Application - Canada Graduate Scholarships-Master's Program

Identification (mandatory)

Applicant

Family Name: Rouleau-Desrochers **First Name:** Christophe

Middle Names:

Application

Application Title Fueling Next Year's Growth of Trees with Carbon and Nitrogen

Language in which the proposal is written (•) English ( ) French

Field of Research natural sciences and/or engineering

Start date or proposed start date of program of study 2024-09-01 **Proposed end date of program of study** 2026-05-04

Number of months of graduate studies completed as of December 31 of year of application

Months of full-time study 0 **Months of part-time study** 0

If you are successful in obtaining a Canada Graduate Scholarship will you consider applying for a Michael Smith Foreign Study Supplement? (•) Yes ( ) No

Supplements/Joint Initiatives

To be considered for one or more Supplements or Joint Initiatives, select all that apply

Proposed Host Organization

Proposed Host Organization #1

Organization The University of British Columbia

Faculty Forestry

Department/Division Forestry

Proposed Host Organization #2

Organization Université du Québec à Montréal

Faculty Sciences

Department/Division Sciences biologiques

Proposed Host Organization #3

Organization

Faculty

Department/Division

Summary of Proposal

Summary

Temperature is a major regulator of temperate and boreal forests, strongly controlling trees' seasonal activity. Human-induced climate change has led to a global rise in temperatures, resulting in the lengthening of the growing season in numerous ecosystems. Shifts in plant phenology —the study of recurring life history events— have already been observed and are expected to continue with warmer temperature. These shifts, towards earlier springs and delayed autumns, could allow trees to fix and store more carbon and nutrients either almost immediately or in the next growing season, though effects in subsequent years are rarely tested. Understanding the response to extended seasons of different tree species is critical to both fundamental tree biology, and climate change forecasting. I hypothesize that extended growing seasons influence trees' carbon and nutrient storage with effects varying across species, such that certain species will show increased growth in years of extended seasons and others in the year following an extended season.

To test how trees respond to extended seasons across species while considering effects across multiple seasons, I will conduct controlled experiments manipulating spring and autumn temperatures across nine tree species. I plan a full factorial experiment manipulating spring and fall warming with two levels each (warming or control), resulting in four treatments. To test that nutrients are not limiting responses later in the season I will additionally add two nutrient enrichment treatments under warmer and regular autumn temperatures. In the first year of the experiment, I will monitor radial growth and track phenology. In the second year, I will assess growth on both the individual and the cellular levels.

Activity details

Certification requirements (mandatory)

Does the proposed research involve humans as research participants? ○ Yes ◉ No

Does the proposed research involve animals? ○ Yes ◉ No

Does the proposed research involve human pluripotent stem cells?

○ Yes ◉ No

Does the proposed research involve controlled drugs and/or substances?

○ Yes ◉ No

Does the proposed research involve human totipotent stem cells?

○ Yes ◉ No

For statistical purposes only

Does this application propose research involving Indigenous people?

○ Yes ◉ No

Sex- and Gender-Based Analysis

Are sex (biological) considerations taken into account in this research proposal?

○ Yes ◉ No

Are gender (socio-cultural) considerations taken into account in this research proposal?

○ Yes ◉ No

Keywords (mandatory)

Carbon fixation, Biology, Ecology, Climate change, Forestry, Phenology, Plant physiology, Temperature effects, Climate change impacts, Forest dynamics

Field of Study

Indicate and rank up to three primary fields of study relevant to your proposal, with #1 the most relevant and #3 the least relevant.

1. PLANT AND TREE BIOLOGY
2. PLANT ECOLOGY
3. EVOLUTION AND ECOLOGY

Special circumstances

Do you have any special circumstances to take into consideration that may have affected your research, professional career, record of academic or research achievement or completion of degrees?

○ Yes ◉ No

Outline of Proposed Research

Title: Fueling Next Year's Growth of Trees with Carbon and Nitrogen

Context: In temperate and boreal forests, temperature plays a crucial role in setting the boundaries for the seasonal physiological activity. Thus, with rising temperatures from anthropogenic climate change, the climatically possible growing season has lengthened in many ecosystems worldwide by up to 11 days (Körner & Basler, 2010; Menzel & Fabian, 1999). Plants have tracked this through shifts in phenology—the study of recurring life history events—which are expected to continue with increasing temperatures (Wolkovich and al., 2012). In particular, trees have shifted earlier in the spring, and may use this opportunity to fix more carbon and grow more during the current growing season (Keenan and al., 2014; Wang and al., 2020). Trees have also delayed autumn events (e.g., leaf senescence) but the impacts on tree fitness are not well understood. Both extended spring and fall events are likely to affect the next growing season, though this is rarely tested.

Research Question: How do extended growing seasons affect tree growth across different species both immediately (in the same year as the extended season) and in subsequent years?

Hypothesis : I hypothesize that an extension of the growing season could modify a tree's capacity to fill carbon and nitrogen storage pools (Chapin and al., 1990; Lawrence & Melgar, 2018). Trees that use this opportunity by fixing more carbon may experience increased growth in the subsequent growing season (Landhäusser and al., 2012; Martens and al., 2007). Thus, species capable of accumulating nutrients, like nitrogen, after leaf senescence, might exhibit growth increment in the following growing season (Schott and al., 2013).

Objectives: First, I aim to assess the tree species potential to prolong or stretch their activity schedule. Second, I will determine whether trees can absorb nutrients beyond their theoretical growing season. I will also examine if increased carbon storage pools translate into growth increment in the following growing season. Finally, I will investigate potential variations in these responses across deciduous and evergreen tree species, aiming to discern whether different patterns emerge within these distinct groups.

Methodology: To investigate the impact of manipulated spring and autumn temperatures on phenological responses, I will conduct experiments across nine different tree species under controlled conditions. For deciduous trees, I have selected seven species spanning both fast and short-life strategies (e.g., *Alnus rubra*) and slow growth and longer lifespan species (e.g., *Quercus macrocarpa*). Since phenological monitoring is more difficult and trends are less likely to be observed for evergreen trees, only two of the nine species will be conifers (Jönsson and al., 2010). I plan a full factorial experiment of spring and fall warming with two levels each (control/warmed) resulting in four treatments: spring or autumn warming, or both, and a control. To test that responses are not limited by nutrient depletion later in the season, I plan two additional nutrient enrichment treatments (6 total treatments across the whole experiment). For this, I will add liquid nutrients to the treatment trees in regular and warmer autumn temperature treatments. I plan on a minimum of 10 replicates per species, adhering to the standards in tree phenological monitoring, which generally require 5-10 replicates (Siegel, 2009).

Throughout the summer of 2024, I will continuously monitor radial growth using magnetic micro-dendrometers and track phenology every 2-3 days. In fall 2025, after the trees have grown in ambient temperatures for the season, I will assess growth on the individual (total biomass) and the cellular level (number of cells and their characteristics).

Research outreach: Given the widespread impacts of climate change on ecosystems, understanding how forest communities respond to prolonged growing seasons is crucial. Observing the reactions of deciduous and conifer species to extended season and nutrient supplementation may reveal potential benefits for some species and harm for others. These shifts are likely to influence forest stand dynamics across North America.

Bibliography and citations

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UQÀM **Université du Québec à Montréal**
Registrariat

RELEVÉ DE NOTES

Date d'émission
25 octobre 2023
Code permanent
ROUC22019809

Rouleau-Desrochers Christophe
6880 RUE MARQUETTE
MONTREAL QC
H2G 2Y8

Programme : **baccalauréat en biologie en apprentissage par problèmes (6713)**

Trimestre	Sigle	Crédits	Titre	Moyenne du groupe	Résultat
			Test de maîtrise du français		S
Activités suivies dans le cadre du certificat en écologie					
	BIO1050	3	BIOLOGIE ANIMALE	3.26	A+
	BIO1700	3	CONSERVATION DE LA BIODIVERSITE	3.30	A+
	BIO2611	3	BIOLOGIE VEGETALE	2.92	A+
	BIO3100	3	ECOLOGIE GENERALE	3.13	A+
	BIO3500	3	SEMINAIRE EN ECOLOGIE ET ANALYSE DES DONNEES	3.41	A+
	BIO6821	3	AMENAGEMENT DE LA FAUNE	3.38	A+
AUT.2021	HIS4592	3	HISTOIRE DES AUTOCHTONES DU CANADA (JUSQU'AU XIX S.)	2.66	A+
AUT.2021	PHI3017	2	PHILOSOPHIE DES SCIENCES BIOLOGIQUES (2 CR.)	3.08	A+
Activités suivies depuis l'admission au programme					
HIV.2022	BIA1002	1	INITIATION A L'ETUDE DE LA CELLULE (1 CR.)		S
HIV.2022	BIA1401	4	DIVERSITE DES MICROORGANISMES (4 CR.)	2.97	A+
HIV.2022	BIA2001	5	BIOCHIMIE ET BIOLOGIE CELLULAIRE (5 CR.)	2.06	A+
HIV.2022	BIA2002	4	REPLICATION ET EXPRESSION DES GENES (4 CR.)	2.37	A+
AUT.2022	BIA2101	5	METABOLISME ET REGULATION DES VEGETAUX (5 CREDITS)	2.16	A+
AUT.2022	BIA2201	6	REGULATION ANIMALE ET HUMAINE (6 CR.)	2.65	A+
AUT.2022	BIA2501	4	IMMUNOLOGIE (4 CR.)	1.98	A+
HIV.2023	BIA1200	2	EVOLUTION ET SELECTION NATURELLE (2 CR)	2.96	A+
HIV.2023	BIA1700	6	ORGANISMES ET ENVIRONNEMENT (6 CREDITS)	3.24	A+
HIV.2023	BIA2600	4	INTERACTION ENVIRONNEMENTALE (4 CR)	2.70	A+
HIV.2023	FSM3300		INIT.A LA RECHERCHE EXPERIM.OU PRAT.PROF.(6CR)	4.18	#
AUT.2023	BIA3010	9	METHODOLOGIE EN ECOLOGIE (9 CR)		A+
AUT.2023	BIA3510		SPECIALISATION I EN ECOLOGIE (4 CR)		*
AUT.2023	COM1859		ENJEUX ET PRATIQUES DE LA COMMUNICATION SCIENTIFIQUE		*

---------- FIN DU RELEVÉ ----------

(#) : Délai autorisé pour la remise du résultat
(*) : Résultat non disponible

Crédits réussis : 73.0

Moyenne cumulative : 4.30/4.3

Copie conforme au dossier
Registraire intérimaire

25 octobre 2023, par LB

EXPLANATORY NOTES

This note is meant to ensure a better understanding of official student progress as recorded on documents issued in French.

Academic file
Student's academic file, includes admission and registration information and degree conferment data as maintained by the Office of the Registrar, in accordance with existing University policies. Students may request a copy of the information kept in his or her file.

Transcript
A transcript is an official document presenting the cumulative academic record of a student's progress in the programme to which he or she has been admitted. It is prepared by the Office of the Registrar in accordance with the existing University policy.

Certified true copy
Students may request a certified true copy of their transcript or file. A certified true copy is issued by the Office of the Registrar. It bears the signature of the Registrar and the words "copie conforme". This document may be given directly to the student. If a transcript is sent to another institution, it bears the Official University Seal. A transcript with an official seal cannot be sent to the student.

Symbols used in this transcript

Symbol H
"H" indicates that the course does not taken toward degree. Credit is not included in the Cumulative Grade Point Average (CGPA).

Symbol I
"I" indicates that the course is Incomplete. The student has nos yet met the course requirements, and final evaluation cannot be submitted.

Symbol K
"K" indicates the granting of credit based on a prior learning assessment which has been carried out in accordance with existing University regulations. Credit appears on the transcript and academic file.

Symbol L
"L" indicates a failed course or activity that has since been completed.

Symbol P
"P" indicates a prerequisite course. Grade is not included in CGPA.

Symbol R
"R" indicates that the grade is to be assigned at a later date.

Symbol W
"W" indicates an audit course or activity. Grade is not included in CGPA.

Symbol X
"X" indicates withdrawal with permission. Credit does not appear on the transcript or academic file.

Grade of S
"S" indicates that the course requirements have successfully completed. Credit granted, but not included in CGPA.

Grade of V
"V" indicates that the course has successfully completed at another institution under a specific agreement. Credit granted, but not included in CGPA.

Credit
Numerical value on the work that student must complete to attain specific course objectives.

Credits earned
"Credits earned" (crédits réussis) is the total number of credits earned towards fulfilment of programme requirements. It includes credits for successfully completed courses and those granted by advanced standing (equivalence). It excludes credit for prerequisite course work (P) and for courses not taken towards the degree (H).

Grading System prior to Fall 1992
A, B, C, and D.

Grading System as of Fall of 1992
A+, A, A-, B+, B, B-, C+, C, C-, D+, D.

Failed Course
A student who does not meet course requirements receives the letter "E" as the grade for that course. Credits for that course do not appear on the transcript.

Credit from another programme within the University
The words "Activité suivie dans le cadre . . . " indicate that the activity has been completed while completing requirements for another programme. Credit for this activity has been assigned to the student's current programme.

Transfer Credits
The words "X Crédits intégrés au programme" indicate that the student has met certain programme requirements prior to admission.

Legend
ABS : Absence EXE : Advanced standing N.A. : Not applicable

Cumulative Grade Point Average

The cumulative grade point average (CGPA) is calculated as follows :

$$M = \frac{\sum PiCi}{\sum Ci}$$

Signification des symboles :

$\sum$ = Combined total of
P = Numeric value assigned to letter grades
C = Number of credits assigned to courses for which the letter grade has a numeric value
i = Specific course or activity
M = Average

Numeric Values of Grades :

A+ = 4,3	A = 4,0	A- = 3,7 ;	Excellent
B+ = 3,3	B = 3,0	B- = 2,7 ;	Very good
C+ = 2,3	C = 2,0	C- = 1,7 ;	Good
D+ = 1,3	D = 1,0 ;		Pass
E = 0 ;			Fail

Calculating the CGPA enroled prior to September 1992

A new grading system was introduced in September 1992 (see grading system above). In accordance with policies accompanying the change, the CGPA of students who began their programme before September 1992 is calculated as follows :

$$M = \frac{\left\{\left(\sum PiCi \text{ calculated before September 1992}\right) \times \frac{4,3}{4,0}\right\} + \left\{\sum PiCi \text{ calculated after September 1992}\right\}}{\sum Ci}$$

Security Features

This transcript has been printed on paper with the following features :
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- the words "Université du Québec à Montréal" are printed as a microline 7/8th inch below the top edge;
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