UNIVERSITÉ LAVAL

Smithsonian Tropical Research Institute

Diversité fonctionnelle des bryophytes et les lichens nordiques

Juan Carlos Villarreal A.

Remerciements

My lab:

Marta Alonso (post-doc)

Dennis Escolástico (Ph.D)

Philip Bell-Doyon (M.Sc.)

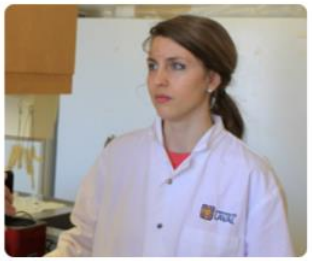
Sandrine Toupin (M.Sc.)

Camille Lavoie (1er cycle)

Adriel Sierra (Ph.D) – Automne 2019 (BESS-FONCER)

Gabriel Peñaloza (Ph.D, ELAP visitor)- Hiver 2019

Post-doctoral researchers



Graduates students

NSERC CRSNG

Fonds de recherche Nature et technologies Québec

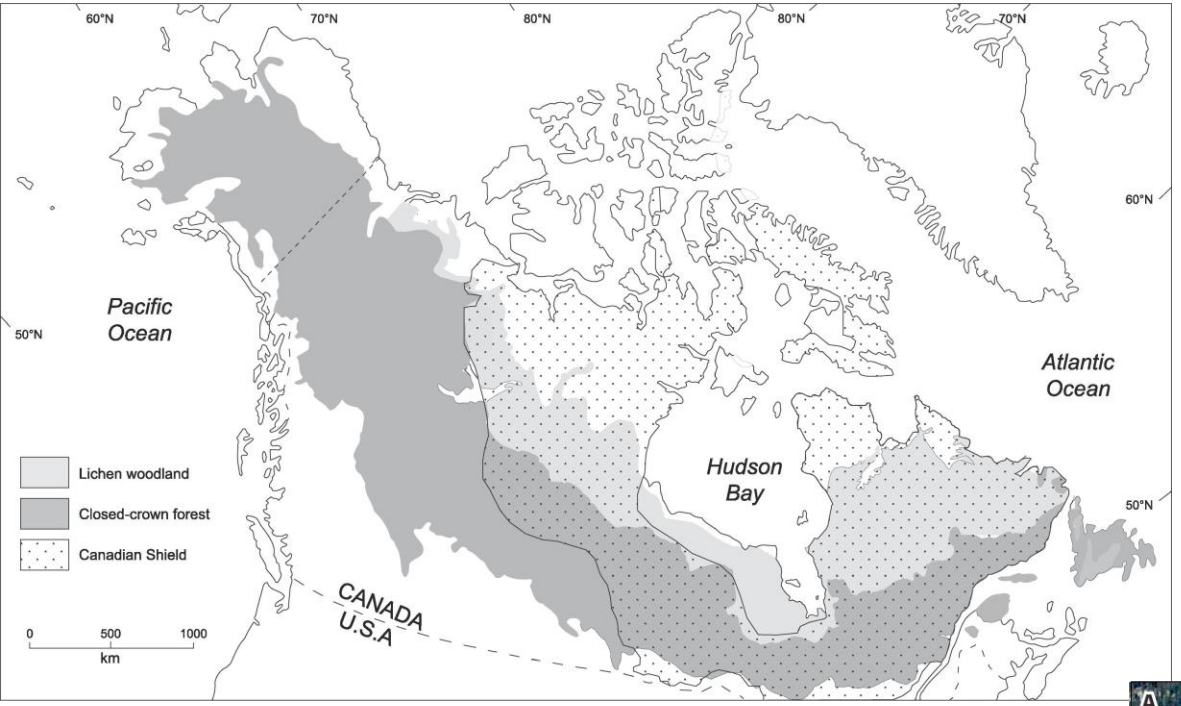
Smithsonian Tropical Research Institute

Lichen evolution and symbiosis

Plant -N^2-fixing symbiosis

Lichens symbiosis

Plant symbiosis



Lichen woodland = pessiére à liche

Over 2 million km^2 in Eastern Canada

299,000 km^2 in Québec
(~1.4 times the size of Great Britain)

Forest Ecology and Management 417 (2018) 167–183

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Tamm review

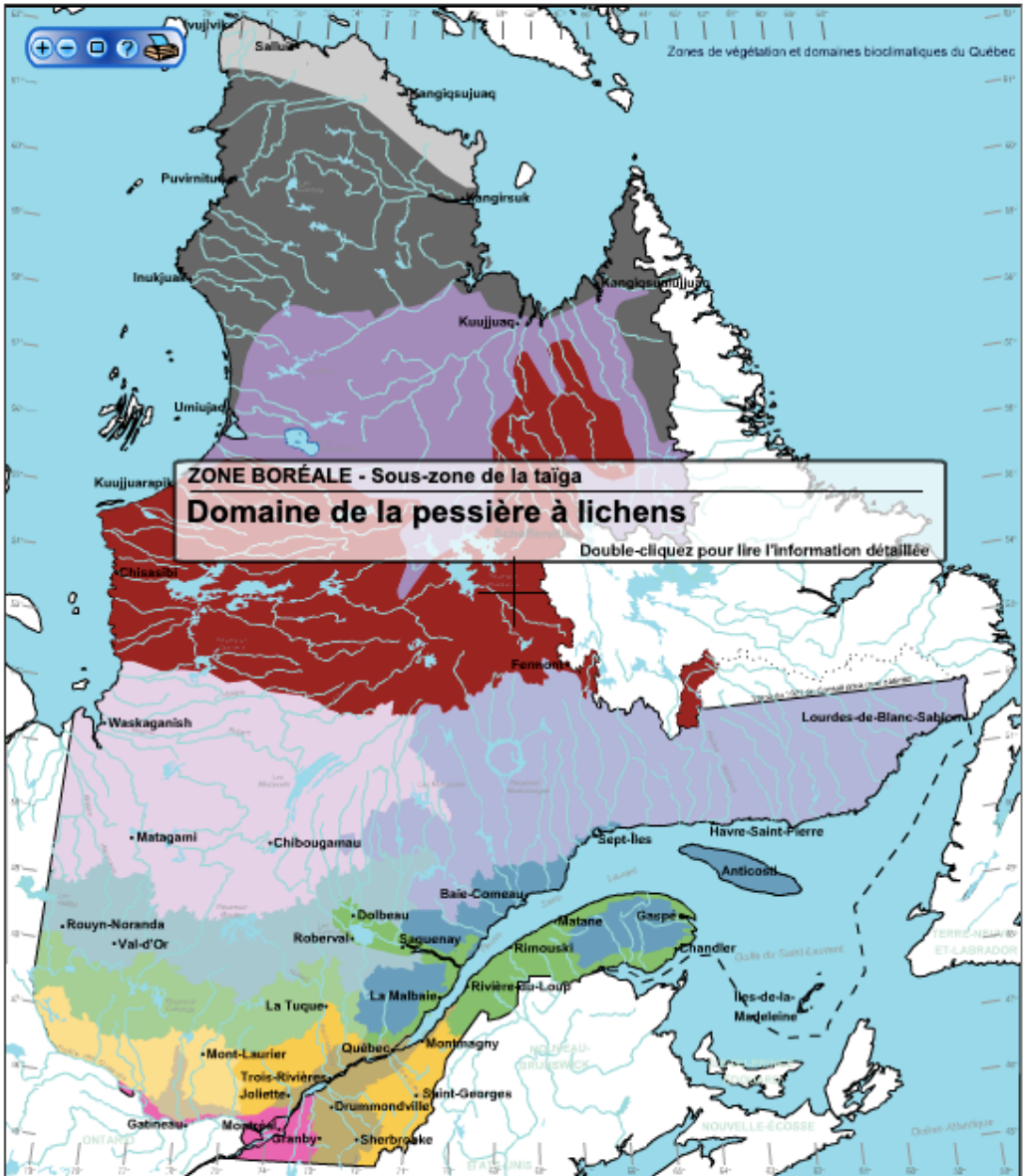
Tamm review: The North-American lichen woodland

Serge Payette[a,*], Ann Delwaide[b]

[a] Département de biologie and Centre d'études Nordiques, Université Laval, 1045, av. de la Médecine, Quebec City, Quebec G1V 0A6, Canada
[b] Département de géographie, Université Laval, 2405, rue de la Terrasse, Quebec City, Quebec G1V 0A6, Canada

Lichens symbiosis

Plant symbiosis



Cladonia stellaris

Lichens symbiosis

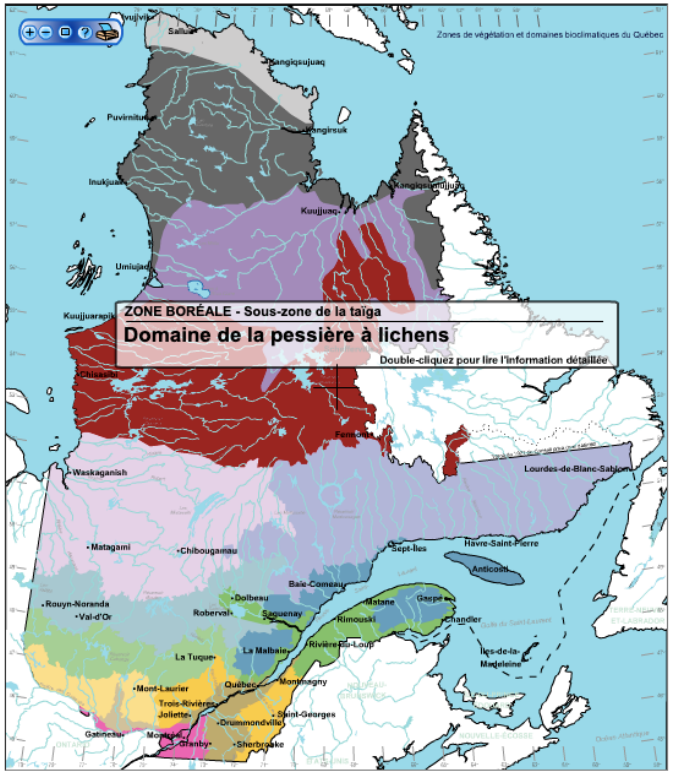
Plant symbiosis

Greening of the Arctic, NASA

Lichens symbiosis | Plant symbiosis

1st project:
The population genomics of the lichen woodland, the microbiome and virome

Focal site: Parc National des Grands-Jardins (PGJ)



PGJ- 500 km south of its usual distribution range (Jasinski & Payette 2005)

Lichens symbiosis

Plant symbiosis

1st project:
The population genomics of the lichen woodland, the microbiome and virome

- Diversity of *Cladonia stellaris* in Québec and after fire succesion in PGJ

The specific objectives are (i) to elucidate the origin of *C. stellaris* found in the southernmost LW of Eastern Canada and (ii) to assess the level of genetic variation within and among populations of *C. stellaris* in five areas of PGJ affected by different fire events.

Lichens symbiosis | Plant symbiosis

Looking for motivated graduate students:

To study the microbiome and virome of lichens along a latitudinal gradient

The impact of fire on the microbiome of lichens in the PGJ

M.Sc.– Diversité génétique, symbiose et microbiomes de lichens nordiques

Ce projet de maîtrise vise à faire une étude comparative entre des populations des lichens *au* Québec, Canada. Une étude des populations et génétique (à l'aide de marqueurs génétiques de type SNPs) de ces populations et des microorganismes (par une approche de metabarcoding) associés couplée à des expériences réalisées en conditions contrôlées permettra de mieux comprendre la symbiose. Le travail de terrain aura lieu au sud du Québec (Forêt Montmorency), mi- Québec et le Grand Nord (Baie d'Hudson) pendant l'été 2019 (ou 2020).

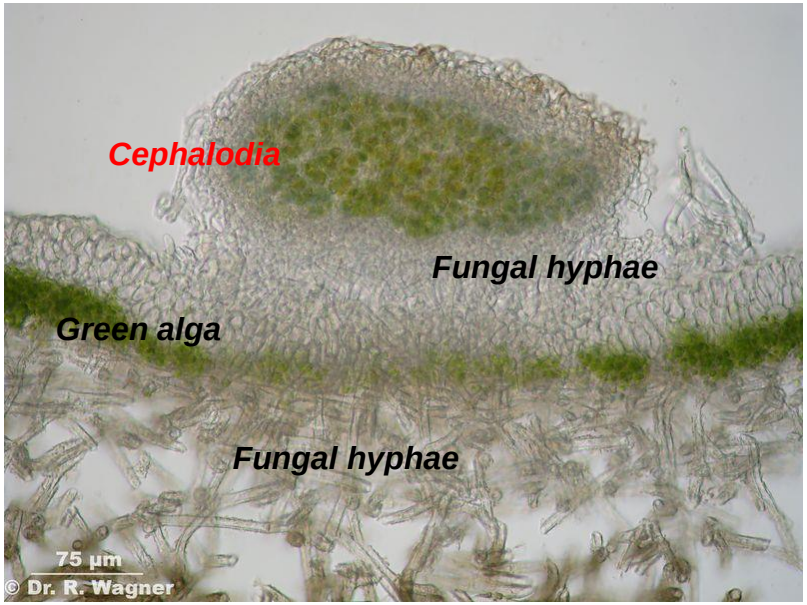
Cette étude permettra :

1. Établir les niveaux de diversité génétique des populations des lichens.
2. Évaluer la diversité des microorganismes associés aux lichens dans un gradient latitudinal
3. Développent de la symbiose entre lichens et bactéries.

Financement :
Conseil de recherches et sciences naturelles et en génie du Canada

What's a lichen ?

Lichens symbiosis | Plant symbiosis



Symbiotic communities « par excellence »

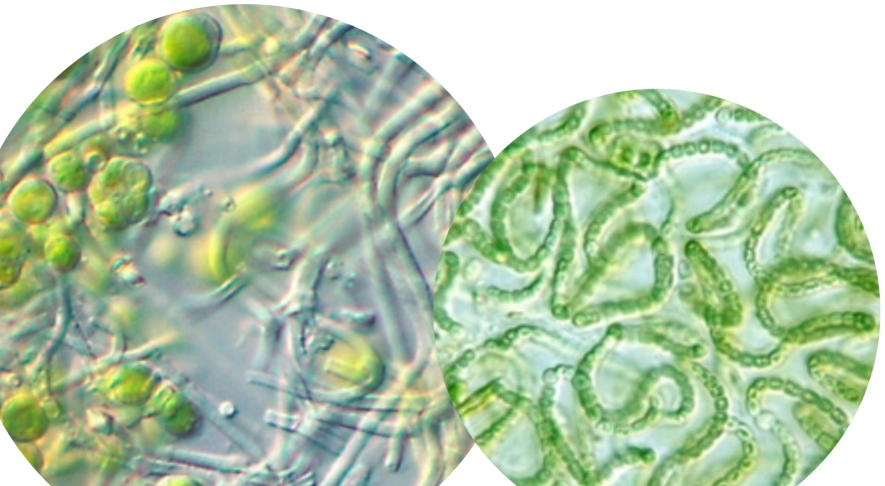
1 or 2 (+) fungi : Asco- and basidiomycetes (yeasts)

A main green algal photobiont

Cyanolichens: Cyanobacteria fix N^2

Cephalolichens : Tripartite communities

Other bacteria associated



Peltigera

Lichens symbiosis | Plant symbiosis

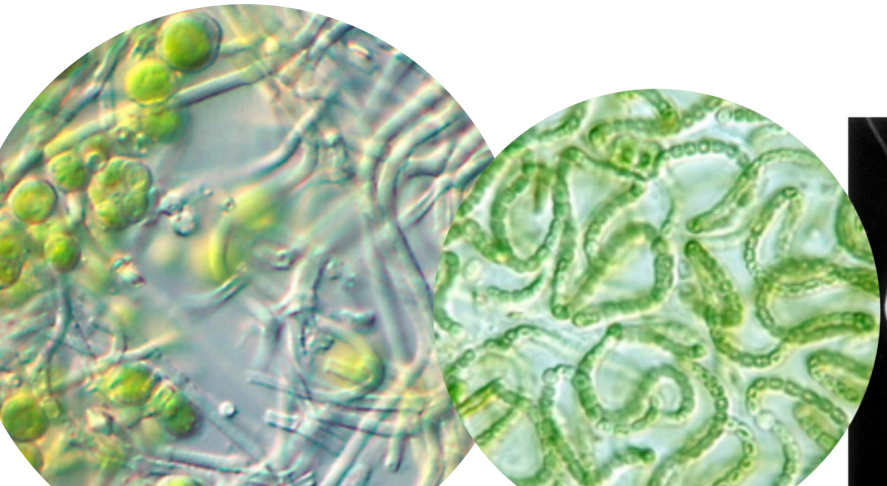
Photo C. Lavoie

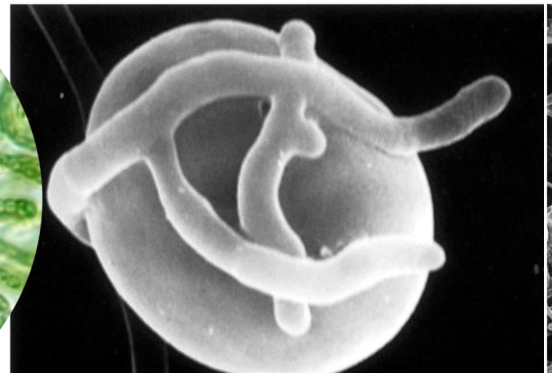
1 or 2 fungi (+) : Asco and basidiomycetes (yeasts)

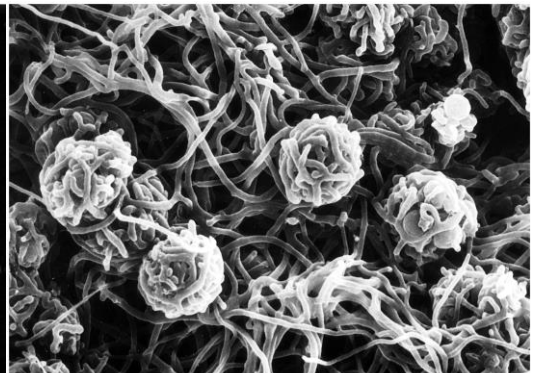
Great diversity of cyanobionts (mostly ***Nostoc***) associated to specialists or generalist species

Large scale studies found supporting and contradicting evidence of specificity

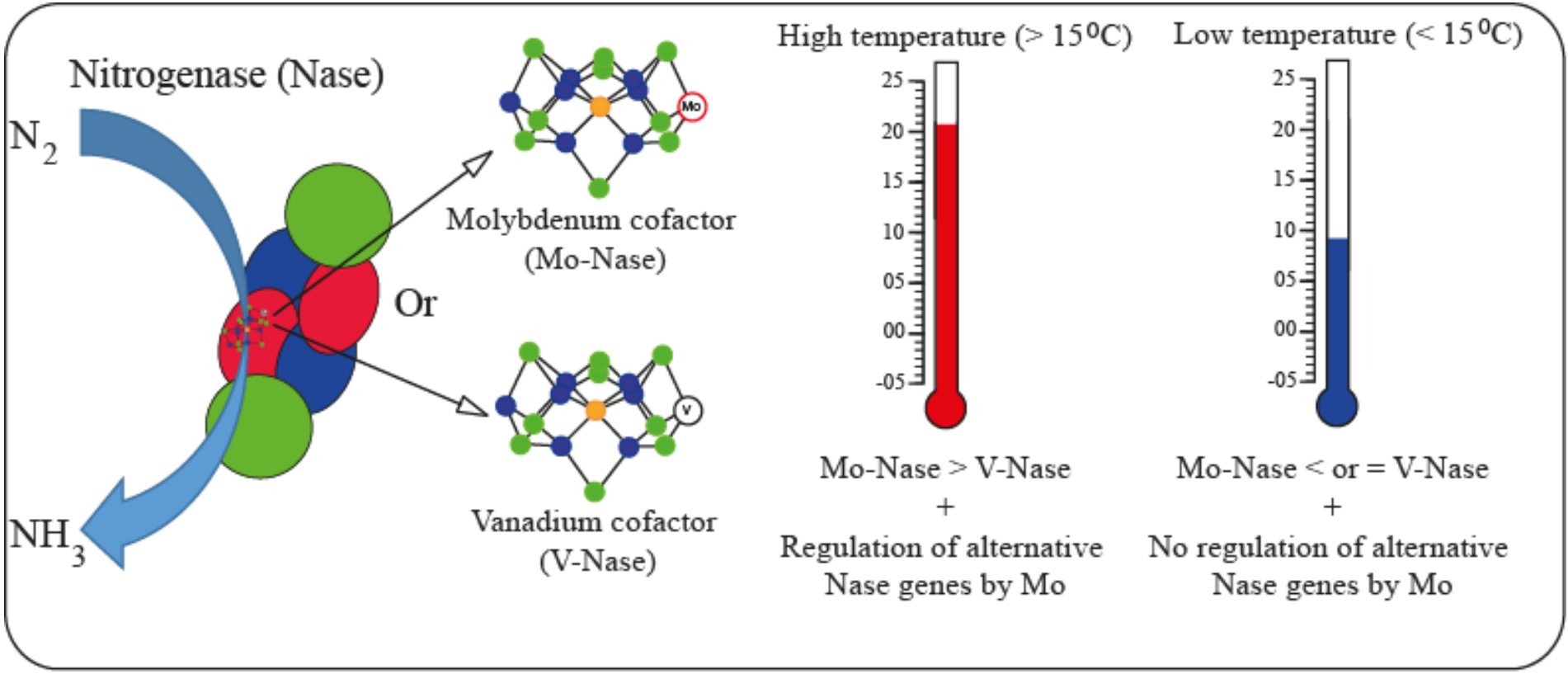
Use of alternative nitrogenases for N^2 fixation in cephalolichens







Lichens symbiosis | Plant symbiosis



Eur. J. Phycol. (2014), **49(1)**: 11–19

Taylor & Francis

Lichen-symbiotic cyanobacteria associated with *Peltigera* have an alternative vanadium-dependent nitrogen fixation system

BRENDAN P. HODKINSON[1,2], JESSICA L. ALLEN[3], LAURA L. FORREST[4], BERNARD GOFFINET[5], EMMANUËL SÉRUSIAUX[6], ÓLAFUR S. ANDRÉSSON[7], VIVIAN MIAO[8], JEAN-PHILIPPE BELLENGER[9] AND FRANÇOIS LUTZONI[1]

Slide by J-P Bellenger (U. Sherbrooke)

Is this a widespread phenomenon across cephalolichens?

Lichens symbiosis | Plant symbiosis

Stereocaulon in Eastern Canada: 12-15 species

Cyanobiont either *Nostoc* or *Stigonema*

A component of post-fire communities, in particular ***Stereocaulon paschale***

Photos: Loren Leport

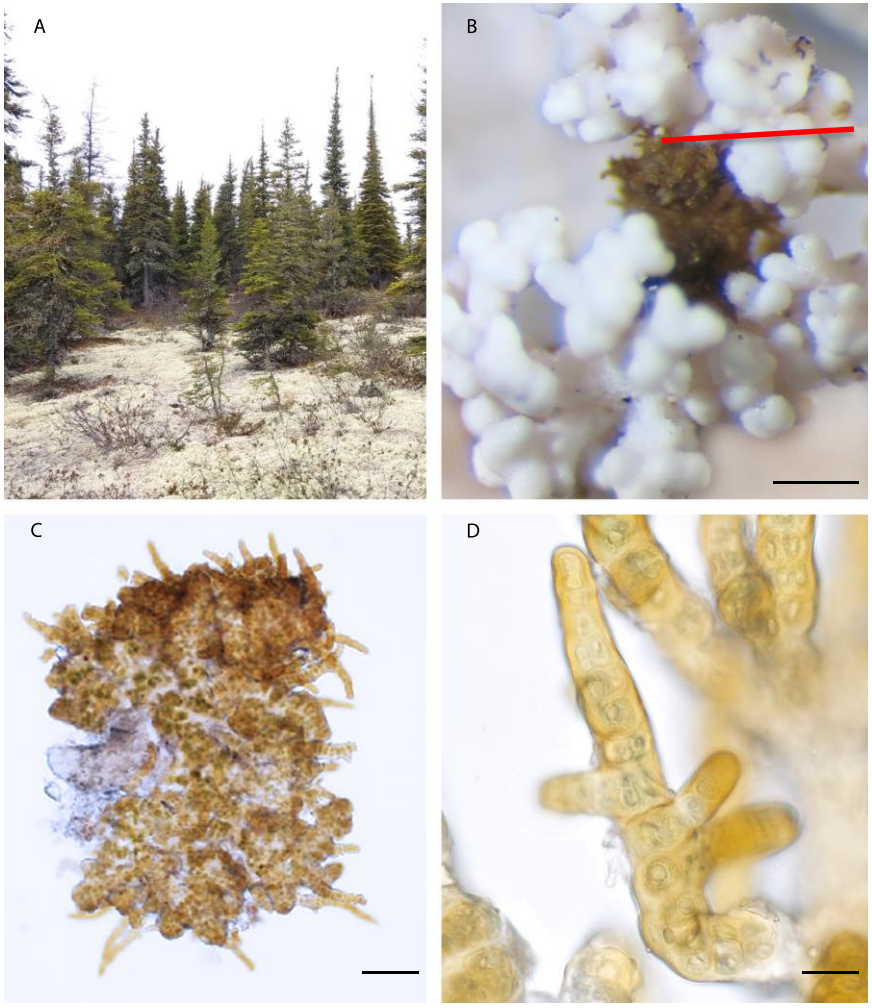
Lichens symbiosis | Plant symbiosis

2nd project:
Nitrogen-fixing bacteria and microbiome of the lichen « de neige

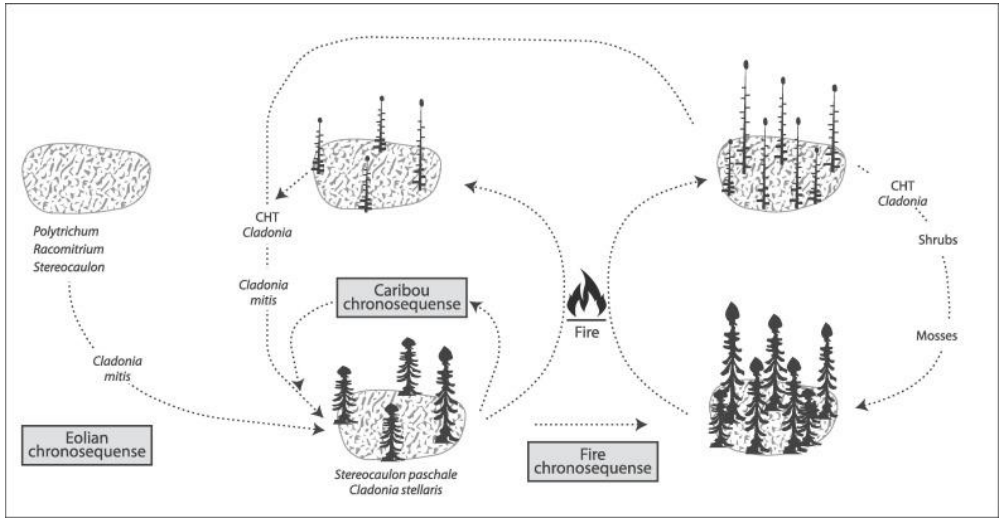
- Focused on *Stereocaulon* in Québec
- Specificity and selectivity
- Nitrogen fixation rates and contribution to the nitrogen budget
- Functional diversity of the associated microbes

Lichens symbiosis | Plant symbiosis

Stereocaulon paschale



Cephalodia



Stigonema

Work by Camille Lavoie

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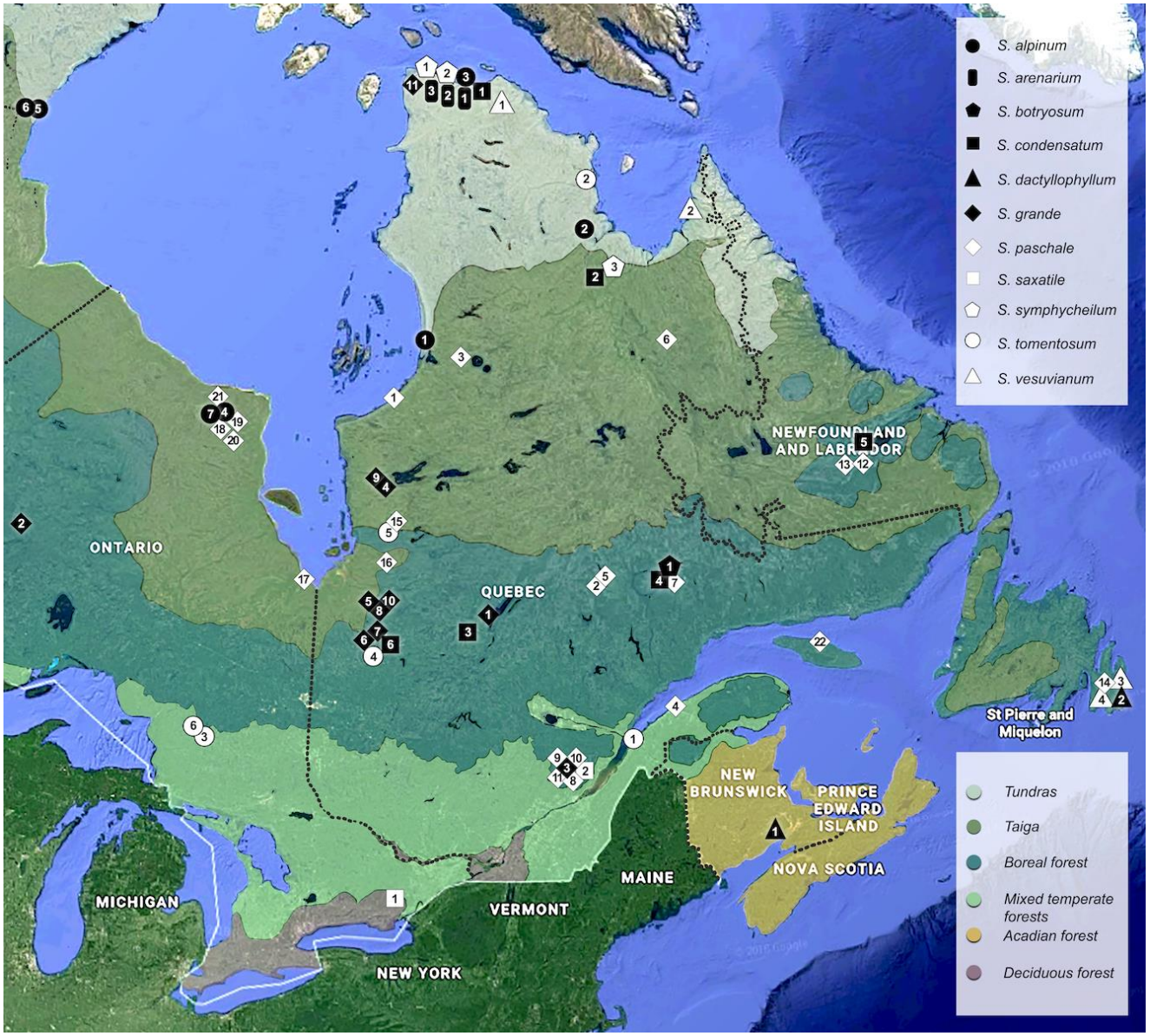
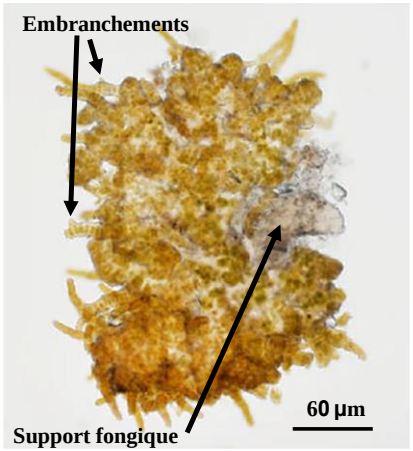
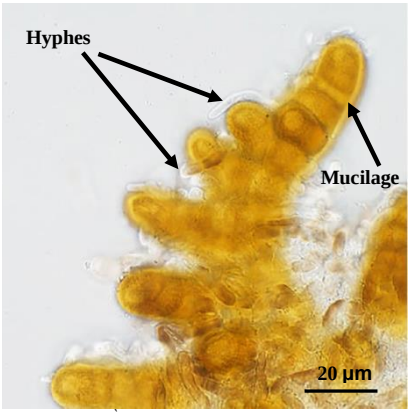
Lichens symbiosis

Plant symbiosis







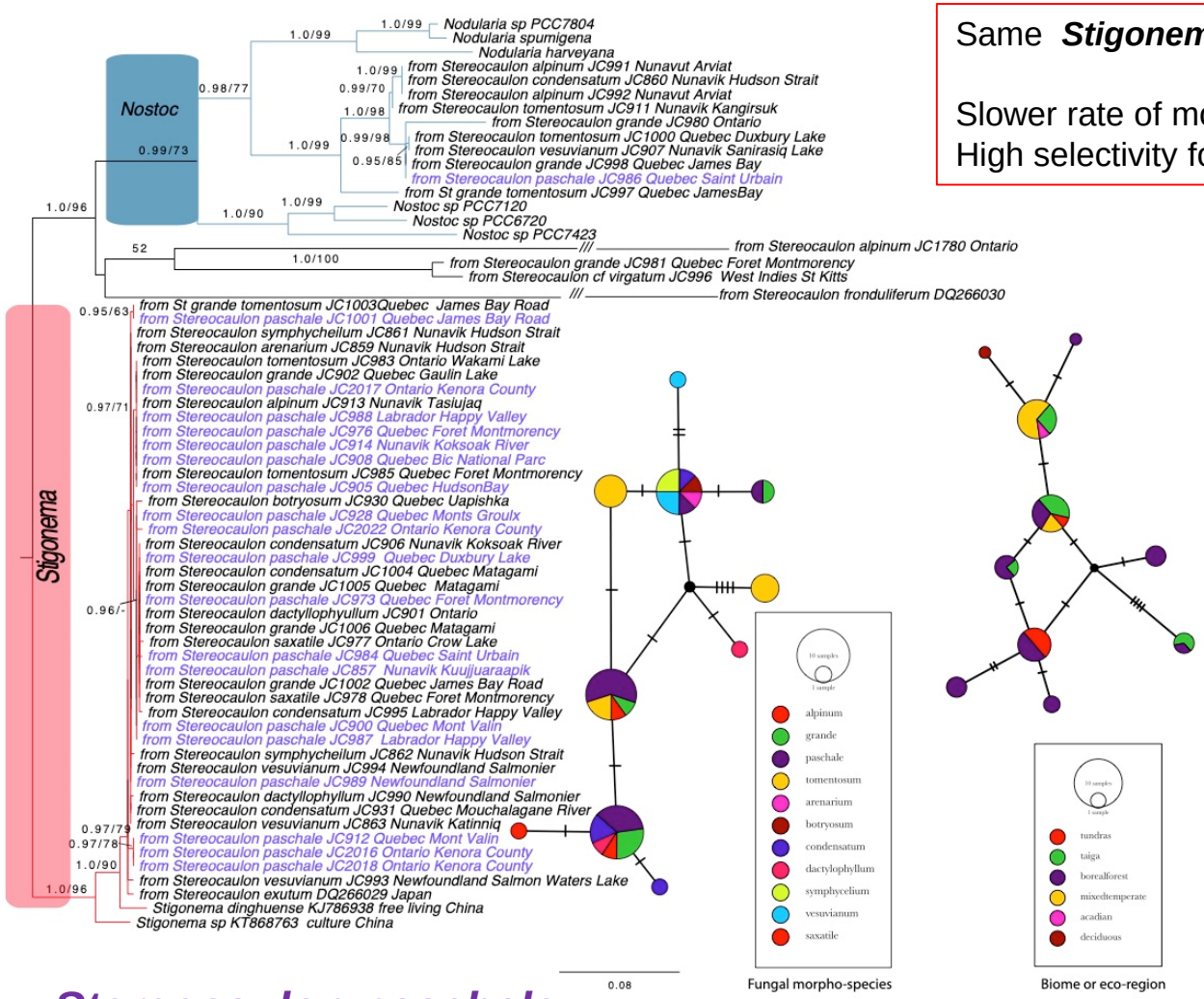
Work by Camille Lavoie, re-submitted to J. Biogeography

Lichens symbiosis

Plant symbiosis

Same ***Stigonema*** haplotype across biomes and species

Slower rate of molecular evolution ?
High selectivity for a particular ***Stigonema***?



Stereocaulon paschale

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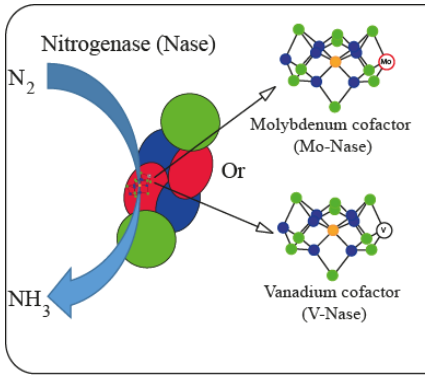
Lichens symbiosis

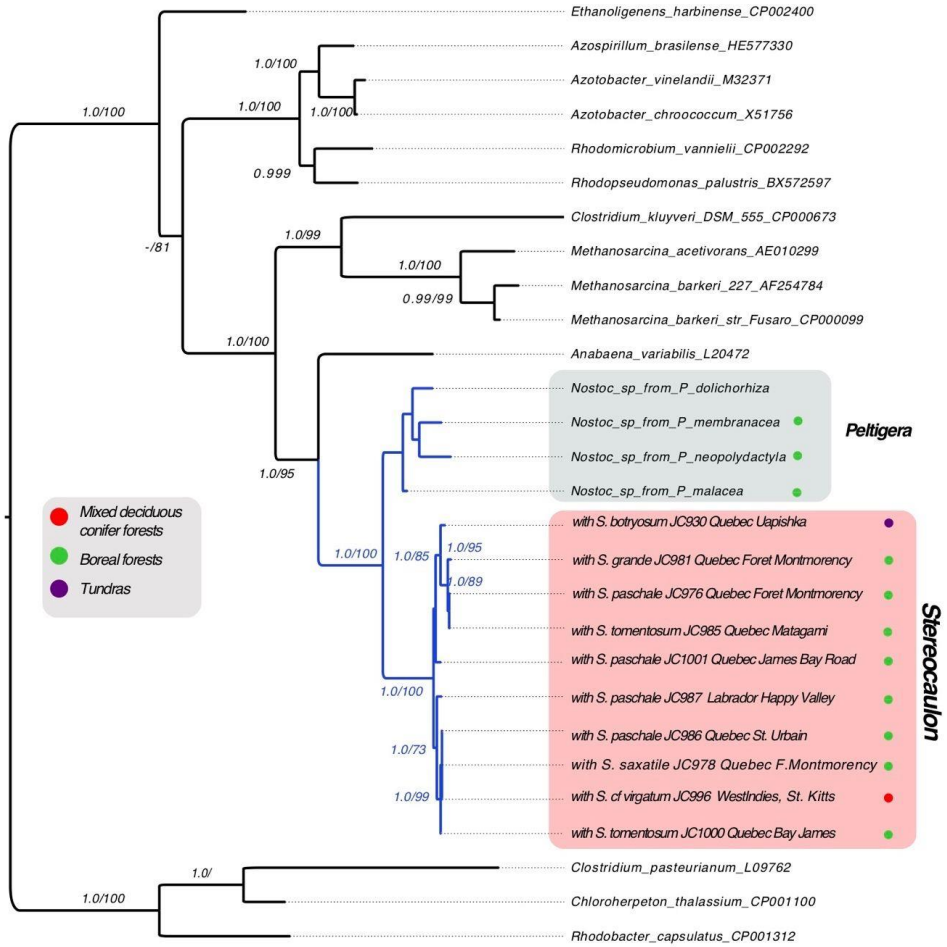
Plant symbiosis



Stigonema uses both nitrogenases

Novel results:
Va- Nitrogenase is functional
at any temperature

Fig. 5.



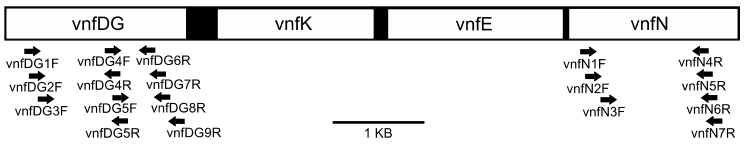


Fig. 2. Primer map of the *vnf* gene cluster in cyanobacteria (see Table 2 for individual primer sequences).

Work by Marie Renaudin, J-P Bellenger

Lichens symbiosis | Plant symbiosis

Looking for motivated graduate students:

M.Sc.– Diversité génétique, symbiose et microbiomes de lichens nordiques

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Lichen evolution and symbiosis

Plant -N^2-fixing symbiosis

Lichens symbiosis

Plant symbiosis

Quantifying nitrogen-fixation in feather moss carpets of boreal forests

Thomas H. DeLuca*†, Olle Zackrisson†, Marie-Charlotte Nilsson† & Anita Sellstedt‡

** School of Forestry, The University of Montana, Missoula, Montana 59812, USA*
† Department of Forest Vegetation Ecology, Swedish University of Agricultural Sciences, SE-901 83 Umeå, Sweden
‡ Umeå Plant Science Center, Department of Plant Physiology, Umeå University, SE-901 87 Umeå, Sweden

Biological nitrogen (N) fixation is the primary source of N within natural ecosystems[1], yet the origin of boreal forest N has remained elusive. The boreal forests of Eurasia and North America lack any significant, widespread symbiotic N-fixing plants[1–6]. With the exception of scattered stands of alder in early primary successional forests[7], N-fixation in boreal forests is considered to be extremely limited. Nitrogen-fixation in northern European boreal forests has been estimated[2] at only 0.5 kg N ha^{-1} yr^{-1}; however, organic N is accumulated in these ecosystems at a rate of 3 kg N ha^{-1} yr^{-1} (ref. 8). Our limited understanding of the origin of boreal N is unacceptable given the extent of the boreal forest region, but predictable given our imperfect knowledge of N-fixation[1,9]. Herein we report on a N-fixing symbiosis between a cyanobacterium (*Nostoc* sp.) and the

Fixation rates from **0.5- 3 kg ha-1 yr-1**.

Feather mosses

Lichens symbiosis | Plant symbiosis

3rd project:
Population genomics and microbiome of nordic mosses

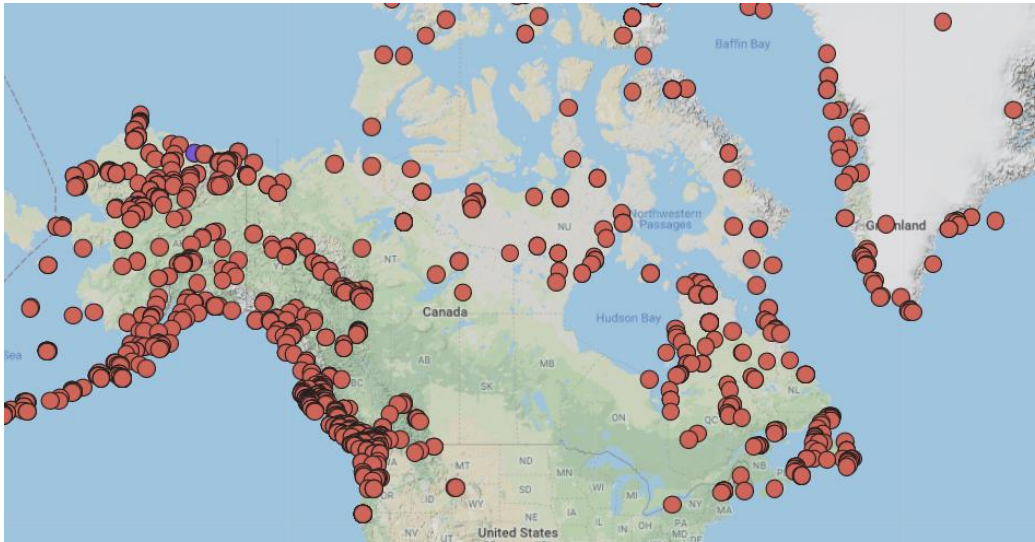
- Focused on *Racomitrium*
- Nitrogen fixation rates and contribution to the nitrogen budget
- Functional diversity of the associated microbes

Lichens symbiosis

Plant symbiosis

Racomitrium- wholly moss

Data suggest that microbes associated fix nitrogen

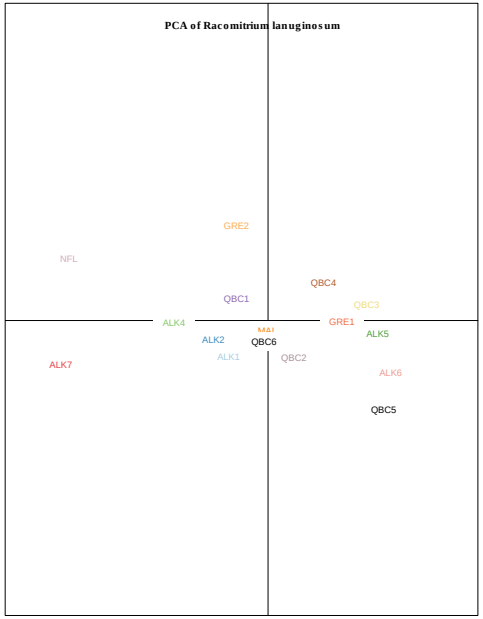


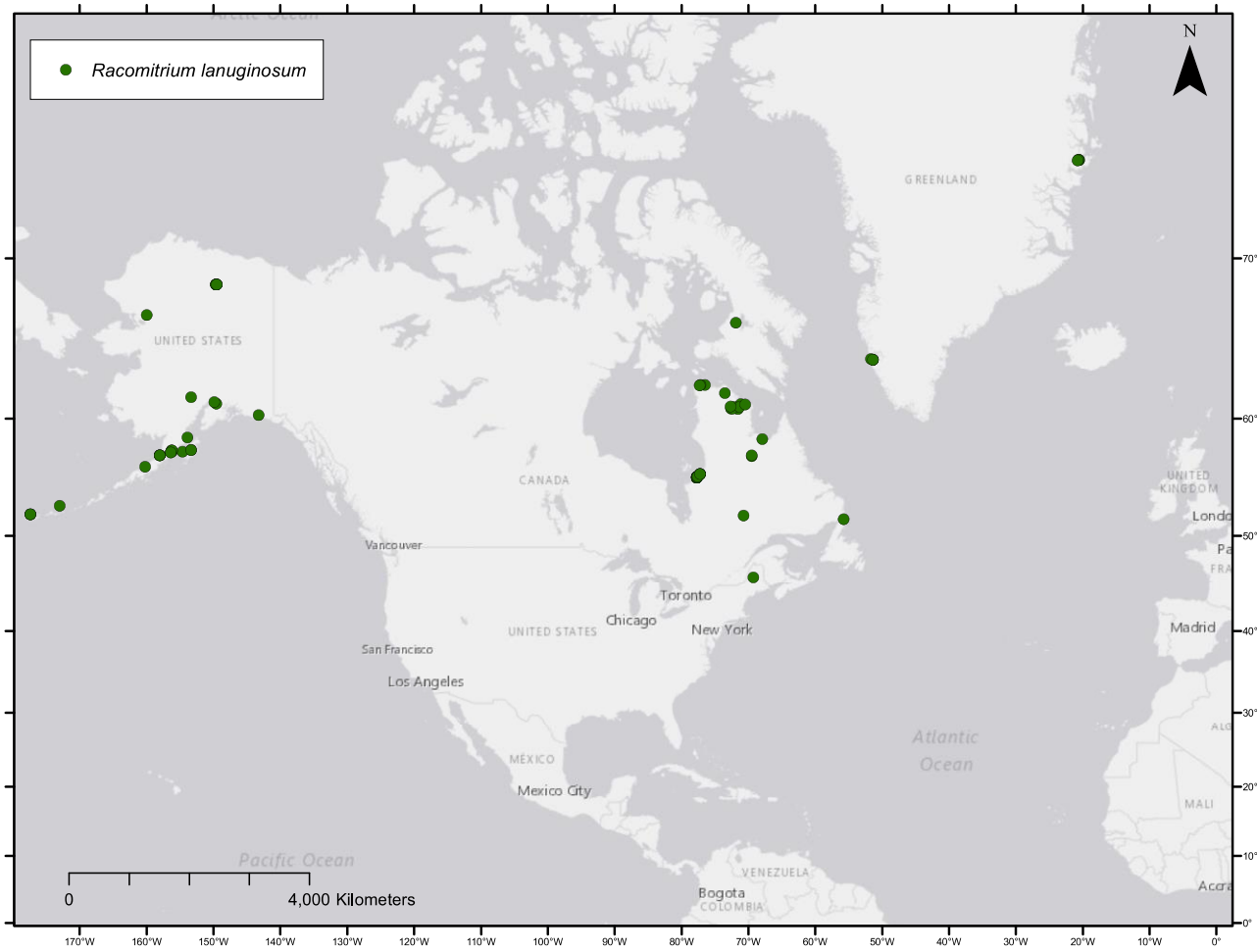
Work by Dennis Escolástico

Lichens symbiosis

Plant symbiosis

Racomitrium wholly moss





Work by Dennis Escolástico

Summary

- Diversity of lichen and mosses in nordic regions using population genomic approaches
- Diversity of microbes and viruses associated to lichens and bryophytes
- Nitrogen flow in cryptogams
- Modelling lichen and bryophyte diversity under current and future climate predictions

A potential chaire CRNSG (2019-2024) to work on tropical gymnosperms and microbes
Looking for students, see http://villarreal-lab.ibis.ulaval.ca/