

UQAT



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UQAM

The Effects of Partial
Harvest and Stand
Structure on Conifer
Regeneration in Black
Spruce Stands
:The MISA project

• Sanghyun Kim •

□ Supervisors

- Miguel Montoro Girona (UQAT-SLU)
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- Patricia Raymond (MFFP)

The World's Largest Land Biome

Boreal Forest



- ❑ 11.5% of total land area.
- ❑ 1/3 forest area, C stock, timber
- ❑ The largest intact forest
- ❑ Contains the most freshwater

+ The Most Common Boreal Tree Species +

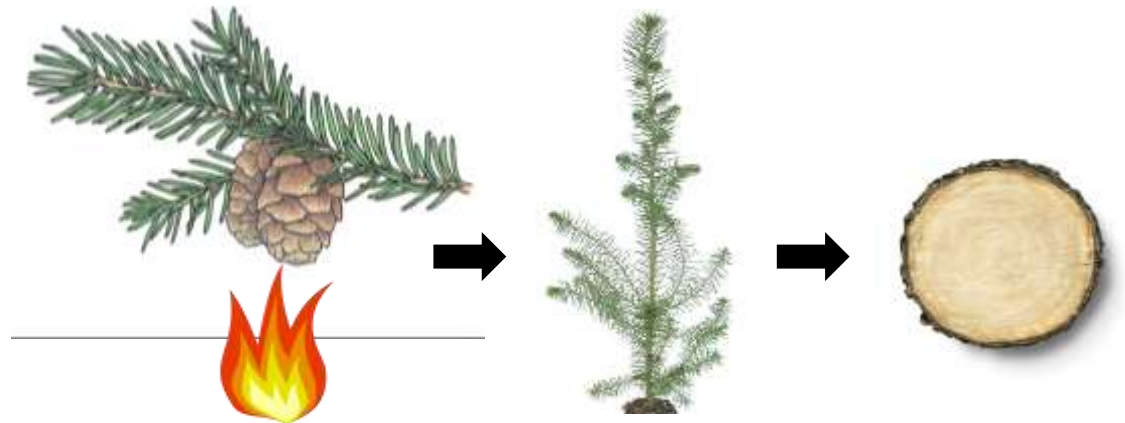
NATURE CONSERVATION
CONSERVANCY DE LA NATURE
CANADA



SOURCE
USGS. 1999. Digital Representation of "Atlas of United States Trees" by Elbert L. Little, Jr..
<http://esp.cr.usgs.gov/data/little>. Downloaded/téléchargé 2015-06-17.

Black spruce (*Picea mariana*)

- Widespread in Canada
- Fire-adapted regeneration
- Excellent timber value
- Even-aged stands



Regeneration Failure



Kalmia augustifolia



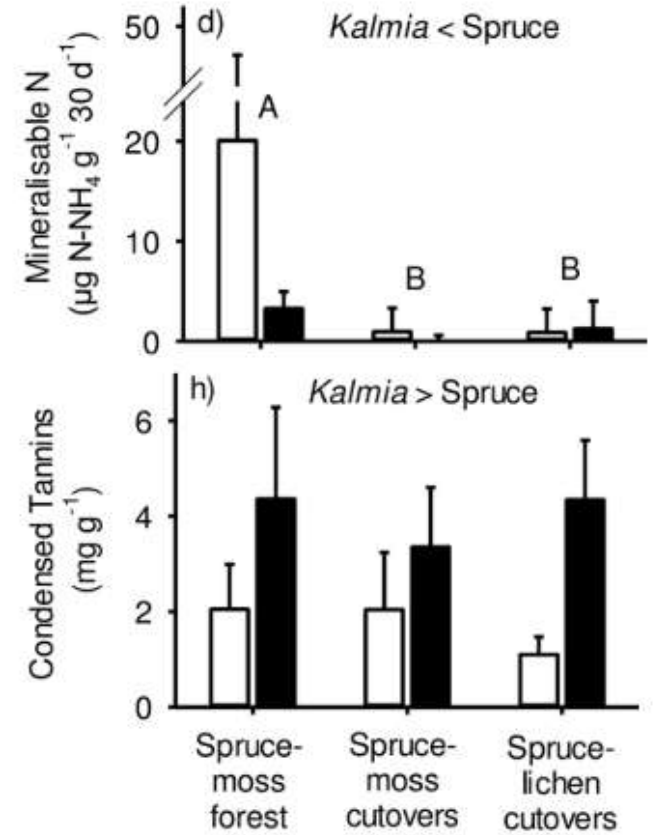
Rhododendron groenlandicum



Ericoid mycorrhiza



Ectomycorrhiza

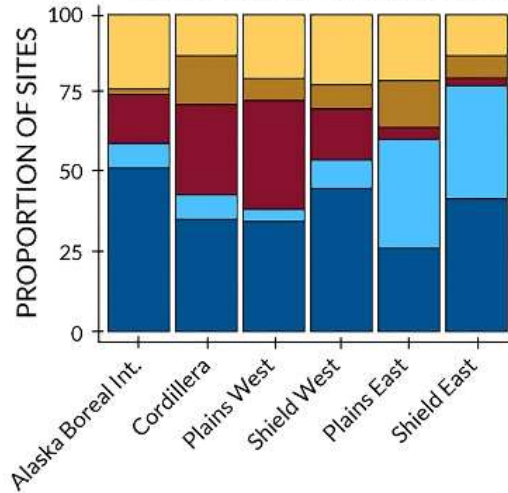


Legend

- Spruce patches
- Kalmia* patches

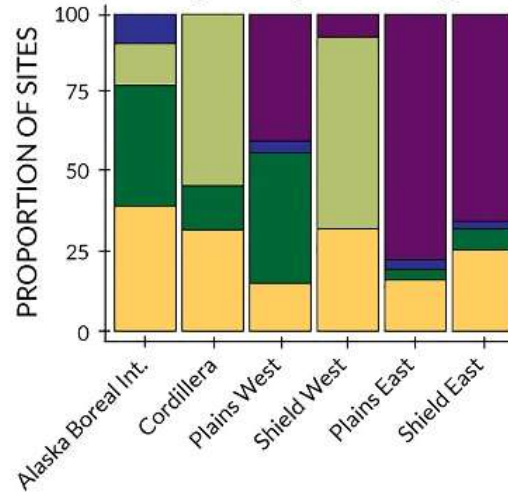
Regeneration Failure

Black Spruce Resilience



- Density Reduction
- Self Replacement
- Regeneration Failure
- Poor Establishment
- Competition

Trajectory of Change



- Jack Pine
- Birch
- Regeneration Failure
- Other Conifer
- Aspen

Baltzer et al. 2021



Climate Change

- Other conifer forest
- Deciduous forest
- Regeneration failure

ECOS^S Center for Ecosystem Science and Society of Northern Arizona University

Mack et al. 2021

- Black spruce forest



Silvicultural Alternatives to Clearcutting



Clearcutting



Silvicultural alternatives

Clearcutting:

To maximize harvesting efficiency

Partial cutting:

To narrow gaps between natural & managed forest



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NEWS | 20 May 2021

Controversial forestry experiment will be largest-ever in United States

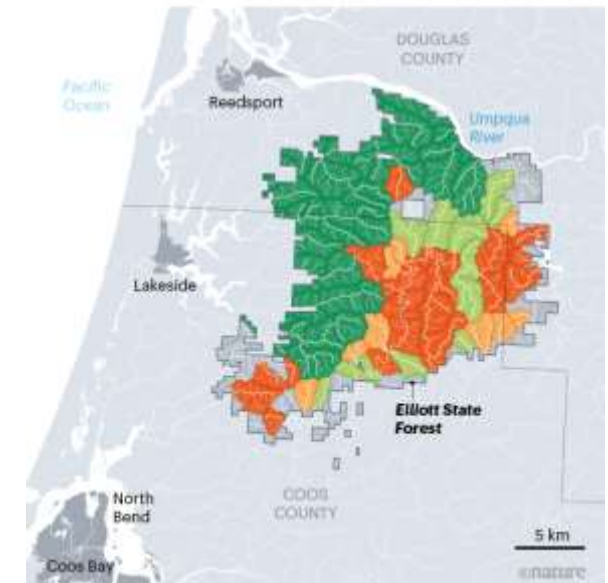
At the Elliott State Forest in Oregon, researchers will explore how best to balance timber production with conservation.

A GRAND EXPERIMENT

The Elliott State Research Forest would test multiple land-management strategies to determine how to balance conservation with timber production.

- Old-growth reserve (no logging)
- 50% intensive logging, 50% reserve
- 100% ecological forestry treatments*
- Mixture of intensive and ecological forestry treatments, with reserves
- Excluded from experimental area

*Includes selective harvesting of trees.



Elliott (Oregon, US) – The world’s largest forestry experiment (2021)

Effaråsen (Sweden) – Trade-offs between biodiversity conservation & forest production (2012)

MISA (Quebec, CA) – Novel partial harvest experiment (2003)

EVO (Finland) – Rehabilitating forest structure & species composition (2001)

EMEND (Alberta, CA) – Variable retention harvest experiment (1998)



Managing Innovative Silvicultural Alternatives (MISA)



Evaluation of silvicultural alternatives in the context of Canadian boreal forest



Post-cutting Mortality Following Experimental Silvicultural Treatments in Unmanaged Boreal Forest Stands

Miguel Montoro Girona^{1,2*}, Hubert Morin³, Jean-Martin Lussier³ and Jean-Claude Ruel⁴

¹ Restoration Ecology Group, Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences, Umeå, Sweden, ² Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Chicoutimi, QC, Canada, ³ Canadian Forest Service, Canadian Wood Fibre Centre, Natural Resources Canada, Québec, QC, Canada, ⁴ Faculté de Foresterie et de Géomatique, Université Laval, Québec, QC, Canada



Radial Growth Response of Black Spruce Stands Ten Years after Experimental Shelterwoods and Seed-Tree Cuttings in Boreal Forest

Miguel Montoro Girona^{1,2*}, Hubert Morin¹, Jean-Martin Lussier² and Denis Walsh¹

¹ Département des Sciences Fondamentales, Université du Québec à Chicoutimi, 555 boul de l'Université, Chicoutimi, QC G7H 2B1, Canada; hubert_morin@uqac.ca (H.M.); Denis_Walsh@uqac.ca (D.W.)
² Canadian Wood Fibre Centre, Natural Resources Canada, 1055 du P.E.P.S., Québec, QC G1V 4C7, Canada; jean-martin.lussier@canada.ca
^{*} Correspondence: miguel.montoro1@uqac.ca; Tel.: +1-418-545-5011 (ext. 2330)



Understanding tree growth responses after partial cuttings: A new approach

Miguel Montoro Girona^{1*}, Sergio Rossi^{1,2}, Jean-Martin Lussier³, Denis Walsh¹, Hubert Morin¹

¹ Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada, ² Key Laboratory of Vegetation Restoration and Management of Degraded Ecosystems, Provincial Key Laboratory of Applied Botany, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, China, ³ Canadian Wood Fibre Centre, Canadian Forest Service, Natural Resources Canada, Québec, Québec, Canada



Conifer Regeneration After Experimental Shelterwood and Seed-Tree Treatments in Boreal Forests: Finding Silvicultural Alternatives

Miguel Montoro Girona^{1,2*}, Jean-Martin Lussier³, Hubert Morin¹ and Nelson Thiffault⁴

¹ Ecology Restoration Group, Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences (S.U.), Umeå, Sweden, ² Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Saguenay, QC, Canada, ³ Canadian Wood Fibre Centre, Natural Resources Canada, Ottawa, QC, Canada

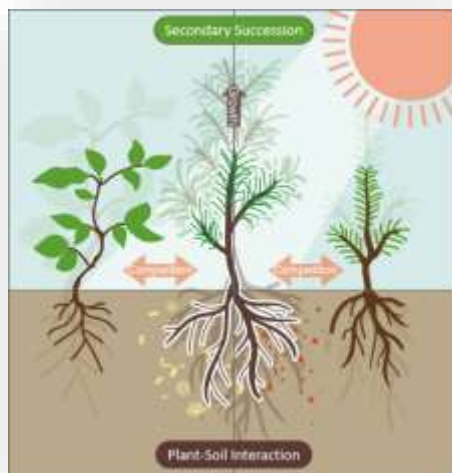




How do conifer regeneration & soil microbiome respond to silvicultural treatments?



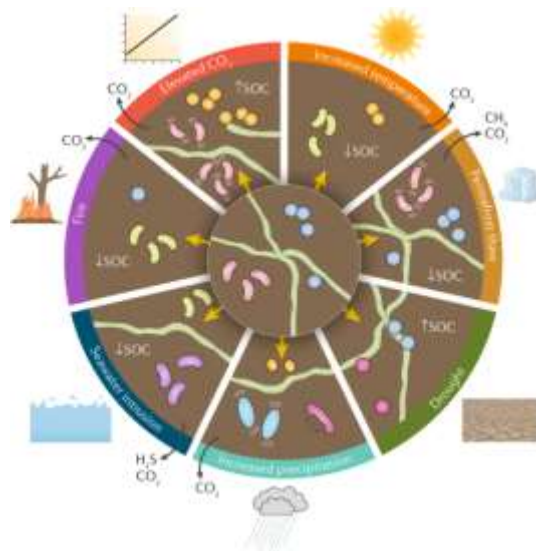
1. Regeneration Dynamics



- Seedling density & growth
- Regeneration driving factors



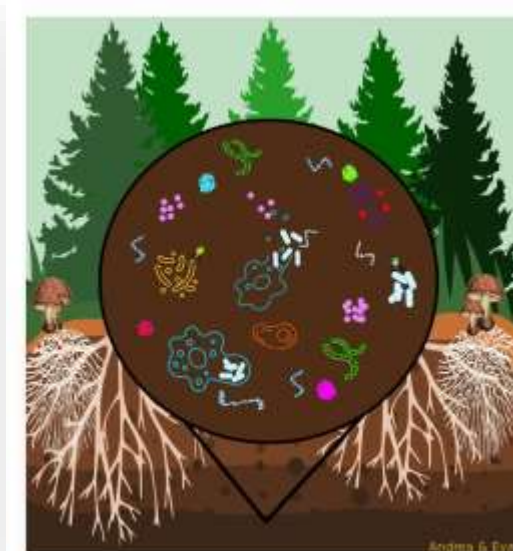
2. Soil Microbiome



- Community structure
- Diversity (fungi, bacteria)



3. Rhizosphere microbiome



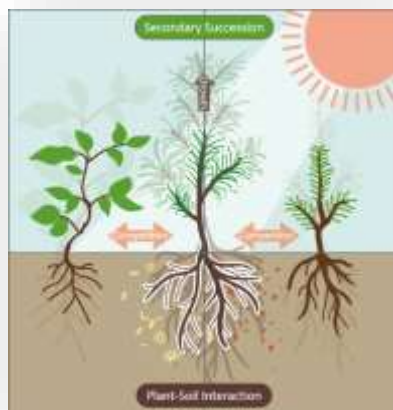
- Functional diversity
- Beneficial microorganisms



Conifer regeneration following uniform shelterwood system in black spruce stands

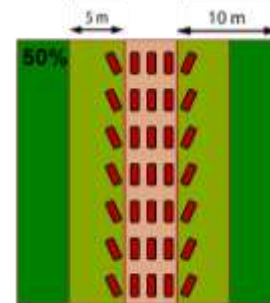


1. Regeneration Dynamics

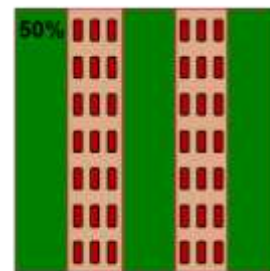


- ❑ Evaluate the impacts of silvicultural treatments and stand structures on seedling growth, density and regeneration driving factors.

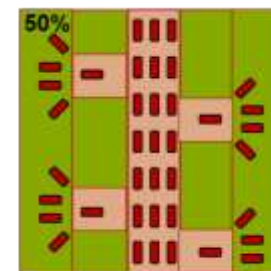
Uniform Shelterwood Systems



Close-selection*



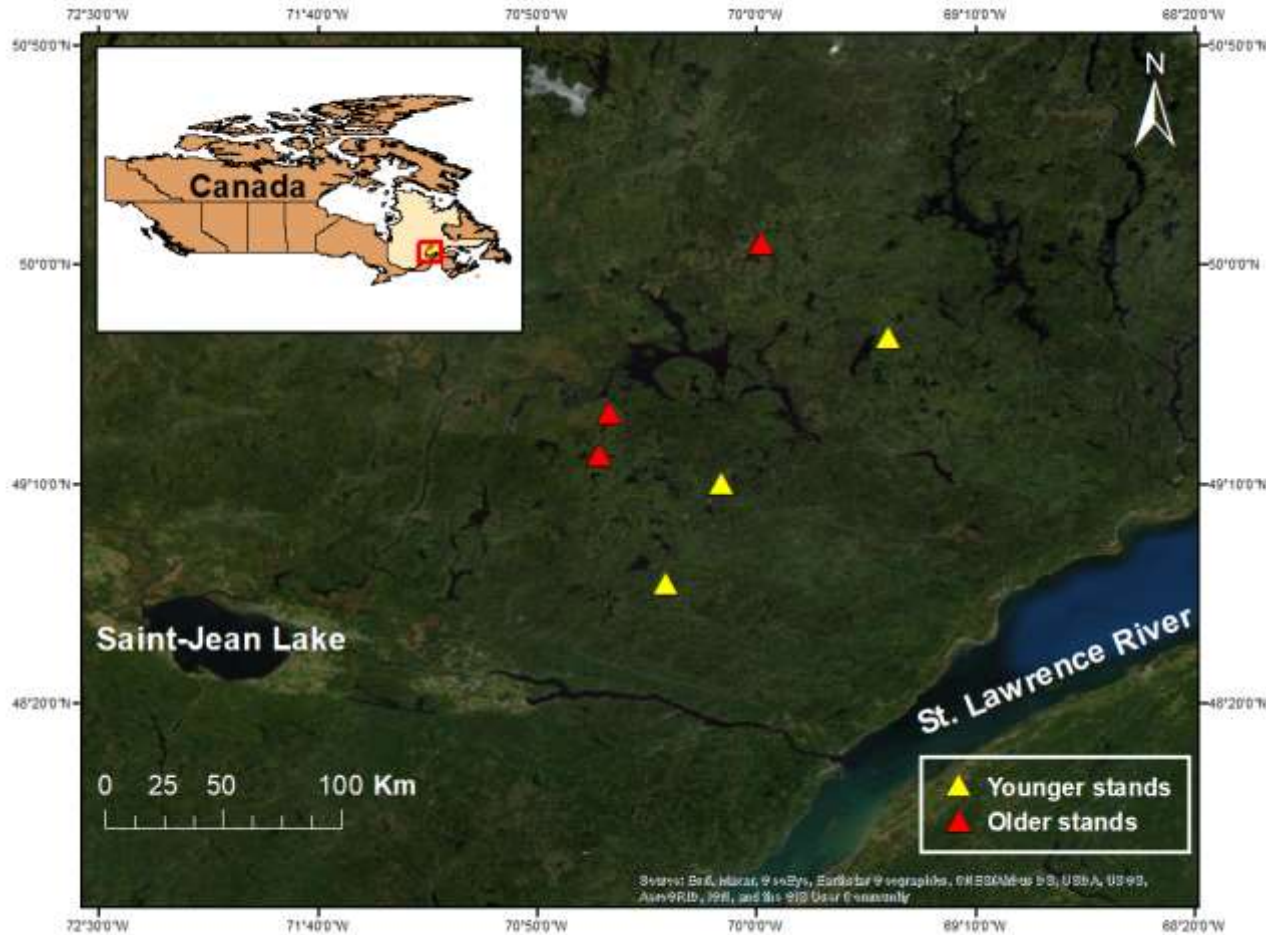
Mini-strip*



Distant-selection*

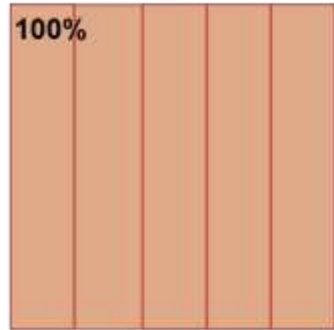
- **Uniform shelterwood system** with spot scarification will favor the establishment of black spruce seedlings than shade-intolerant deciduous plants.

Study Area

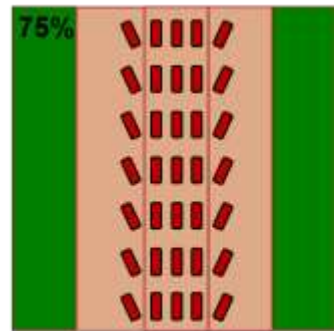


- Natural even-aged black spruce stands
- Northern Saguenay & North Shore Regions
- Two bioclimatic regions: Balsam fir-white birch & black spruce-feather mosses
- Younger & Older stands from fire history

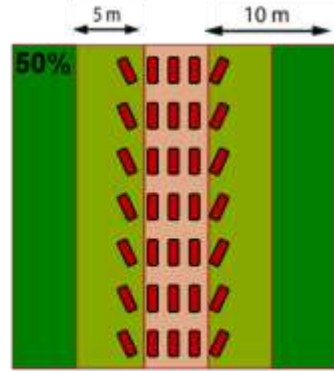
Experimental Silvicultural Treatments



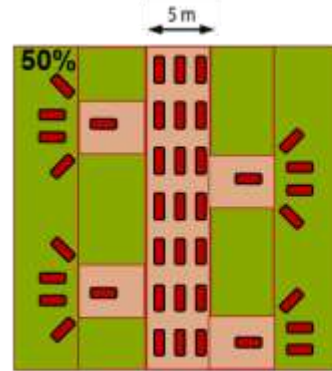
Clear-cut



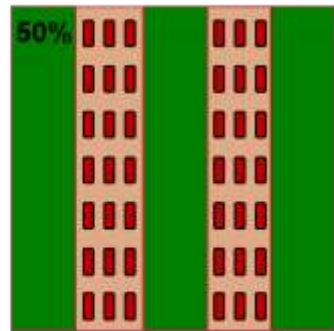
Seed-trees



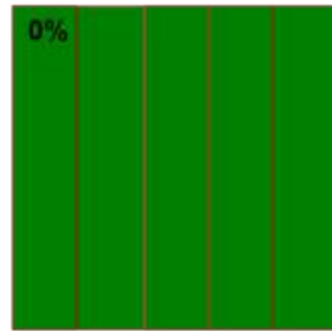
Close-selection*



Distant-selection*



Mini-strip*



Unmanaged

-  Scarification plot
-  Total harvested
-  Partial harvested
-  Intact residual strip
- * Shelterwood



Harvesting (2003)

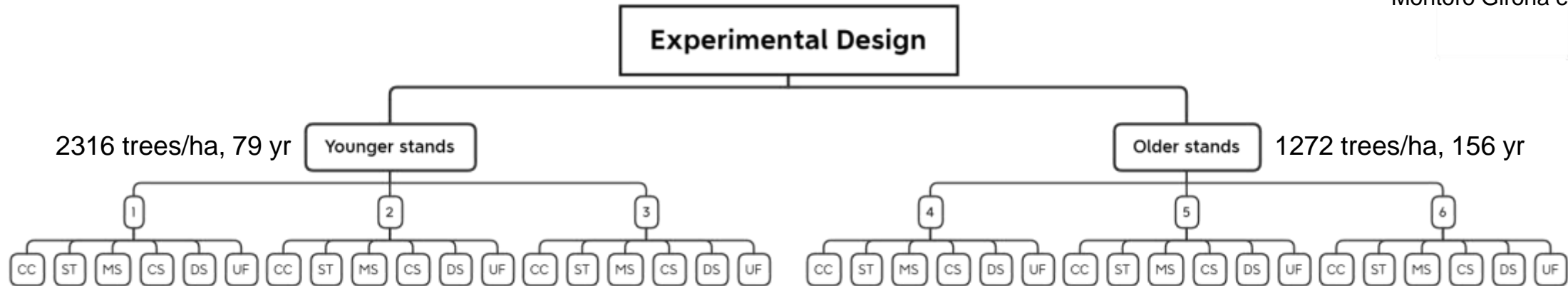


Spot scarification (2004)

- Harvesting Intensity - CC (100%), ST (75%), SW (50%), UF (0%)
- 3 variants of shelterwood by Spatial pattern & Scarification

Experimental Design

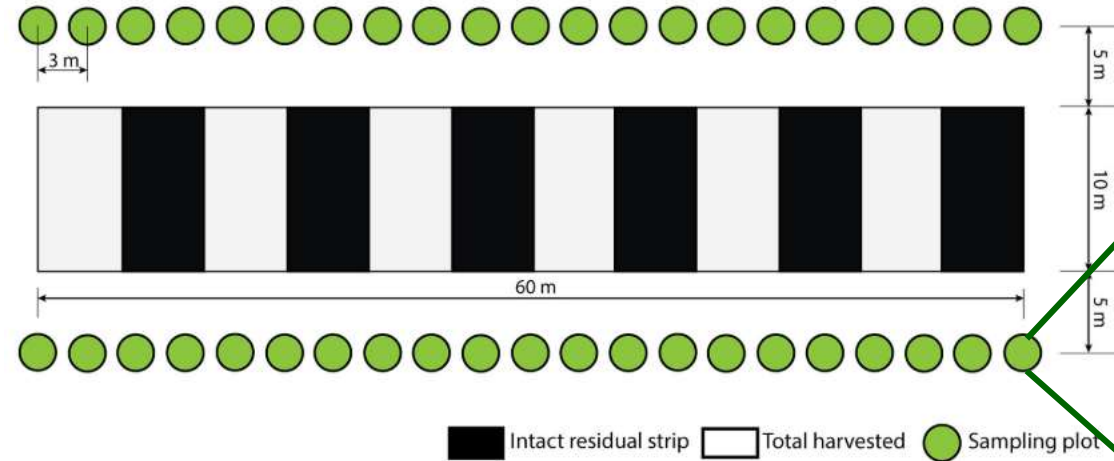
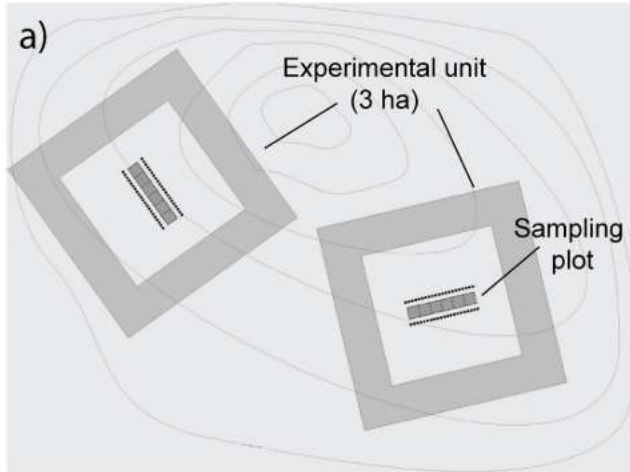
Montoro Girona et al. 2018



Stand type	Block	Density <i>trees/ha</i>	Stocking	Dominant height <i>m</i>	Diameter at breast height		Basal area <i>m²/ha</i>	Volume <i>m³/ha</i>	Species composition (%)			
					Mean <i>cm</i>	Coefficient of variation <i>%</i>			Black spruce	Balsam fir	Aspen	Paper birch
Younger	1	2542	0.64	17.0	15.0	22	45.7	248.6	97.0	1.3	0.2	1.1
	2	2325	0.61	17.3	14.4	24	39.5	209.2	94.6	3.5	1.6	0.3
	3	2919	0.69	17.4	12.8	31	41.9	251.3	95.7	0.0	4.2	0.1
Older	4	1981	0.55	17.1	15.3	22	37.7	209.0	98.8	0.7	0.3	0.2
	5	1556	0.46	18.1	16.4	24	34.2	202.6	97.0	2.5	0.3	0.2
	6	1075	0.35	18.3	15.7	28	22.8	134.9	92.5	7.5	0.0	0.0

- 3 sites x 2 stand characteristics x 6 silvicultural treatments = 36 experimental units

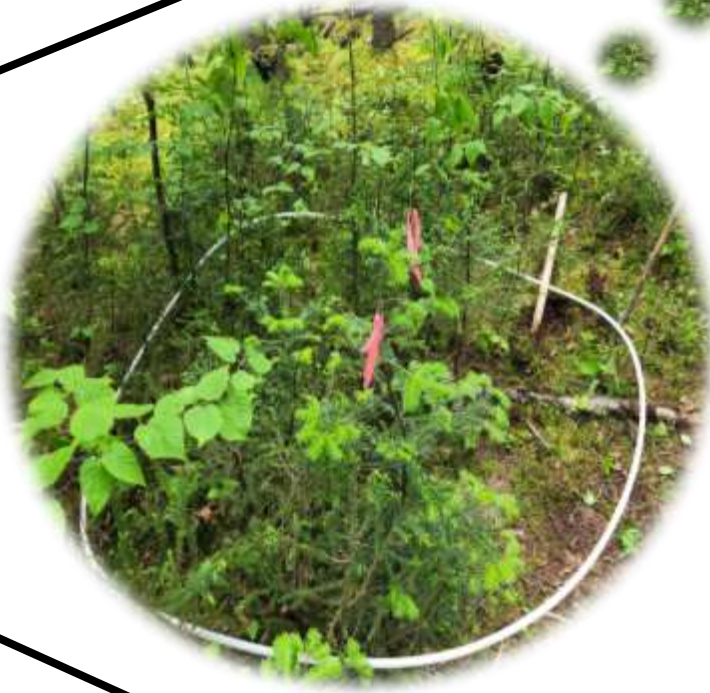
Sampling Design



- **3 sites x 2 stand structures x 6 silvicultural treatments = 36 experimental units**
- **x 42 microplots = 1,512 permanent plots**

Regeneration Assessments

Sampling plot
(4m²)



Seedling Density

- Count by species & height class

Dominant conifer seedling

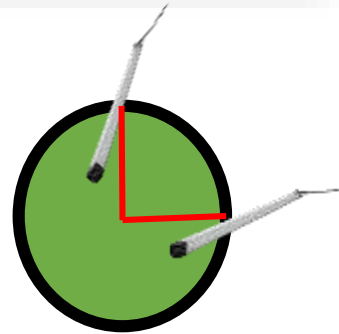
- Age
- Class
- Height
- Diameter
- Disturbances
- Bryophyte cover
- Terminal shoot length

Regeneration Assessments

Sampling plot
(4m²)



Soil Moisture/EC/
Temperature

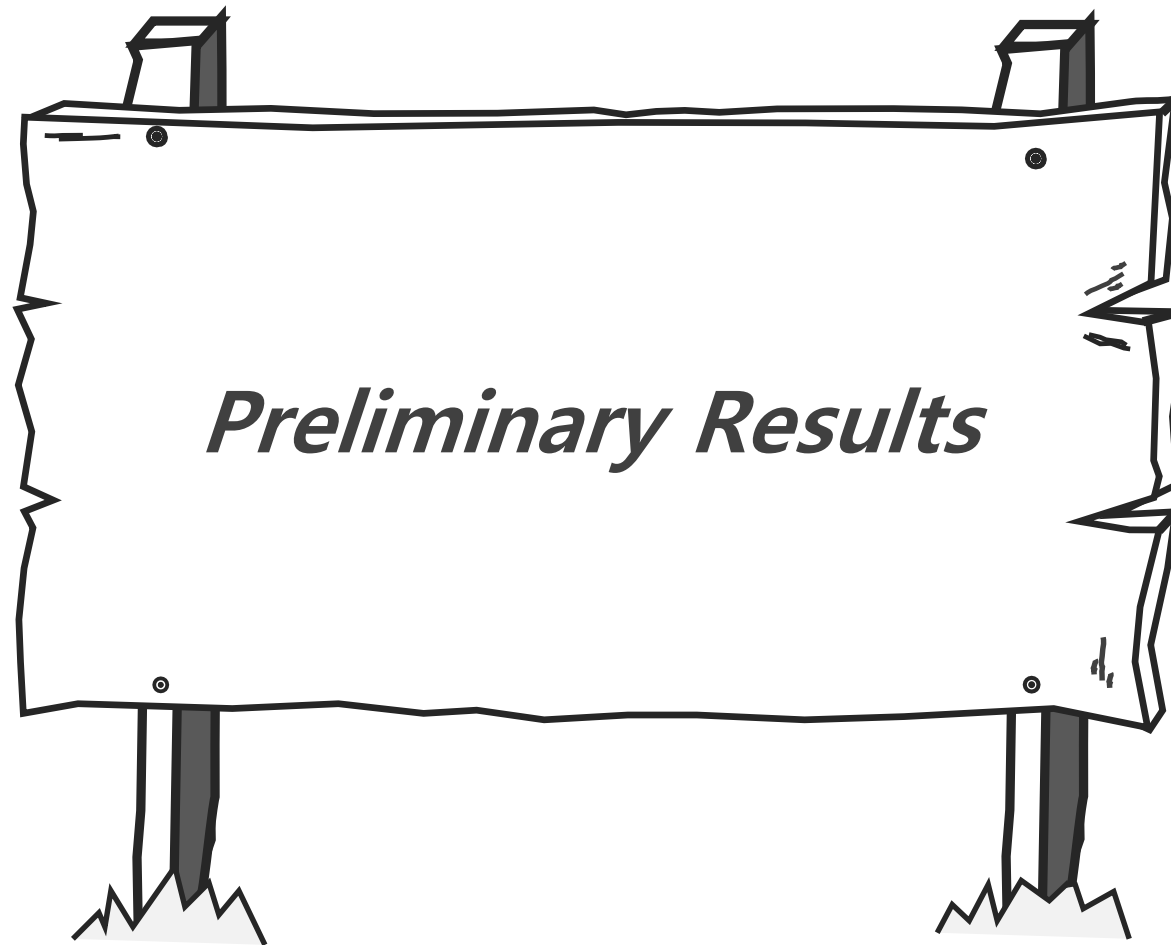


LI-COR Pyranometer

- Percentage transmittance of photosynthetically active radiation (PAR; 400-700 nm)
- 1m above ground
- Orthogonal measurement

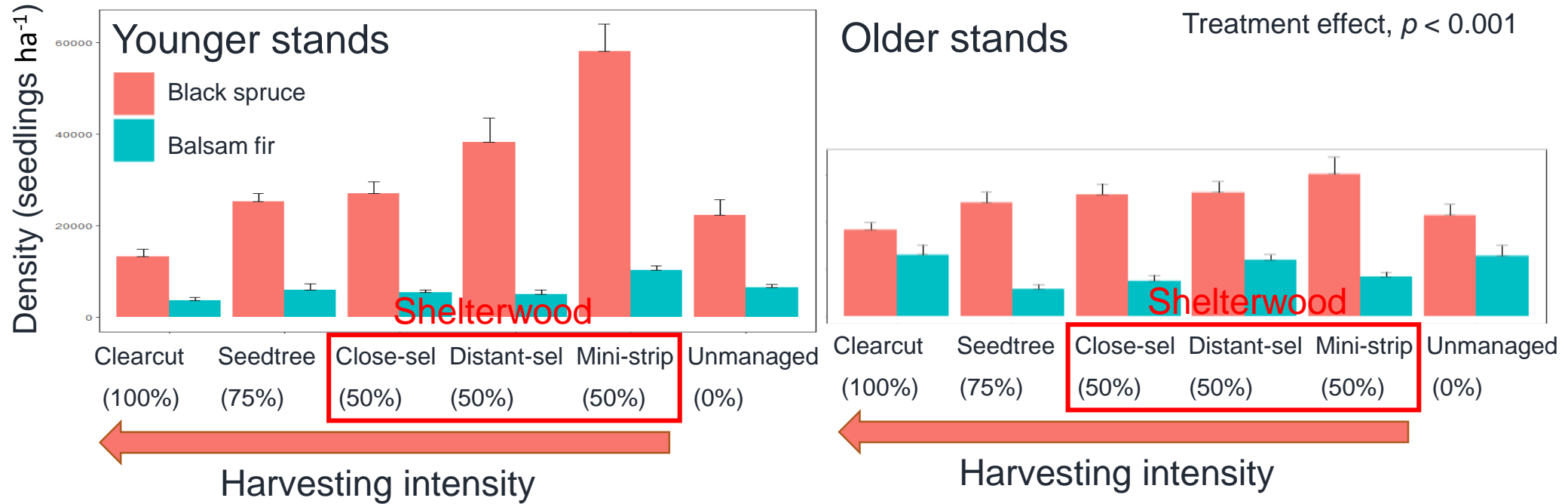
Microstation (WatchDog)

- Soil moisture
- Soil & Air temperature
- Electric Conductivity





Partial harvest Promotes Black Spruce Regeneration



Seedling Competition
(harvesting trail - shelterwood)

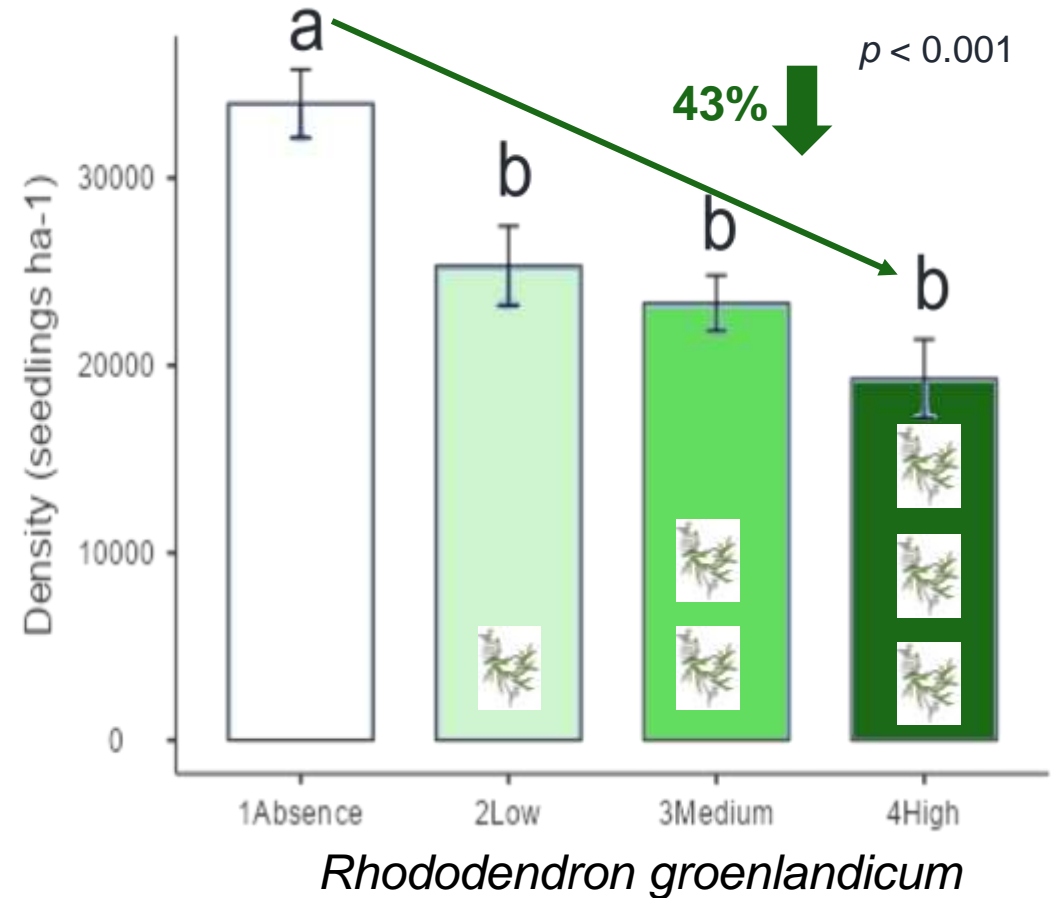
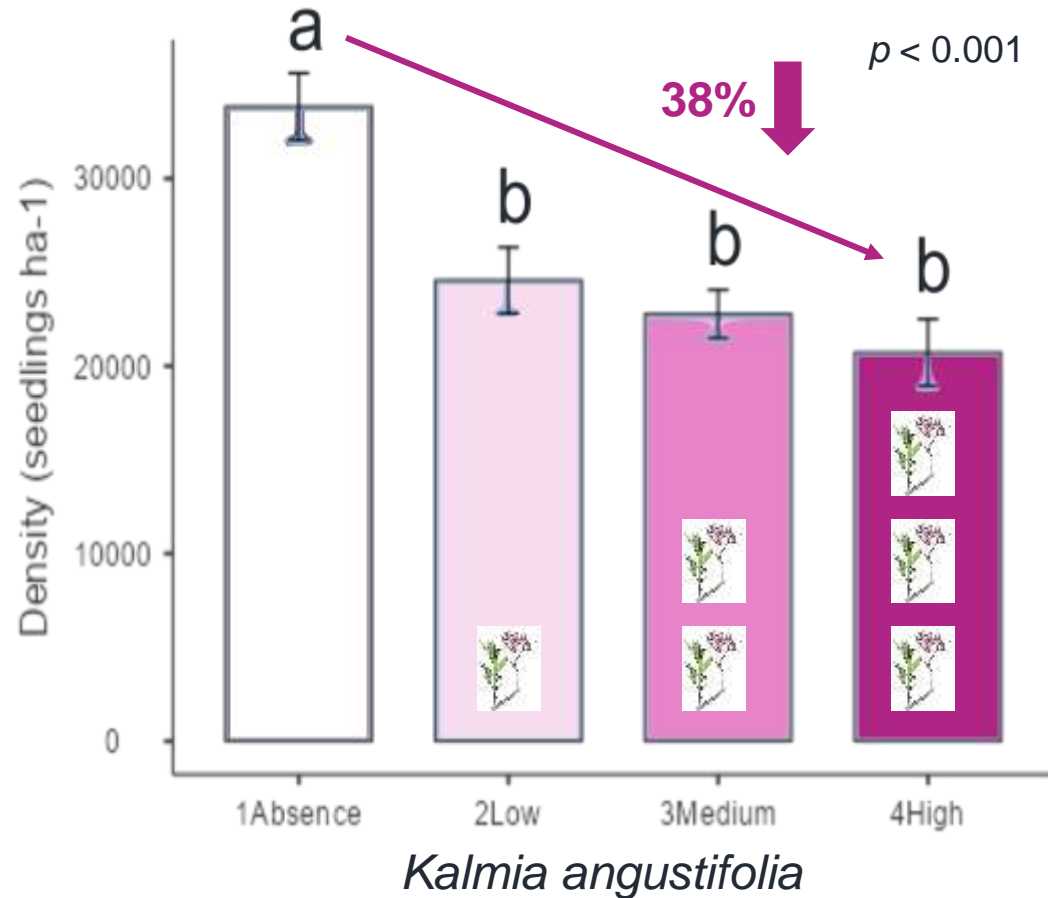


Black spruce dominance
(scarification - shelterwood)



Kalmia heath
(clearcut)

The Negative Effects of Neighboring Plants



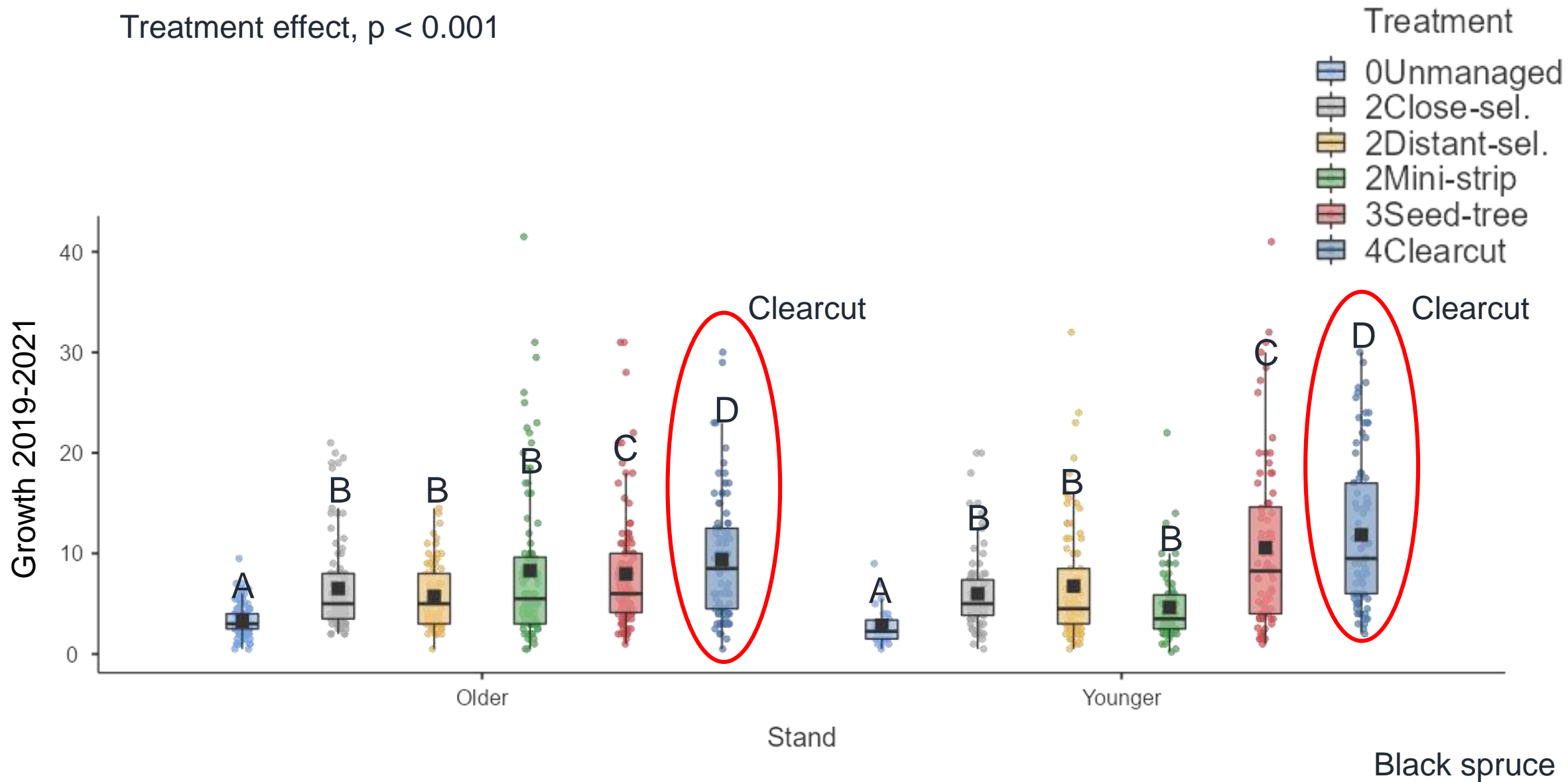
- **Black spruce seedling density was lower in the presence of Ericaceous shrubs.**



Terminal Shoot Growth by Treatments

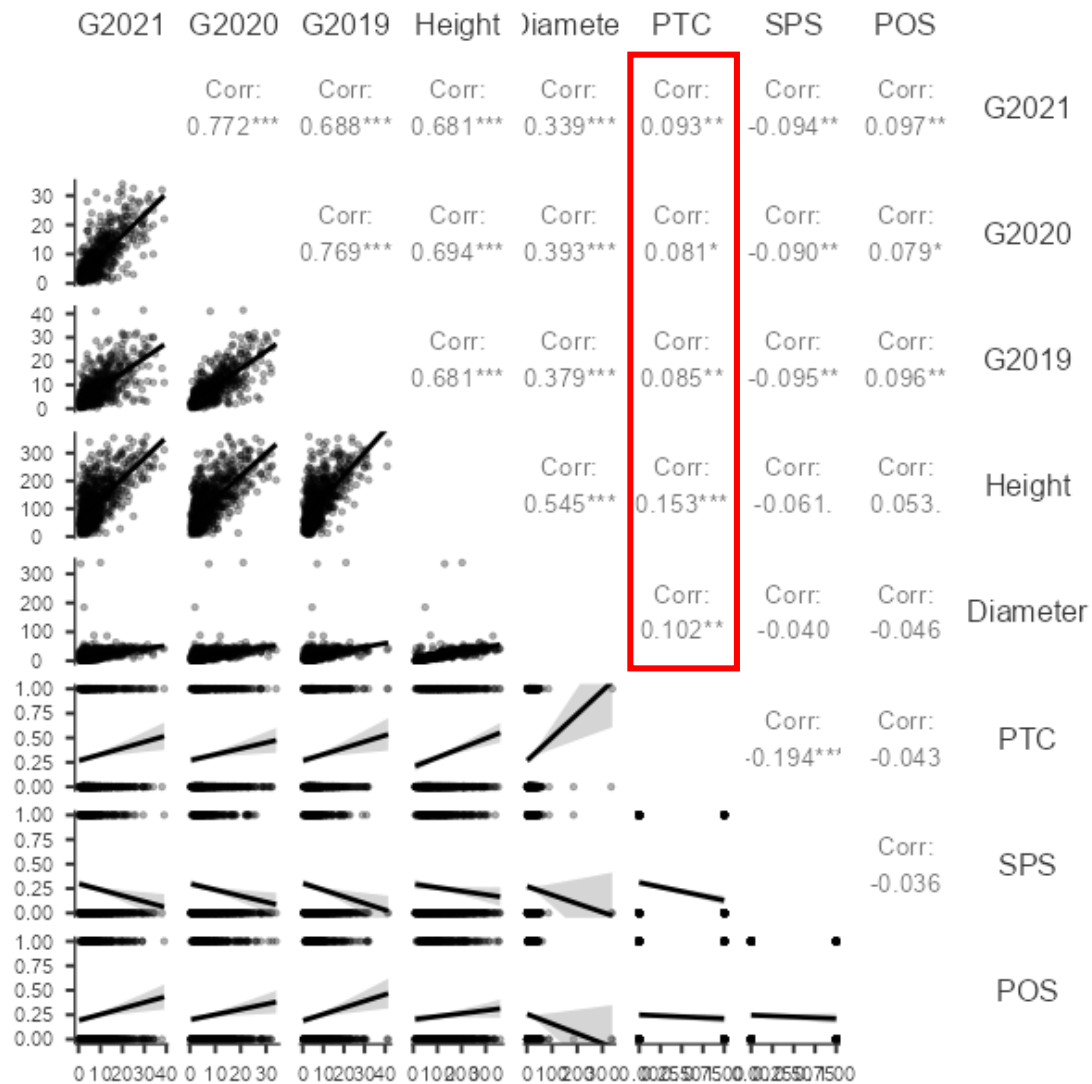


Treatment effect, $p < 0.001$





Correlation Matrix - Seedling Growth & Bryophytes



- *Ptilium crista-castrensis*



Positively correlated with height & diameter as well as 3 years bud growth (p<0.05)

- *Polytrichum sp.*



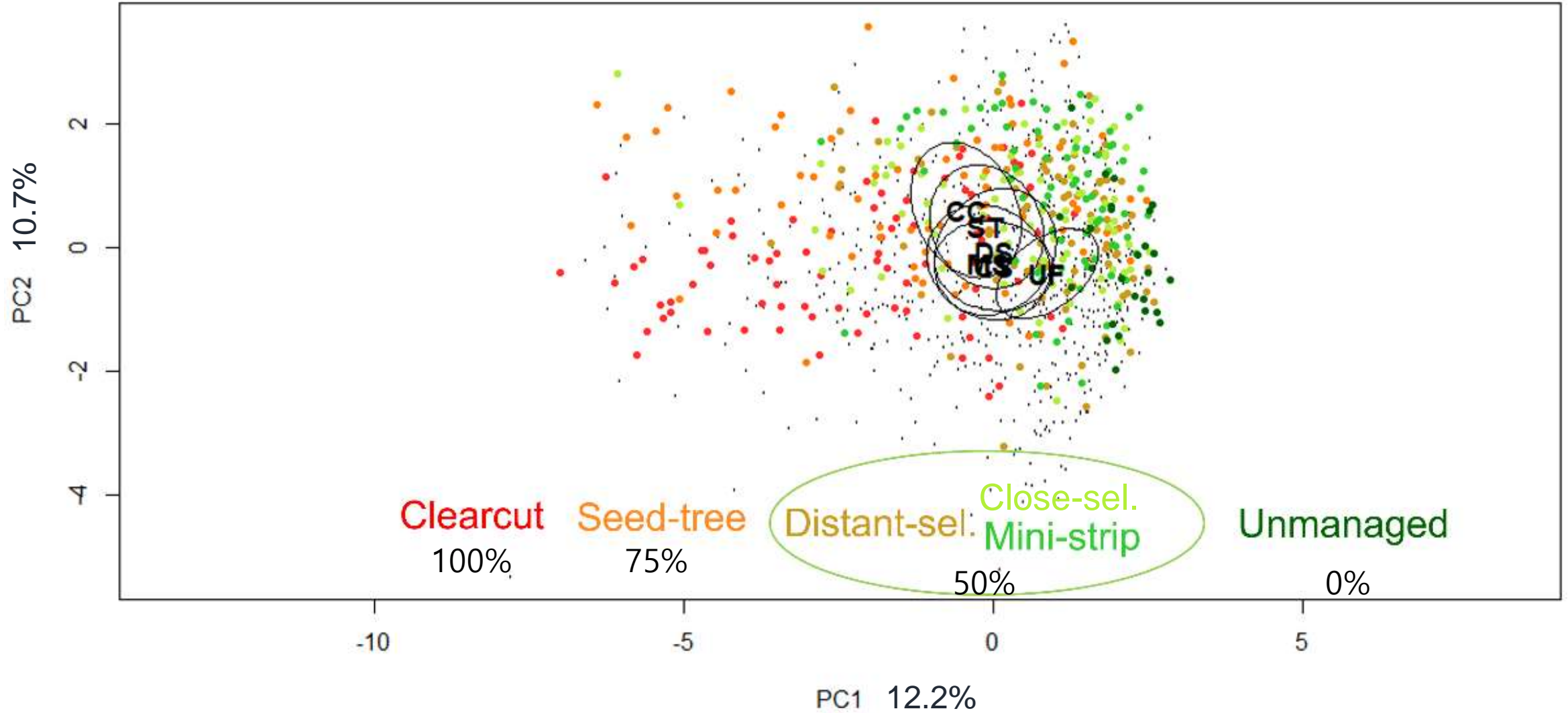
Positively correlated with 3 years bud growth

- *Sphagnum sp.*

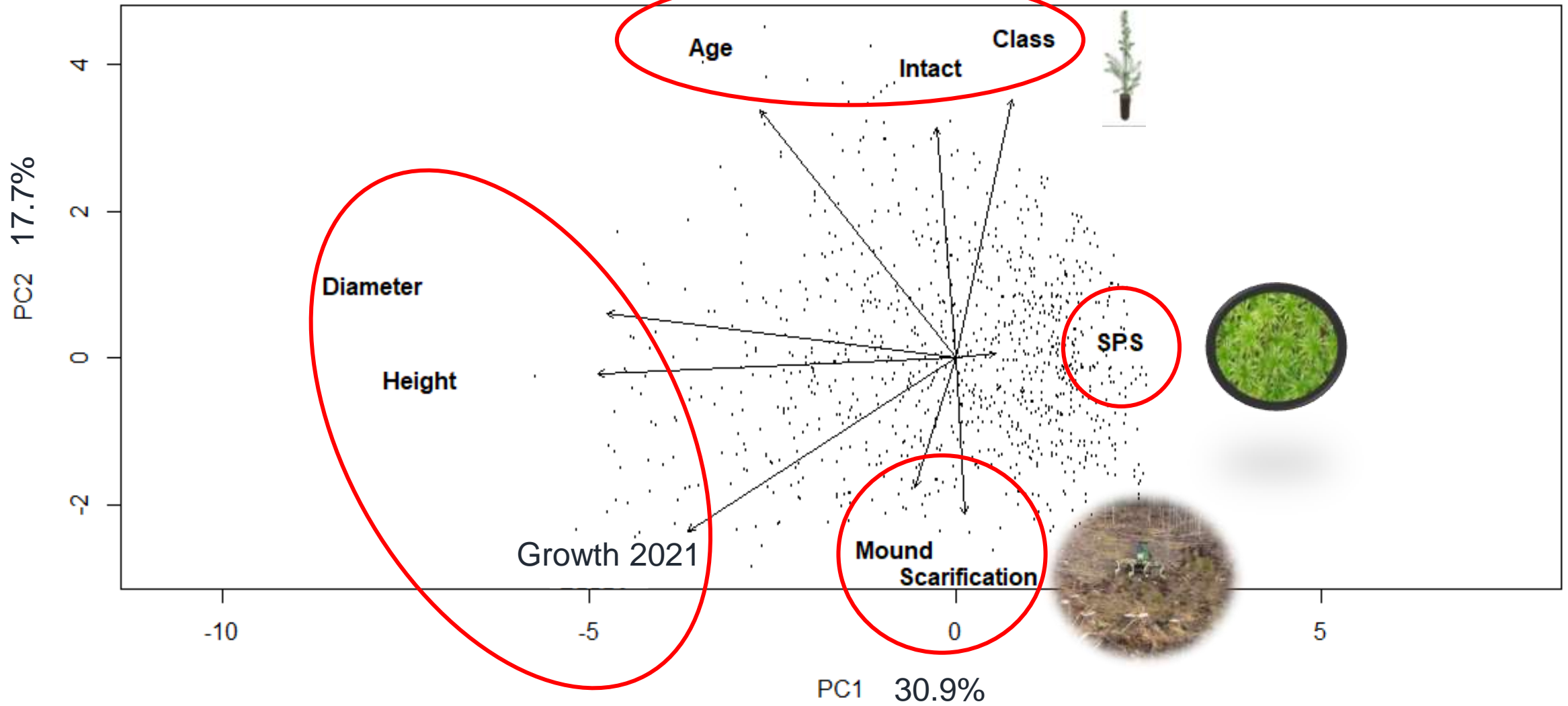


Negatively correlated with 3 years bud growth

PCA from Regeneration Assessment



PCA from Regeneration Assessment





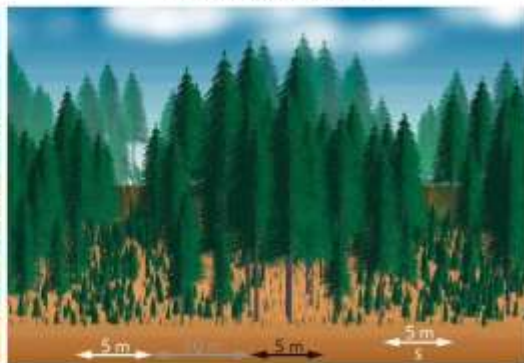
Discussion



Mini-strip shelterwood



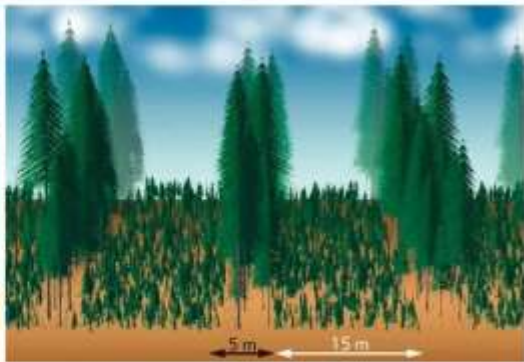
Distant selection



Close selection



Seed-trees



 Intact residual strip  Partially harvested  Total harvested

Montoro Girona et al. 2018

- Uniform shelterwood system promote the natural regeneration of black spruce in boreal forests (seedling density)
- Black spruce & balsam fir had different growth responses to silvicultural treatments.
- Some bryophyte species (e.g., *Ptilium sp.*) may contribute to conifer seedling growth positively or negatively.
- The additional soil variables is needed to explain the regeneration dynamics more clearly.

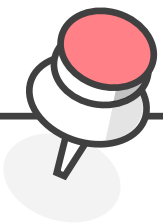


Contribution



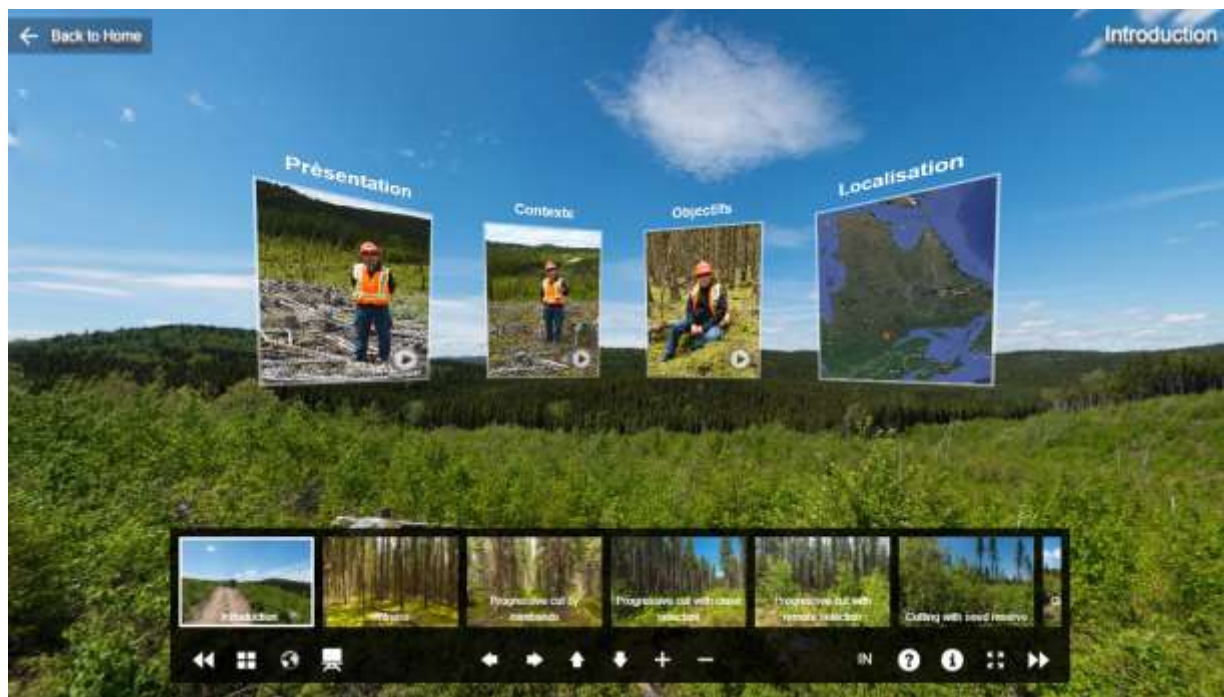
- **Resolve the lack of ecological knowledge between partial- and clear-cut systems**
- **Understand black spruce regeneration dynamics in post-harvest stands**
- **Appropriate seedbed for black spruce forests**
- **Silvicultural options to meet various management goals**





For More Information – MISA Virtual Visit

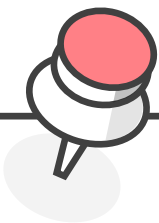
MISA Virtual Visit



Website: <https://visitesvirtuelles.partenariat.qc.ca/monts-valin/fr/>

Partial harvest (Mini-strip)





Acknowledgement

Supervisors

- Miguel Montoro Girona (UQAT-SLU)
- Yves Bergeron (UQAT-UQAM)
- Patricia Raymond (MFFP)



Committee

- Annie Desrochers (UQAT-IRF)
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- Antoine Villeneuve
- Anoj Subedi
- Akib Hasan
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Natural Resources
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UQAC

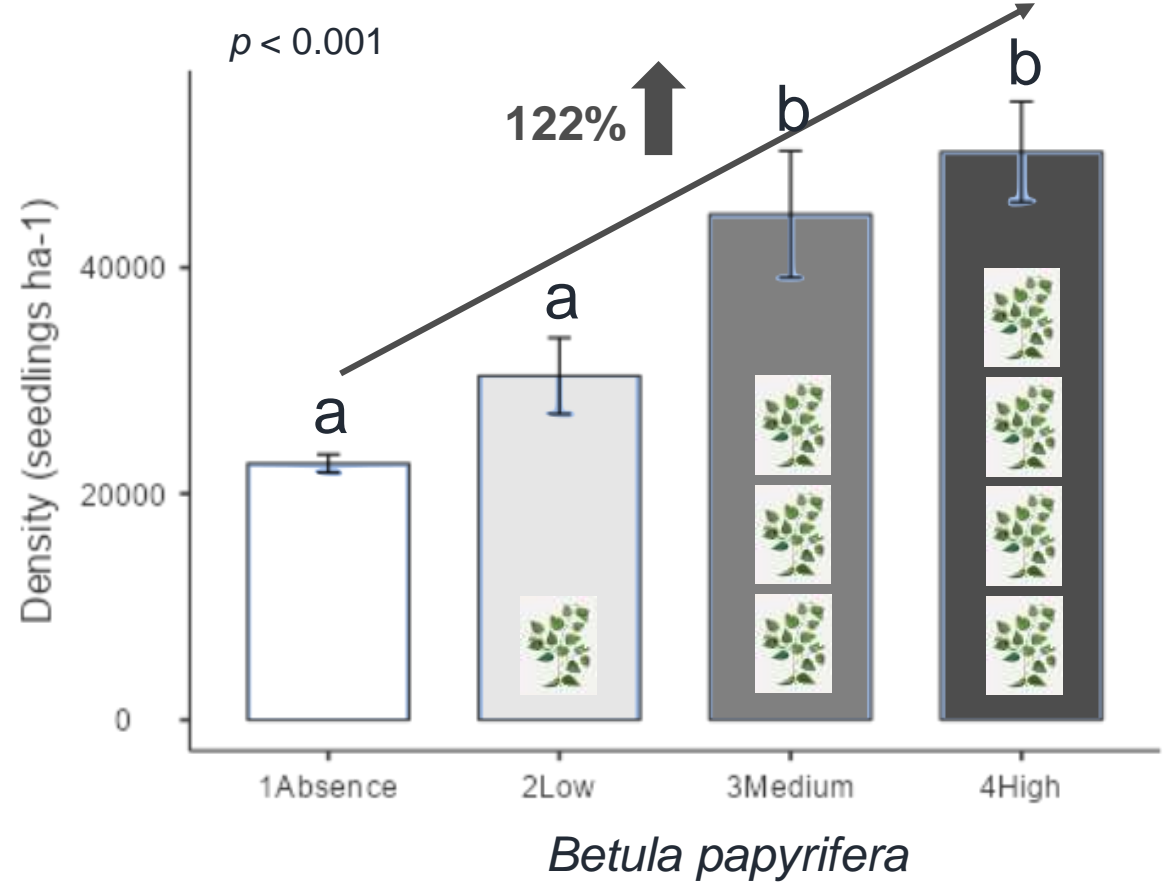
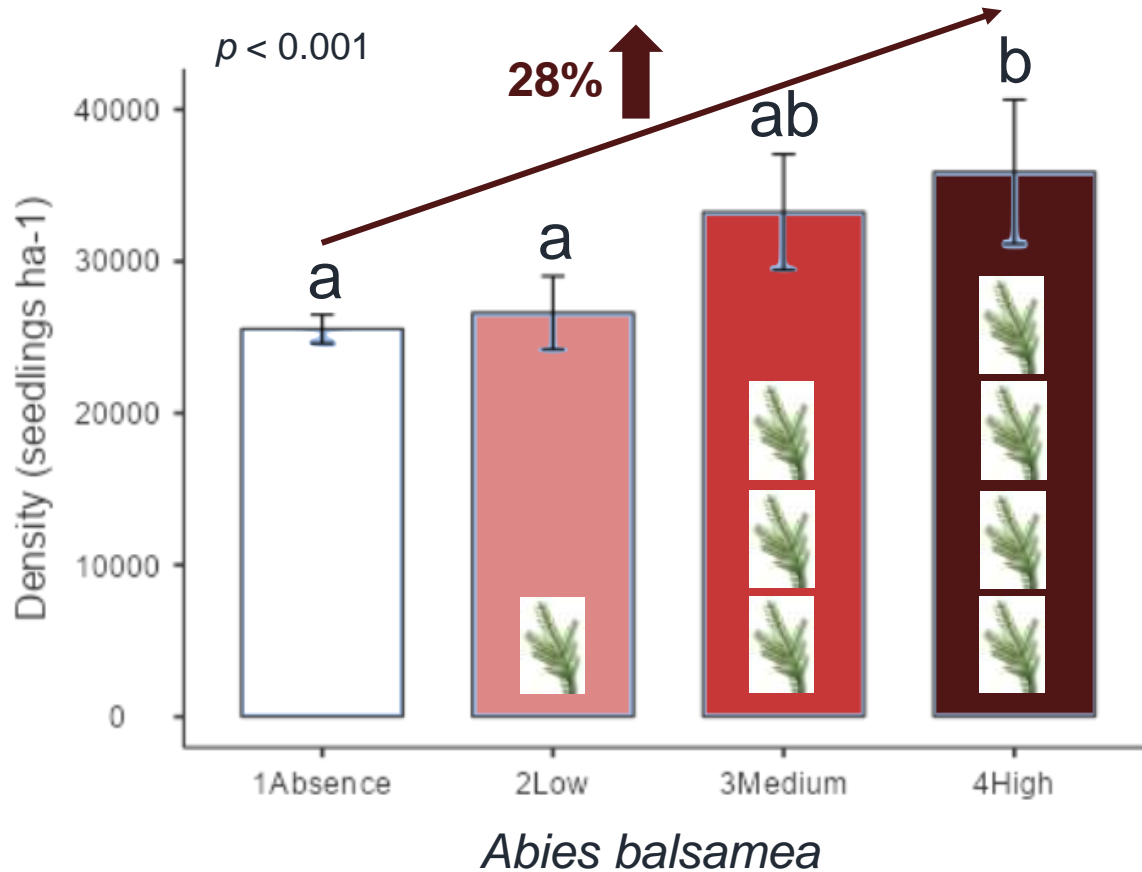


EZ BioCloud



1st Prize for best poster in CEF 2021 (500\$)

The Positive Effects of Neighboring Plants



- **Black spruce seedling density was higher in the presence of conifer & deciduous seedlings.**