Strategic Project Grants Progress Report

Due Date: **June 30, 2017**
Covers the Period: **September 30, 2015 to June 30, 2017**

Is your personal information below correct? (please enter an "x" in the appropriate box)

	Yes
x	**No** (please make the necessary corrections)

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Is the project information below correct?

x	**Yes**
	No (please make the necessary corrections)

Project title: Designing successful forest renewal practices for our changing climate

File Number: STPGP 478832 - 15

Co-investigator(s):

L.M. Lavkulich, Land and Food Systems, British Columbia
W.W. Mohn, Microbiology and Immunology, British Columbia
J. Pither, Biology, Okanagan, British Columbia
J.D. Karst, Renewable Resources, Alberta

Collaborator(s):

Cathy Koot, Alex Fraser Research Forest, Williams Lake, B.C.
Sue Grainger, John Prince Research Forest, Fort St. James, B.C.
Tyler Hodgkinson, Kalesnikoff Lumber Co. Ltd, Thrums, B.C.
Kori Vernier, Canfor Corp., Cranbrook, B.C.
Randy Waterous, Interfor Corp.,Castlegar, B.C.
Rob Ballinger, West Fraser Mills, 100 Mile House, B.C.
Erik Leslie, Harrop-Proctor Community Forest, Harrop, B.C.
Rene Pike, B.C. Timber Sales, Merritt, B.C.
First Nations groups

Supporting Organization(s):

D.E. Bakker, Brinkman & Associates Reforestation Ltd
G. O'Neill, B.C. Ministry of Forests, Lands and Natural Resource Operations
Jena and Michael King Foundation
Columbia Basin Trust

Forest Enhancement Society of B.C.
(The latter three organizations were not identified in the grant proposal).

1. Progress Towards Objectives/Milestones

Using approximately 5 pages, please provide in the box below:

- a brief description of the overall objectives of the research project as awarded;
- the list of milestones as presented in the application and a description of the progress made towards each milestone/objective during the period covered by this report; and
- a description and justification for any deviations from the original objectives and a discussion of the path forward.

Long-term objectives:
(1) To develop new understanding and adaptive, innovative methods for improved forest regeneration during climate change.
(2) To identify key indicators of success for forest regeneration, productivity, resilience, carbon cycling, and maintenance of diversity (taxonomic, phylogenetic, functional).
(3) To communicate the results to government and industry so they can be immediately integrated into forest policy and practice.

Short-term objectives:
(1) Renewal methods: To design and test novel forest renewal methods, including variable retention harvesting and seedling establishment in multi-species mixtures, which increase the diversity, productivity and success of forest regeneration.
(2) Legacies: To investigate the role of legacy trees (healthy, stressed and dying) in forest regeneration, including their ability to promote the success of new generations of seedlings through maintenance of beneficial soil properties, including root symbionts.
(3) Seed sources: To investigate the performance of locally-sourced versus genetically selected seed provenances, during the first few years post-plantation, enabling selection of optimal mixtures of natural and genetically selected seeds.
(4) Integration: To investigate the effects of novel forest renewal methods on seedling regeneration, soil carbon storage and nutrient cycling by microbes, productivity and biodiversity, and use this synthesis to formulate recommendations for best practices.

Milestones
(The dates in parentheses are the anticipated completion dates in the original proposal)

Advance planning (Mar 31, 2016): Acquisition and stratification of seed sources; Ordering of seedlings for plantation experiments; Determination of final field locations with assistance of partners. Activities were completed by Dec, 2016.

Legacy tree survey (Aug 31, 2016): Legacy trees and seedlings in core of sites tagged, sized, aged, mapped; foliage, bole cambium, root cambium sampled following bud burst; root system architecture described; ECM tubercules and fine roots sampled to assess functional properties of mycorrhizas. In progress.

Field site establishment (Aug 31, 2016): (CxH) Delineate experimental sites (100% completed by June 30, 2017); conduct initial diversity assessments and pre-harvest structural composition data (50% completed by June 30, 2017)*; collect locally-sourced seed (not completed**); sample microbial communities and soil nutrients (50% completed by June 30, 2017); assist with oversight of harvesting treatments (40% completed by June 30, 2017; harvesting is ongoing).

*The preharvest assessments were completed for three sites in one climate location by August 31, 2016, but the selection of the remaining 12 sites (four climate locations) was still underway. The delay was due to the time required to develop relationships with the licensees and research forests, review their logging plans together with our climate envelope mapping, and collaborate with the licensees and research forests on the final site selection. This was a lengthy but highly successful process and we were able to complete all of it by the midterm report. Because the site selection was more time consuming than we expected, the preharvest assessments and sampling is being completed in the spring and summer of 2017. All sites are on track to be harvested in the fall of 2017, as originally planned.
**Collection of local seed from the harvest areas was not done due to timing logistics. Seed would have to have been collected in early fall 2016, but we had not yet finalized all of the site locations. Instead, we are using local seed from the provincial registry.

Initiation of greenhouse experiments 1 & 2 (May 31, 2016): Collection of soil for greenhouse experiments related to Objective 3 Exp. 1 and Exp. 2; planting of seed for both Experiments. All activities completed on time.

Field experiment installation (Sep 30, 2016): RxMN) Installation of mesh-lined cylinders; sowing of seed; planting of seedlings (these 3 activities to be done spring 2018)*. Installation of weather stations and soil monitoring probes and data loggers; begin collection of PAR, soil volumetric water content, and soil nutrient availability data (these activities are all in progress; to be completed Sept 2017).
*As described above, due to greater amount of time required to select sites than anticipated, the installation of the field experiment, including installing the mesh cylinders, sowing of seed and planting of seedlings will be completed in the spring of 2018.

DNA and soil analyses I (Apr 30, 2017)*: Rhizosphere community sequencing (100% completed); soil chemical analysis (in progress, 50% completed); legacy tree and ECM tubercule microsatellite DNA sequencing (in progress, 50% completed); prepare manuscript on rhizosphere communities of CxH (in progress, 25% completed); prepare manuscript on genetic structure of legacy host and symbiont populations (in progress; 25% completed).
*As described above, sampling for this milestone was delayed due to the logistics of site selection. However, this milestone is well under way toward completion and will be completed as planned in 2017.

Integration of Year 1 field data (Apr 30, 2017): Analysis of diversity data from different sources; initial community assembly randomizations; prepare manuscript on multiple biodiversity components of CxH treatments (in progress).*
*We are in the process of collecting the diversity data. Because the analysis and manuscript flow from the data we are collecting, these activities are also delayed. However, they will be completed in Dec 2017, after all pretreatment data is collected.

Completion of greenhouse experiments 1 & 2 (Mar 31, 2017): Stable isotope probing and harvesting of greenhouse experiments; measurement of growth traits, isotope content, defense enzymes + ECM colonization; prepare manuscripts on RxMN effects on signal transfer under different levels of density and herbivory. All of these milestones were completed by June 30, 2017, except the density manuscript, which is still in progress.

ExL and fungal biomass experiment installation (May 14, 2017): (ExL) Sowing of seed; planting of seedlings; burying of mesh bags for fungal biomass collection; burying of litter bags (in progress).*

*This milestone and associated activities have not been fully completed yet. We have ordered the materials and constructed the mesh bags, but they have not yet been installed at the field sites. The field installation was delayed because harvesting was delayed due to the extended site selection process. All of these activities will be completed in the spring of 2018.

Monitoring I (Aug 31, 2017): Seedling survival, growth and health recorded; rhizosphere microbial communities sampled; soil core sampling. *The monitoring of seedlings and sampling of rhizosphere microbial communities and rhizosphere soils have been delayed because harvesting and planting has been delayed as explained above. This milestone and all of the activities will be completed following planting, which will occur in early spring 2018. The anticipated completion date of this milestone and all associated activities is Aug 31, 2018.

Field legacy SIP experiment (Mar 31, 2018): Initiation of tree girdling; SIP at 0, 1, 3, 12 months; seedling harvest for IRMS analysis; foliage samples collected; seedling rhizosphere samples collected; 13C-DNA amplicon sequencing; prepare manuscript on legacy tree impacts on seedlings and microbes. In progress.This milestone will be completed by August 31, 2018.

Field seed source SIP experiment (Aug 1, 2017): Initiation of seedling 13C-CO2 labeling experiment; defoliation followed by labeling and harvesting; and analyzed for 13C, defense enzymes and mycorrhizal fungi. In progress. Pilot lab and field studies have been completed for this milestone. However, the completion of all activities will be done after the planting has been completed in the spring of 2018.

DNA and soil analysis 2 (Apr 30, 2018): Rhizosphere community sequencing; soil chemical analysis; isotope analyses of seedlings and ECM fungi with IRMS; defense enzyme analyses; prepare manuscript on fungal biomass in CxH treatments; prepare manuscript on field seed source SIP experiment. The milestone and all associated activities will be completed in 2018, following planting.

Integration of Year 2 field data (Apr 30, 2018): Analysis of diversity data from different sources; comparison between years 1 and 2; community assembly randomizations; prepare manuscript on multi-year biodiversity components of CxH and RxMN treatments. This milestone will be completed following planting in 2018.

Monitoring 2 (Aug 31, 2018): Seedling survival, growth and health recorded; rhizosphere microbial communities sampled; soil core sampling. Not started. This milestone will be completed by Aug 31, 2018.

Seedling harvest (Aug 31, 2018): Harvest of sub-sampled seedlings in each treatment; growth, biomass, foliar element analysis, isotope abundance, and foliar defense enzyme measurements; amplicon sequencing of root DNA; prepare manuscripts on results of ExL and RxMN treatments. Not started. This milestone will be completed by Aug 31, 2018.

Synthesis (Mar 31, 2019): Analysis of diversity data from all field seasons; final data analysis and dissemination of information; prepare manuscripts on multi-year biodiversity data; synthesis manuscript to be co-written with partners on results of SPG analyses. Not started. This milestone will be completed by March 31, 2019.

DNA and soil analyses 3 (Mar 31, 2019): Sequencing and analysis of rhizosphere communities; chemical analysis of soil samples; prepare manuscript comparing rhizosphere communities between mature trees and seedlings across all treatment. Not started. This milestone will be completed by March 31, 2019.

There are no deviations from the original objectives. However, we had to delay planting and harvesting due to the extended site selection process, as described in Section 5 below; this has resulted in delays in the other activities. We had originally planned to select five climate regions (each with three replicate sites) for the project but instead have selected six climatic regions (each with three replicate sites). The Forest Enhancement Society of BC will be providing $700,000 towards the project over two years (July 1, 2017–June 30, 2019), which will allow us to set up three additional sites and conduct the following additional activities: detailed carbon budget and modelling with LANDIS, wildlife assessments; fire hazard assessments; additional extension including production of a 25 minute documentary film.

The lengthy site selection and harvest planning processes are not surprising given the complexity of working with multiple collaborators who are operating under their own constraints that are beyond our control. For example, once the 18 sites were selected, cutting permits, cutting boundaries and silviculture prescriptions all required revision, which triggered a number of additional reviews within the companies, research forests and community forests. The NSERC review team anticipated that these processes would be time consuming and difficult, and from the outset expected that some of the milestones may be delayed as a result. The review team also suggested that we apply for a one-year extension to the project, which is wise. I did contact NSERC in March 2016 to request this one-year extension, but I was advised that my request should be made at the mid-term report submission in June 2017 instead. To that end, I would like to apply for a one year extension to this project.

2. Research Team

Please provide an overview of the participation in, and scientific contributions to, the project for each member of the research team (principal investigator, co-investigators, collaborators, company and government scientists, research associates, postdocs, students, etc.).

Suzanne Simard (Principal investigator) – Project leader, overall management of work, technical and professional advisor, supervision of students, supervision of student research, liason with licencees, research forests and FLNRO, site selection, field work

Jean Roach (Research associate) – Project management including budgeting, meeting organization, planning, site selection, management of field work, field measurements, training students, assisting graduate students, working with licensees and research forests

Erica Xie (Research technician) – Mapping research plots

Brian Pickles - Project development, project implementation advice, contributing mycorrhizae and AMAT study expertise (now stationed in Britain)

Jason Pither (Co-PI)– Supervision of biodiversity work and weather station deployment, data management, project implementation advice

Les Lavkulich (Co-PI) – Co-supervision of graduate students Asay and DeFrenne, contributing soils expertise and project implementation advice

Jason Karst (Co-PI) – Supervision of graduate student Joseph Cooper, project implementation advice

Bill Mohn (Co-PI) – Microbiology expert, co-upervision of graduate student Gabriel Orrego

Tyler Hodgkinson (Kalesnikoff Lumber) – Providing research site locations, contributing to harvesting treatment prescription development, treatment block layout, overseeing harvesting

Kori Vernier and Paul Freeze (Canfor) – Providing research site locations, contributing to harvesting treatment prescription development, treatment block layout, overseeing harvesting

Cathy Koot (Alex Fraser Research Forest) - Providing research site locations, contributing to harvesting treatment prescription development, treatment block layout, overseeing harvesting

Sue Grainger and Dexter Hodder (John Prince Research Forest) - Providing research site locations, contributing to harvesting treatment prescription development

Randy Waterous (Interfor) - Providing research site locations, contributing to harvesting treatment prescription development

Lennart Holm (West Fraser Mills) - Providing research site locations, contributing to harvesting treatment prescription development

Rene Pike (BC Timber Sales) - Providing research site locations, contributing to harvesting treatment prescription development

Deb McKillop (FLNRO, Kootenay-Boundary Regional office) – Assisting in finding site locations in the Kootenay Region, providing advice regarding project implementation

Nina Sigloch (FLNRO, Thompson-Okanagan Regional office) – Assisting in contacting licensees in the Thompson-Okanagan Region

Louise deMontigny (FLNRO, headquarters office) – Providing advice during project implementation

Greg O'Neill (Tree Improvement Branch, FLNRO) – Providing advice during project implementation and seedling ordering

Deborah Bakker, Timo Schrieber, Robert Seaton and Dirk Brinkman (Brinkman and Associates) – Providing practical advice during project development and implementation, working with licensees to find sites

David Isaac (W Dusk Group) – Liasing with First Nations, communicating project to First Nations

Teresa Ryan (Post doctoral fellow) – Liasing with First Nations, communicating project to First Nations

Monika Gorzalek (PhD candidate) – Kin-selected defense signalling in Douglas-fir through mycorrhizal networks. Field seed source SIP experiment (objective 3) and greenhouse kin - pest injury-defense experiment 2 (objective 3).

Amanda Asay (PhD candidate) – Kin selection in Douglas-fir, including investigations of tree population genetics, density dependence and interspecific competition. Greenhouse kin-density experiment 1 (objective 3).

Camille DeFrenne (PhD candidate) – Douglas-fir fine root and mycorrhizal fungal traits, foraging strategies and plasiticity across the climatic gradient. Field survey (objective 2).

Dixi Ghael (PhD student) – Analyzing soil microbial communities and interaction mechanisms in adult tree rhizospheres. Field survey (objective 2).

Gabriel Orrego (MSc student) – Investigating the effects of mycorrhizal networks of legacy trees on understory regeneration. Field survey and and field legacy SIP experiment (objective 2).

Joseph Cooper (Msc student) – Investigating effects of climate, time and neighbours on the architecture of ectomycorrhizal networks of Douglas-fir. Field survey (objective 2).

Jessica Fostvedt (MSc student) – Investigating effects of climate on understorey seedling regeneration and mycorrhizal colonization in Douglas-fir. Field survey (objective 2).

Huamani Orrego (MSc student) – Investigating the role of forest legacy retention (Mother Trees) in socio-ecological linkages in First Nations communities and their conservation in forest renewal practices. Integration (objective 4).

Yifan Sun (undergraduate) – BSF Thesis project, completed in April 2017. Relationships between interior Douglas-fir (*Pseudotsuga menziesii*) fine root biomass and soil properties across a climatic gradient in southern-central British Columbia.

Tayler McCord (undergraduate) – BSF Thesis project, completed in April 2017. The effects of clearcut harvesting on understory plant communities in British Columbia forests.

Eva Snyder (undergraduate) – field and lab work

Alexia Constantinou (undergraduate) – field and lab work

Rachel Green (undergraduate) – field and lab work

Sophie Vanderbanck (undergraduate) – field and lab work

Abbey Clancy (undergraduate) – field and lab work

Joshua Green (undergraduate) – field and lab work

Dan Malvin (undergraduate) – field and lab work

Alex Girard (undergraduate)– field and lab work

Josh Friedman (undergraduate)– field and lab work

Luca Marsaglia (undergraduate)– field and lab work

Volunteers - 58 undergraduates have assisted with field and lab work for a total contribution of 1080 hours (names and other details available upon request).

3. Training

Please list **each** trainee (Undergraduate Students, Master's Students, Doctoral Students, Postdoctoral Fellows, Research Associates, Technicians …) on a separate line in the table below providing: a) the number of years they have been on the project, b) the percentage (%) of time each type of trainee spent on this project, and c) the percentage (%) of funding from this strategic grant. If a trainee is fully paid from other sources, enter "0" in the "% of funding from this grant" column. Insert additional rows if necessary. (DO NOT INCLUDE PERSONAL NAMES.)

Specify type of trainee (e.g. M.Sc., Ph.D. etc) **(one trainee per line)**	**(a) Number of calendar years on the project**	**(b) % of research time spent on this project**	**(c) % of salary from this grant**
Undergraduate	0.25	100	100
Undergraduate	0.5	100	100
Undergraduate	0.5	100	100
Undergraduate	1	100	100
Undergraduate	1	100	100
Undergraduate	1	100	100
Undergraduate	1	100	100
Undergraduate	1	100	100
Undergraduate	1.75	100	100
Undergraduate	0.75	100	0
Undergraduate	0.75	100	0
M.Sc.	0.25	100	100
M.Sc.	0.25	100	0
M.Sc.	0.25	20	0
M.Sc.	1	100	0
M.Sc.	1	100	50
M.Sc.	1.75	100	100
Ph.D.	1.75	100	0
Ph.D.	1.75	100	0
Ph.D.	1.75	100	100
Ph.D.	1.75	100	100
Ph.D.	1.75	100	100
Post doc	1.75	25	25
Technician	1	100	25
Research associate	1.75	100	100

4. Dissemination of Research Results and Knowledge and/or Technology Transfer

4.1 Please provide the number of publications, conference presentations, and workshops to date arising from the research project supported by the grant in the table below.

Publications, Conference Presentations, etc.

None to date

- OR -

Status	Number of publications, presentations...		
	Refereed Journal Articles	**Conference Presentations/ Poster**	**Other (including Technical Reports, Non-Refereed Articles, etc.)**
Accepted/Published	7	23	22
Submitted	0	0	2

4.2 Please provide the bibliographical reference data for the above publications, conference presentations and workshops under the corresponding headings. For publications, specify whether submitted, accepted or published.

Included in this list are publications, conference presentations, workshops and other reports and media etc. where this project has been presented and discussed since its inception in September 2015. The published articles we present below discuss the scientific basis and inspiration for the project, but do not necessarily contain data specifically collected in the study sites since we are not yet at that stage.

Refereed Journal Articles:

Beiler, K.J., Simard, S.W. and D.M. Durall. 2015. Topology of *Rhizopogon* spp. mycorrhizal meta-networks in xeric and mesic old-growth interior Douglas-fir forests. Journal of Ecology, 103(3): 616-628.

Gorzelak, M., Pickles, B.J., Asay, A.K. and S.W. Simard. 2015. Inter-plant communication through mycorrhizal networks mediates complex adaptive behaviour in plant communities**.** Annals of Botany Plants 7: plv050.

Pickles, B.J. and S.W. Simard. 2017. Mycorrhizal networks and forest resilience to drought. In: Johnson, N.C., Gehring, C. and Jansa, J. (eds.). Mycorrhizal Mediation of Soil – Fertility, Structure, and Carbon Storage. Elsevier, Amsterdam, pp. 319-339. ISBN 9780128043127

Pickles, B.J., Wilhelm, R., Asay, A.K., Hahn, A., Simard, S.W., and W.W. Mohn. 2016. Transfer of 13C between paired Douglas-fir seedlings reveals plant kinship effects and uptake of exudates by ectomycorrhizas. New Phytologist, 214: 400-411.

Simard, S.W. 2017. The mother tree. K. Verlag and the Haus der Kulturen der Welt, Berlin. Springer, A.S. and Turpin, E. (eds.). The Word for World is Still Forest. ISBN 978-3-9818635-0-5

Simard, S.W., Asay, A.K., Beiler, K.J., Bingham, M.A., Deslippe, J.R., He, X., Philip, L.J., Song, Y. and F.P. Teste. 2015. Resource transfer between plants through ectomycorrhizal networks. In: Mycorrhizal Networks. T. R. Horton (ed.). Springer, Netherlands. Ecological Studies 224, pp. 133-176. ISBN 978-94-017-7394-2

Song, Y.Y., Simard, S.W., Carroll, A., Mohn, W.W. and R.S. Zheng. 2015. Defoliation of interior Douglas-fir elicits carbon transfer and defense signaling to ponderosa pine neighbors through ectomycorrhizal networks. Nature / Sci. Rep. 5, 8495; DOI:10.1038/srep08495 (2015).

Conference Presentations/Poster:

Asay, A., Simard, S.W., Aitken, S., Durall, D.M., Dudley, S., Pickles, B.J., and R. Willhelm. 2016. Mycorrhizal faciltation of kin recognition in Douglas-fir. Poster presentation. TerreWEB Annual General Meeting, Vancouver, BC.

Gorzelak, M. and S.W. Simard. 2016. Kin selected defense signalling through mycorrhizal networks in Douglas-fir. Poster presentation. International Society for Microbial Ecology. Montreal, QC, Canada.

Orrego, G. 2017. The effect of nurse logs on coastal western hemlock regeneration and fungal community. CEBAS, CSIC. Murcia, Spain. Invited speaker.

Orrego, G., Pickles, B.J. and S.W. Simard. 2016. The effect of mycorrhizal network on coastal western hemlock regenerating on coarse woody debris of different decay classes. Poster presentation. Pacific Ecology and Evolution Conference. Bamfield, BC, Canada.

Pickles, B.J. 2016. Impacts of mycorrhizal biodiversity on plant responses to global change. EU COST Action FP1305 Biolink - Belowground biodiversity and global change meeting, Oct. 24-26 2016, Czech Republic. Invited speaker.

Ryan, T. 2017. Ancestral knowledge systems (Applied knowledge in the Mother Tree Project). Elders Council, Assembly of First Nations, Ottawa, ON. June 2, 2017. Invited speaker.

Simard, S.W. 2015. If these roots could talk. Vancouver Parkfest, Vancouver, BC. Nov. 17, 2015.

Simard, S.W. and T. Ryan. 2016. Mother Tree walking tour through Stanley Park. TED2016, Vancouver, BC. Feb. 2016.

Simard, S.W. 2016. Genomics of mycorrhizal networks in Douglas-fir forests. New Mexico BioInformatics, Science and Technology (NMBIST) Symposium, Santa Fe, NM. March 17, 2016.

Simard, S.W. 2016. Uncovering the language of trees. Bill and Melinda Gates Foundation - Plant Communication for Agriculture Innovation, Seattle, WA. April 13, 2016.

Simard, S.W. 2016. Climate change in forests of Canada. Youth Climate Change Conference, Nelson, BC. April 22, 2016.

Simard, S.W. 2016. Soil microbial ecology research in the forests of western Canada. Laval University special seminar, Quebec City, QC. June 14, 2016.

Simard, S.W. 2016. How trees talk to each other. TED Summit, Banff, AB. June 19, 2016.

Simard, S.W. 2016. Mother tree tour in Banff National Park. TED Summit, Banff, AB. June 29, 2016.

Simard, S.W. 2016. The evolving tale of the Mother Trees. Nature Conservancy of Canada`s "Why Forests Matter" Tour, Calgary, AB. Oct. 26, 2016.

Simard, S.W. 2016. The evolving tale of the Mother Trees. Nature Conservancy of Canada's "Why Forests Matter" Tour, Montreal, QC. Nov. 9, 2016.

Simard S.W. 2016. The language of trees. Disruptive Innovation Festival, UK. Nov. 11, 2016.

Simard, S.W. 2016. The evolving tale of the Mother Trees. Nature Conservancy of Canada`s "Why Forests Matter" Tour, Toronto, ON. Nov. 15, 2016.

Simard, S.W. 2016. We are one. TEDxSeattle, Seattle, WA. Nov. 18, 2016.

Simard, S.W. 2017. How do trees collaborate? NPR. Jan. 13, 2017.

Simard, S.W, Roach, W.J. and T. Ryan. 2017. Roots of wisdom and ancestral connections: a presentation on the Mother Tree Project. Masset Lecture Series, Masset, Haida Gwaii, BC. April 11, 2017

Simard, S.W. and T. Ryan. 2017. Hidden connections in the forest (Mother tree walking tour through Stanley Park), TED2017, Vancouver, BC. April 25 and 27, 2017.

Other (Including Technical Reports, Non-Refereed Articles, etc.):

Asay, A. 2016. Mother Tree: Parenting 101. A short film. https://www.youtube.com/results?search_query=amanda+asay

Asay, A., Orrego, G. and J. Dordel. 2016. Mycorrhizas: from microscopy to macroscopy. A short film. https://www.youtube.com/watch?v=RE04lwoRS6M

Defrenne, C. and J.A. Maddison. 2016. From roots to sky: drawing my PhD. A short film. https://www.youtube.com/results?search_query=camille+defrenne.

Gorzelak, M. 2017. Kin-selected signal transfer through mycorrhizal networks in Douglas-fir. PhD Dissertation, DRAFT. Will be defended August, 2017.

Johnston, A.C. 2017. Using BEC plot data to evaluate patterns of functional and phylogenetic diversity in understory and canopy plants. M.Sc. thesis. UBC Okanagan, Kelowna, BC.

Maddison, J.A. 2016. Networks of Communication: Defense-related signal transfer between tree seedlings via mycorrhizal networks and an educational mycorrhizal-focused video game. MSc Thesis. University of British Columbia, Vancouver, BC.

Maddison, J.A. 2016. Shroomroot. A digital game. https://play.google.com/store/apps/details?id=com.areadenialgames.shroomroot&hl=en

Maddison J.A., Krzic, M. and S.W. Simard. 2017. Shroomroot - an action-based digital game to enhance postsecondary teaching and learning about mycorrhiza. America Biology Teacher, submitted.

McCord, T. 2017. The effects of clearcut harvesting on understory plant communities in British Columbia forests. BSF Thesis, FRST 498, University of British Columbia, Vancouver, BC.

Orrego, G. 2016. Nurse logs. A short film. https://www.youtube.com/results?search_query=gabriel+orrego

Orrego, G. 2017. Como los arboles se comunican entre elllos (How trees communicate with each other). http://www.endemico.org/index.php/2017/03/27/como-los-arboles-se-comunican-entre-ellos/

Orrego, G. 2017. Mycorrhizal networks built by kids. A short film. https://vimeo.com/210878544

Pickles, B.J. 2016. Landscape-level vegetation planning for future climates, presented using examples from Mother Tree project. Workshop: Farming, woodlands, and water. University of Reading. April 19, 2016.

Ryan, T. 2016. Branchlines article with Teresa Ryan: Big Tree Walk – TED Experience, Vancouver, BC.

Simard, S.W. 2016. Plant communication. NPR Voice of America radio interview. May 2016.

Simard, S.W. 2016. From tree to shining tree. NPR Radiolab podcast. June 2016.

Simard, S.W. 2016. Trees have their own fungal internet. CBC Quirks and Quarks radio interview. Sept. 2016.

Simard, S.W. 2016. How do trees collaborate? NPR TED Radio Hour. Oct. 2016.

Simard, S.W. 2016. Leaf Litter: Q&A with Suzanne Simard. Published interview. Oct. 2016.

Simard, S.W. 2016. Exploring how and why trees 'talk' to each other. Yale Environment 360: Interview with Diane Toomey. Sept. 2016.

Simard, S.W. 2016. Healing Forests: Article: Loneliness and Its Forest Cure.

Simard, S.W. 2016. Ecologist studies underground networks to heal. Thunderbird UBC: Interview with Alexander Kim. April 2016.

Simard, S.W. 2016. Unseen connections. Branchlines article, Faculty of Forestry, University of British Columbia, Vancouver, BC.

Sun, Y. 2017. Relationships between interior Douglas-fir (*Pseudotsuga menziesii*) fine root biomass and soil properties across a climatic gradient in southern-central British Columbia. BSF Thesis, FRST 498, University of British Columbia, Vancouver, BC.

Other media covering the concepts:

Intelligent Forest: Immerse Yourself in Nature: a full dome film by Benjamin River Productions. In progress. (trailer at https://www.youtube.com/watch?v=jZS5dAvQrcU)

CNN: Article published in 2017 by Paula Erizanu "The secret life of trees: Is nature less selfish than we think?" http://www.cnn.com/2017/02/07/world/secret-life-of-trees/index.html

Fantastic Fungi, a film by Louie Schwartzberg. In progress. (trailer at http://fantasticfungi.com/)

Intelligent Trees: a film by Films for the Earth (https://filmefuerdieerde.org/en/films/planet-earth)

Smarty Plants: Uncovering the Secret World of Plant behaviour. A film by Erna Buffie and David Suzuki. Aired again June 4, 2017. CBC-TV, The Nature of Things. http://www.cbc.ca/natureofthings/episodes/smarty-plants-uncovering-the-secret-world-of-plant-behaviour

Psychology Today. 2017. Smart Trees Teach. (http://psychologytoday.com/blog/mothering-natu

Ontario Nature. 2017. Article by Stephanie Muckle "5 Things You May Not Know About Trees."

The Planet Magazine. 2017. Article by Allura Peterson "The Web of the Woods." (https://theplanetmagazine.ne

4.3 Patents and Licences

Please provide in the table below the **number** of patents (filed and issued) and licences to date arising from the research project supported by the grant in the table below. (Provide details in 4.4.)

x Not applicable

- OR -

None Yet Filed/Issued

	Number of Patents				
Description	**CANADA**	**U.S.**	**EP**	**OTHER**	**TOTALS**
# of Patent Applications Filed					
# of Patents Issued					

# of Licences [ ] **(Provide details in 4.4.)**

4.4 Please provide details (titles, patent application number, patent number…) about the above listed patent applications, patents, and licences under the corresponding headings.

Patent Applications Filed:

n/a

Patents Issued:

n/a

Licences: (licencees, exclusive/non-exclusive…)

n/a

4.5 Describe how the results achieved to date are being transferred to the user sector and the prospects for their commercial/industrial exploitation or their use by other sectors (e.g., revising or formulating policy or regulations).

Prospects for the Transfer of the Results to the User Sector

We are still in the process of installing the experiments, so to date results have generally not been transferred to the user sector. However, after post-treatment data has been collected, the prospect for applying our findings and revising policy is extremely good. A crucial, practical outcome of our integrative analysis will be the identification of optimal strategies for forest renewal in response to increased climatic stress. These strategies will be communicated to the forest industry and provincial government (B.C. Ministry of Forests, Lands and Natural Resource Operations) sectors. One of our three long-term objectives is communicating results to a range of stakeholders so they can be integrated into forest policy and practice. Communication will include workshops, field trips, journal articles and extension notes.

5. Problems Encountered

Identify the main problems encountered during this instalment of the grant from the list below (select all that apply):

X	Technical or scientific problems
	Problems with direction of research or findings
	Equipment and facilities
	Staffing issues (including students)
	Funding problems
	Partner withdrew from project
	Partner interaction issues
	Other (specify)

- OR -

	No problems occurred during this instalment of the grant

Briefly describe the main problems identified above and the steps taken to resolve each one.

It took longer than anticipated to identify field sites because of the timing of the grant award and the complex logistics involved. This has pushed back other activities (i.e. harvesting, planting, and post-planting measurements) which of course could not be carried out until the sites were secured. The project start date of September 30, 2015 left only a month of snow-free conditions to visit potential sites that fall. We made initial contacts with licence holders in fall and winter of 2015/16, but the first site visits were delayed until late May 2016 when sites were snow-free. Licensees were unable to fully commit to the project and provide field sites in fall 2015 because lead time was required to apply to the provincial government for permission to alter their logging and regeneration plans to accommodate our specialized treatments. We selected sites where logging plans were already in place to minimize such lead time; still considerable back and forth communication between licencees and government was required to attain approval for deviations from "normal" practices (i.e., clearcutting and planting standard species/provenances). As well, relationship-building was an important step in getting licensees on board with the project and this took time. Steps taken to resolve the issue were to move forward with finding sites in spring/summer 2016 and ordering seedlings in fall 2016.

Harvesting is ongoing, planting will take place in May/June 2018, and post-planting measurements will be shifted forward to late summer 2018. Because of the very significant interest in our project across many groups in the province to date (e.g., provincial government, forest industry, research forests, First Nations, Forest Enhancement Society, Columbia Basin Trust) we anticipate further funding contributions after the final year of NSERC funding to continue with longer term measurements, analysis and, importantly extension.
We inquired about receiving an extension from NSERC in spring 2016 when we realized we would be behind schedule but were advised to wait until the project was further underway.The reviewers of the original proposal correctly anticipated that we would not be able to achieve all our objectives within the limited timeframe of the strategic grant (three years). We are applying for a one-year extension at this time.

6. Collaboration with Supporting Organizations

6.1 Who initiated this strategic project?

x	The university researcher
	The industry partner (if applicable)
	The government partner (if applicable)
	Other (specify)

6.2 In what way were the partners directly involved in the project (select all that apply)?

	Partners were not involved in the project apart from their financial and/or in-kind contributions
x	Partners were available for consultation
x	Partners provided facilities
	Partners participated in the training
	Partners received training from university personnel
x	Partners discussed the project regularly with the university team
	Number of meetings during the period covered by this report: 20 or more
x	Partners were involved in the research

6.3 Describe the partner's involvement and comment on the collaboration.

Collaboration with partners and enthusiasm for the project has been exceptional. Communication with all of the various partners has been ongoing since they joined the project. Staff of FLNRO (Nelson and Kamloops regional offices) and Brinkman and Associates contacted license holders in the Kootenay-Boundary and Thompson-Okanagan Regions and were instrumental in securing sites in those areas. The Tree Improvement Branch of FLNRO provided site location assistance as related to the AMAT study and technical advice and assistance when seed was ordered. Harrop Nursery is growing and storing the seedlings for us. The licensees (Kalesnikoff, Canfor, West Fraser Mills and Interfor), Research Forests (Alex Fraser and John Prince), Community Forest (Harrop Proctor) and FLNRO staff at the district, regional and headquarters levels participated with us in finalizing harvest treatment specifications. The licensees and research forest staff accompanied us on field visits to potential sites and worked together with us to map treatment units. In the field, they laid out the blocks and marked trees to leave in the partial retention treatments (this is completed at three of the six site locations, and ongoing at the others). They are also conducting the harvesting, which is now near completion at two of the six sites. Brinkman and Associates will be assisting in transporting the seedlings to the field and planting in 2018. We have also

been provided with inexpensive accommodation in the camps at Alex Fraser and John Prince Research Forests.

6.4 Was any cash committed to this project?

x Yes
No

6.5 Was any in-kind committed to this project?

x Yes
No

6.6 If any cash or in-kind was committed, please enter the amounts below, along with the amount of cash and in-kind that has been received (if any) to date. If no cash or in-kind was received, please enter "0". Where cash or in-kind was not committed enter "n/a".

	Amount Committed	**Total Amount Received to Date**
Cash	$13,000	$13,000
In-Kind	$172,000	$145,000

6.7 Describe the in-kind received and explain variations between commitment and actual cash and in-kind contribution if applicable.

In May 2017, the Jena and Michael King Foundation contributed $13,000 (US$10,000) for vehicle expenses and Columbia Basin Trust awarded us with $5,000 for student wages for July/August 2017. The Forest Enhancement Society of BC is providing $700,000 over two years (July 1, 2017 to July 1, 2019) for work associated with the project, including field costs and extension. These three amounts were not part of the original budget.
In-kind contributions to date are: (1) $50,000 from Brinkman and Associates for contributions to project development and liasing with forest licensees in the site location process. They will provide a further in-kind contribution of $25,000 in the next fiscal year for assistance with seedling planting. (2) $90,000 from the Tree Improvement Branch, BC Timber Sales and the Ministry of Forests, Lands and Natural Resouces Operations (FLNRO) at the provincial, regional and district offices for site location assistance, as well as $4,000 for consultation and contributions to project development and implementation including assistance in ordering seedlings. They will provide another $2,000 in the next fiscal year for further consultation and contributions to project implementation. (3) $1000 from various tree seed suppliers who contributed free seed for growing the seedlings (this contribution was not in the original budget).

7. Financial Information

The purpose of this section is to provide additional project-specific detail; it cannot be substituted with a Statement of Account (Form 300).

Please provide the following financial information:

Amount remaining in grant account as of June 30th: **$ 7,765.54**

Budget Item	Budget for Year 1	Actual Expenditures	Budget for Year 2	Actual Expenditures to date in current grant year	Projections from now to September 30 (current year)	Planned Expenditures for the Next year of Support
Salaries and Benefits						
Students	77,000	37,947	112,000	125,406	54,919	108,000
Postdoctoral fellows						
Technical/professional assistants	20,000	24,281	20,000	23,941	4,284	17,136
Summer assistants (3)	18,000	4,336	18,000	7,541		
Equipment or Facility						
Purchase or rental						
Operation and maintenance costs						
User fees (greenhouse)	5,000	5,186	5,000	4,308		
Materials and Supplies						
Materials and supplies	100,000	90,874	100,000	96,535	5,932	43,488
Travel						
Conferences	6,000	341	6,000	4,516		
Field work	25,000	38,960	25,000	39,442		1,870
Collaboration/consultation	2,000	2,546	2,000	399		
Dissemination Costs						
Publication costs	1,000	1,097	1,000	114		
Other (specify)						
Other (specify)						
Research associate salary	44,000	62,026	44,000	53,440	14,027	56,109
Totals	298,000	267,592	333,000	355,642	79,162	226,603

Please provide detailed explanations for any deviation in the current period and in the budget for the coming year. (Note that deviations from the budget of greater than 20 per cent require pre-approval from NSERC.)

Deviations:

1. Student salaries: In year 1, the actual expenditures were lower than the proposed budget for three reasons: (a) we were still recruiting students, (b) two of the PhD students held their own NSERC's, and (c) some of the other student stipends were partially covered by NSERC CREATE.
2. Summer assistants: In years 1 and 2, the actual expenditures were lower than the proposed budget for two reasons: (a) some of the work planned for student assistants was performed by technical assistants, and (b) some of the work was carried out by student volunteers, representing cost savings in this category.
3. Conferences: In year 1, the actual expenditures on conferences by students were lower than the proposed budget due to the delays in site selection and thus data collection. However, seveal presentations were made, as shown in the report, with costs covered by the conferences or other sources.
4. Field work: In years 1 and 2, the costs for field work were higher than anticipated because site searching and selection was more difficult, time consuming and took more travel than ancticipated. As well, the remote locations of the sites has increased costs of field work due to great travel times.
5. Collaboration/consultation: In year 2, colloboration/consultation costs were lower than planned because most of those activities were accomplished in year 1.
6. Publication costs: In year 2, less was spent on publication costs than anticipated because we targeted journals with no page charges.
7. Research associate salary: In years 1 and 2, we required more time, and hence salary, for the research associate because the laison with the forest companies and site

selection was more difficult and time consuming than anticipated. The research associate had to perform these tasks because of her established networks and experience. Students were not qualified to conduct these activities.