern populations on seedlings of lodgepole, hybrid, and jack pine provenance material. These stacked bar graphs show the progression of disease symptoms over 24 weeks, starting with early signs of infection through to the manifestation of galls.

Slide 53:

We see clear evidence that lodgepole pine is more susceptible to infection than jack pine with either source of inoculum, and that it is most susceptible to the western population of *E. harknessii*. On the other side of the coin, jack pine shows very little susceptibility to the western population of *E. harknessii*, and more susceptibility to the eastern population. Hybrids are intermediate.

So this gives us more evidence to suggest that there is a coevolutionary relationship between the pine hosts and their pathogen populations. It tells us that identifying resistance in lodgepole pine is going to have the greatest impact in a breeding programme, and it also tells us that comparing jack pine with lodgepole pine might reveal genetic mechanisms of resistance.

Slide 54:

So we just finished a massive resistance screen of about 2000 lodgepole and hybrid seedlings. There is a considerable spectrum of susceptibility to western gall rust across these families. Some of the most resistant families are ringed in green boxes, and some of the most susceptible families are ringed in red boxes. We’re now processing this material for genetic analyses.

Slide 55:

We wanted to know whether our seedling resistance screen reflected disease susceptibility patterns for mature trees, and from this graph you can see that there is a good correlation between the disease indices for seedling material and mature trees from the same family out in the field. This gives us confidence that resistance that is detected in seedlings under controlled growth conditions translates reasonably well to mature trees in the field.

Slide 56:

So once all of the DNA is ready later this spring, these samples will be sent away for DNA marker analysis using a genotyping chip developed by Sally Aitken’s group. We validated this chip by analyzing nearly 4000 individuals from
different projects, and from this we identified a robust set of SNPs to use in the present analyses. Even though the chip was originally designed for lodgepole pine, we were pleased to find out that we can also use it for jack pine and hybrids. We used some fairly stringent procedures to identify about 20000 high quality robust SNPs for lodgepole pine, about 10000 high quality robust SNPs for jack pine, and about 17000 for hybrids.

Slide 57:
So before the end of 2018, we expect to have all of the disease index and DNA marker data so that we can start the association genetic and genomic selection analyses.

Tim
Wow Janice! That is pretty cool.

Looking forward, we all are asking ourselves how a changing climate will affect future forest management activities and what can we do to ensure that the today’s silviculture treatments are able to survive and thrive in the future. The CWFC is collaborating with Dan McKenney and his team in developing tools to evaluate and predict the risks associated with a changing climate. John, can you give us a summary of the work going on in Dan’s group?

John
Thanks Tim!

Slide 58: Under projected levels of climate change, forests planted today are expected to experience significant climate change as they grow. Since different seed sources are best suited to different climate conditions, a certain level of climate change adaptation can be effected by selecting seed sources that are expected to grow well under future climate. Our work with the CWFC explores the biophysical and economic trade-offs associated with climate-smart seed source decisions, with a focus on developing tools and approaches to help in this context. Partners in this work include the CWFC (of course!), the Ontario Ministry of Natural Resources and Forests, various universities (including Lakehead and U of G), the US Forest Service, and NGOs including Forests Ontario and the Forest Gene Conservation Authority.

Slide 59: Much of our work with CWFC has focused on our Seedwhere software. This is a tool that allows users to identify pixels across an area of interest that are climatically similar to a location of interest. The analysis is based on a Gower metric which can include any number of climate variables and varies between 0 and 1. Analyses can be
undertaken with or without climate change: for example, in the top map shown here, warm colored pixels indicate locations with climate that is similar to the point of interest in the absence of climate change; in the middle map, warm colors indicate locations that currently have climate that is similar to the climate projected for the point of interest in the next 30 years – in other words, locations from which suitable seeds could be procured for planting today; conversely, the bottom map shows locations that, in the future, are projected to have climate similar to that currently found at the point of interest – in other words, potential planting sites for seed deployment from the location of interest. We have recently made a number of improvements to the Seedwhere software that I will talk about in the next few slides.

Slide 60: This slide illustrates several recent upgrades to the Seedwhere software. A number of these upgrades are display-related: to help orient users geographically, Seedwhere is now linked to an underlying GIS database that displays roads, cities, and political boundaries; a table is provided showing climate values at the location and across the area of interest; users can download results from an analysis; and the point of interest and the region of interest can now be selected by either entering the coordinates by hand or through mouse controls. From a functional perspective, we have incorporated an option for users to set cutoffs for each climate variable of interest. This would be used in cases where users have knowledge about the transfer limits of a particular species. In the example shown here, only locations with mean annual temperature within 2°C and annual precipitation within 200 mm of the seed collection location are shown as possible planting sites.

Slide 61: As noted, the basic Seedwhere analysis employs a Climate Similarity Index, which assumes that local climate is optimal for matching seed sources and planting sites. However, the use of provenance data allows more complex growth-climate relationships to be elucidated and mapped. Using provenance data, we have developed Universal Response Functions for black spruce and white pine. These functions have been incorporated into Seedwhere and allow users to estimate the expected growth of any seed source at any planting site. Shown here is a URF-based analysis showing potential planting sites under climate change for white pine seeds originating near North Bay, Ontario. Note that, in this case, the optimal planting sites are actually located south of seed source origin (the lime-green colored pixels). This is the opposite of a simple climate matching approach (which would almost certainly dictate a northward seed transfer) and is driven by provenance data that suggests that white pine growing in the northern portion of their range – i.e., locations such as North Bay - actually prefer much warmer temperatures than they currently inhabit. Such populations may experience improved growing conditions under a certain degree of climate change... assuming precipitation levels remain adequate.
I’d like to mention a few other efforts that we have undertaken over the past year in the area of forest regeneration under CC. First, we have been closely involved with the Ontario Ministry of Natural Resources and Forests in their ongoing efforts to develop a new seed transfer system; this included helping to organize a seed transfer workshop this past summer here at GLFC. We have also provided several talks on the subject of forest regeneration under a changing climate, including a CIF lecture in November. I already mentioned several recent Seedwhere upgrades, but significant time and resources have also gone into getting Seedwhere back online under new federal cyber security rules... and I’m happy to announce that, barring any unforeseen problems, Seedwhere should be back online by the end of this fiscal year. Finally, we have started to analyze survival data from provenance studies in order to get a sense of how far seed sources can be moved before significant declines in survival are encountered. To date, we have carried out preliminary analyses for 7 boreal tree species. Shown here is a graph for Lodgepole pine using data shared with us by Greg O’Neill from BC Ministry of Forests – briefly, the graph shows that Lodgepole pine seeds can be moved nearly 4 C northward before showing a 10% decline in survival as compared to planting them locally. This suggests that significant seed transfers can occur with relatively small impact on near-term seedling survival, which may facilitate the assisted migration of seed sources under climate change.

Patrick

Slide 63: That is great John!

Thank You/Merci!