VEGETATION DYNAMICS OF ALPINE SUMMITS IN THE BOREAL FOREST ZONE, QUEBEC, CANADA

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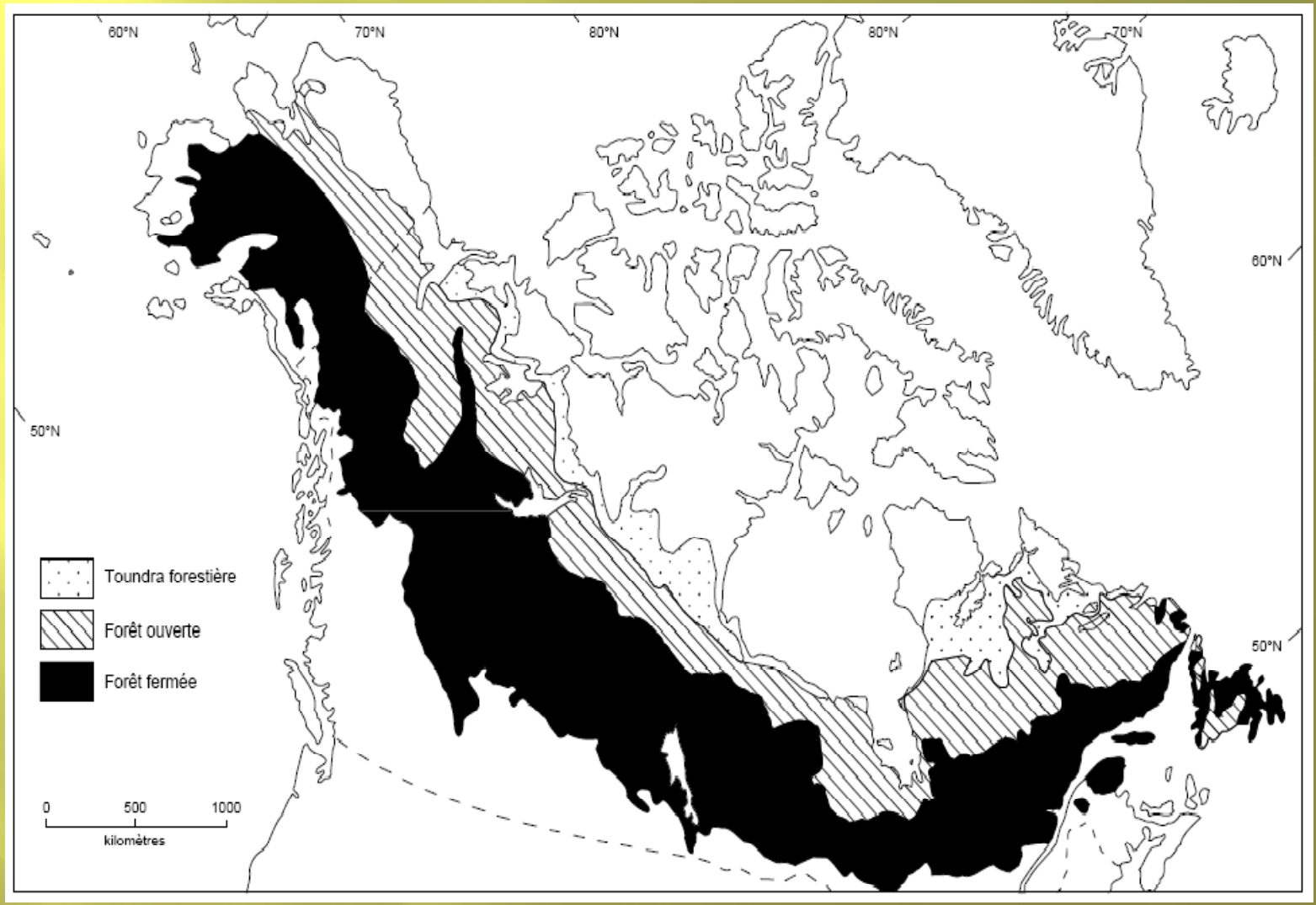
- Boreal forest covers 70% of Quebec
  - From 47° N to 58° N
- 3 major subdivision in the boreal forest
  - Closed forest
    - North of the Temperate zone
    - 3 types of forests
  - Open forest
  - Forest tundra
    - South of the Arctic zone
- Four main tree species
  - Black spruce
  - White spruce
  - Balsam fir
  - White birch





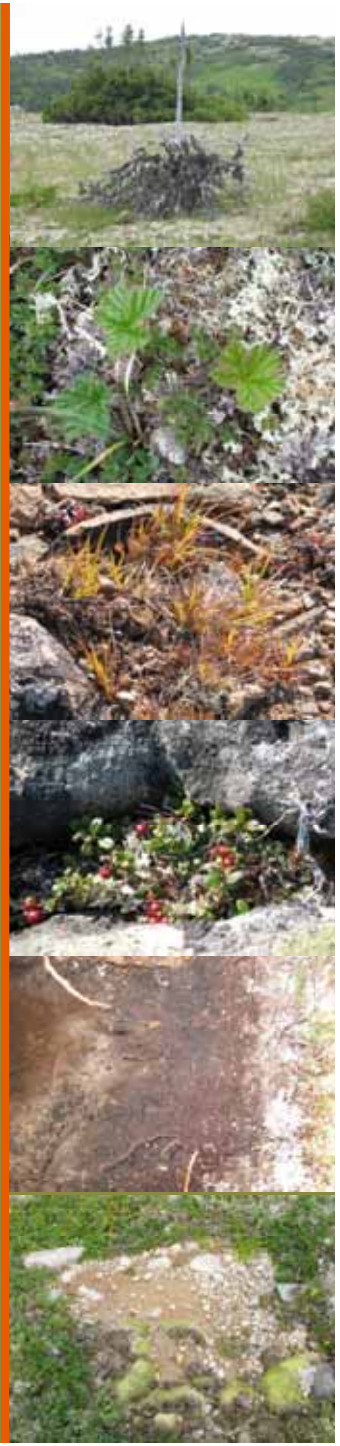


60°N
70°N
80°N
80°N
70°N
60°N
50°N
50°N
Toundra forestière
Forêt ouverte
Forêt fermée
0
500
1000
kilomètres

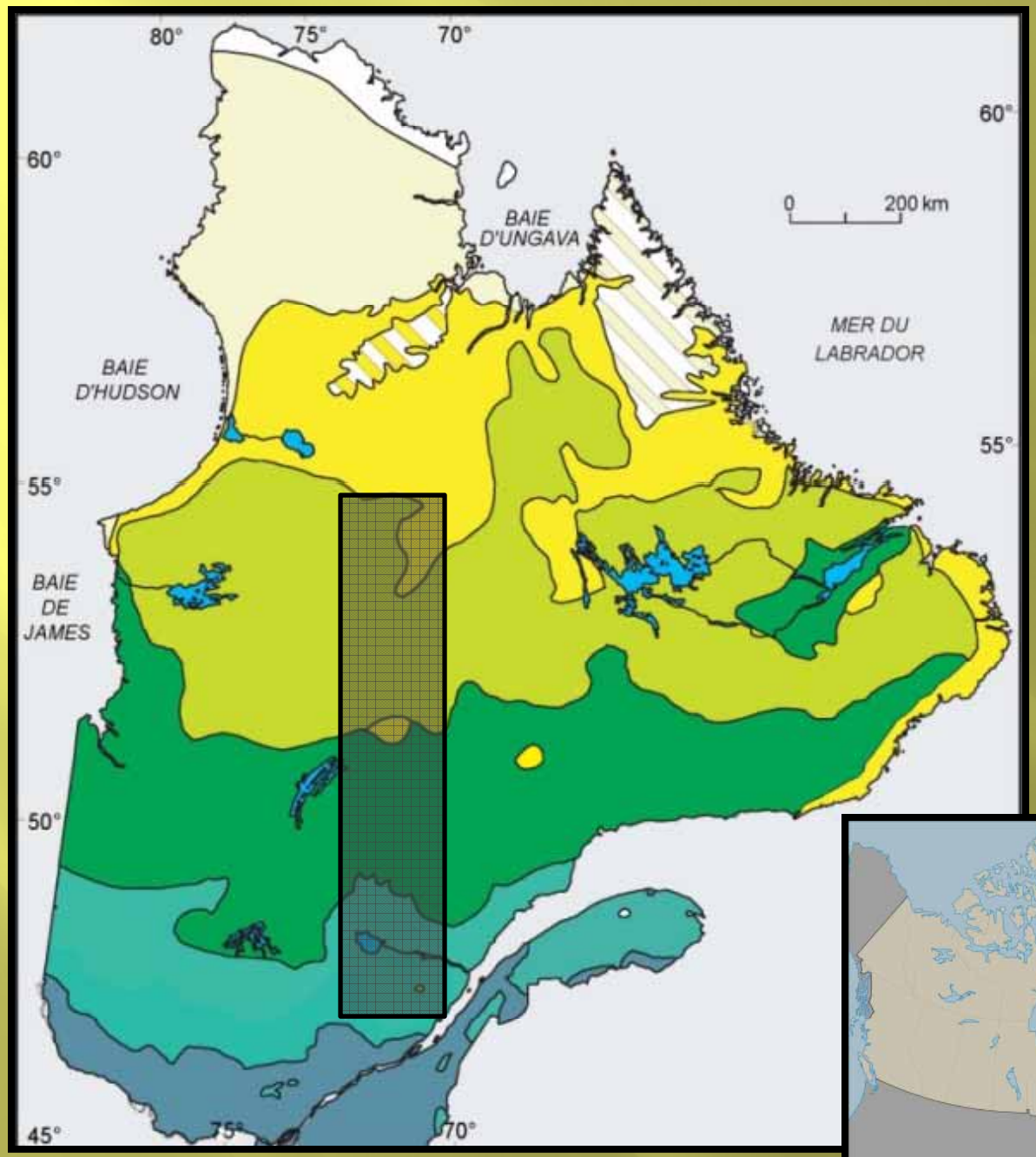
- Occurrence of tundra vegetation on mountain summits
  - Old growth forest maintained for hundreds of years were burned
- Presence of arctic-alpine plant species
  - High exposition to sun and wind
  - Permafrost
  - Frost boils
- Several possible impacts of global warming
  - Tree establishment on open summits
  - Local extinction of arctic-alpine plant species
  - Lost of biodiversity in the boreal forest zone

Study aims

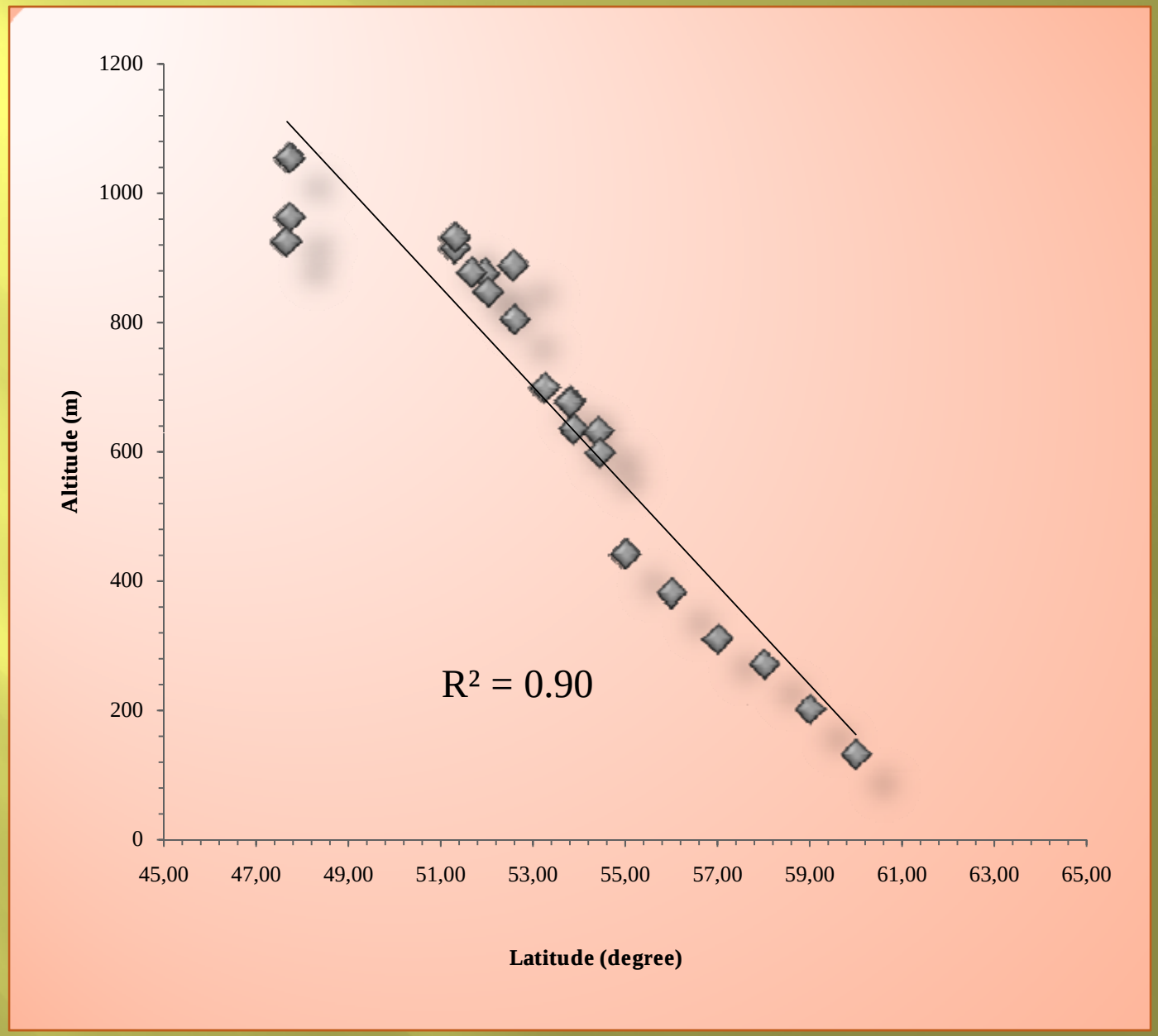
- Study potential impacts of climate change on flora diversity of alpine tundra
- Explain the correlation existing between treeline altitude and latitude

- 16 sites
- Vegetation survey → Line-intercept method
  - 132 species recorded
- 14C dating of charcoal
- Bare ground area
  - Between 1% and 30%
- Organic matter pH
  - Between 3 and 4
- Soil texture
- Shannon Diversity and Evenness indices





- From 47° N to 55° N at 70° W
- Altitude of 600 to 1200 m
- Tundra summits of 8 ha to 80 ha


1200
1000
800
600
400
200
0
Altitude (m)
45,00
47,00
49,00
51,00
53,00
55,00
57,00
59,00
61,00
63,00
65,00
Latitude (degree)
R² = 0.90

- Positive correlation between tundra area and time elapsed since last fire
  - $R^2 = 0.62$
- Positive correlation between bare ground and latitude
  - $R^2 = -0.56$
- Weak correlation between time since last fire and latitude
  - $R^2 = 0.33$
  - $p > 0.05 \rightarrow$ not significant
- Positive correlation between time since deforestation and latitude
  - $R^2 = 0.66$
  - Northern sites were opened earlier than southern ones






- Main factors affecting diversity and species frequency
  - Latitude
  - Summit area
  - Bare ground cover

- Latitude is the main factor explaining the frequency of many key species
  - *Empetrum nigrum* ($R^2 = 0.29$)
  - *Alectoria ochroleuca* ($R^2 = 0.86$)
  - *Cladonia mitis* ($R^2 = 0.57$)
  - *Flavocetraria nivalis* ($R^2 = 0.44$)
  - *Dicranum elongatum* ($R^2 = 0.43$)
  - *Ptilidium ciliare* ($R^2 = 0.34$)

- Tundra area explains changes in diversity
  - H' Index ($R^2 = 0.67$)
  - J' Index ($R^2 = 0.44$)
  - Total species number ($R^2 = 0.28$)
  - Lichen species number ($R^2 = 0.32$)
  - *Cladonia amaurocraea* ($R^2 = 0.36$)
  - *Cetraria nigricans* ($R^2 = 0.49$)
- Bare ground cover explains changes in frequency of some key species
  - *Arctous alpina* ($R^2 = 0.41$)
  - *Diapensia lapponica* ($R^2 = 0.41$)
  - *Cladonia stygia* ($R^2 = 0.41$)

Variable	Main explicative factor	Direction of change	Model R^2
H' Index	Summit area	↘	0.67
Total species #	Summit area	↗	0.71
Vascular species #	pH	↗	0.61
Lichen #	Bare ground	↗	0.62
A. alpina	Bare ground	↗	0.54
D. laponnica	Last fire	↗	0.98
E. nigrum	Latitude	↘	0.54
K. procumbens	Summit area	↗	0.59
A. ochroleuca	Latitude	↗	0.86
C. amaurocraea	Summit area	↗	0.86
C. mitis	Latitude	↗	0.71
C. nigricans	Summit area	↗	074
C. stygia	Bare ground	↘	0.65
F. nivalis	Latitude	↗	068
D. elongatum	Latitude	↗	0.80
G. corralioides	pH	↘	0.90
P. ciliare	Latitude	↘	0.71

- In agreement with the theory of succession after a disturbance
  - Highest species diversity soon after a disturbance
  - Decrease of species number over time
- Number of species closely associated with tundra area
  - In accordance with the theory of Insular Biogeography (MacArthur & Wilson, 1963)
  - A large area can shelter more species than a small one
- Species respond strongly to factors associated with climate
  - Latitude
  - bare ground cover
  - tundra area






- Climate do not have much influence on fire frequency
  - Climate influence on post-fire successional patterns only
- Little Ice Age
  - Post-fire tundra associated with colder climate
- Scenario of global warming
  - Lost of arctic-alpine species
  - Lost of ecosystems caused by the progression of treeline and forest

Thank you!

Questions?