The following presentation is my Master project that I begun in summer 2005.

Plan of the presentation

- Context
- Objectives and methods
- Preliminary results
- Conclusion

To this date, the diversity of mushrooms in Québec have been approximate to about 3000 species. Even though several species may be edible, only a small part of them are characterised “choice species”.

The growth and development of those organisms is assure by 3 mode of growth : symbiosis, parasitism and saprophytism.

Great majority of fungi seen in grocery stores are saprophytic species, which means that they do not need the presence of a tree host for the development of fructifications. Then, it assures a constant production of fructifications, all year long.

But the majority of coveted edible “choice” species use symbiosis to assure their growth, a more complex process. While mushroom increase the uptake of water, nitrogen and phosphorus of the associated plant, the host plant provide photosynthats produced to the mushroom.

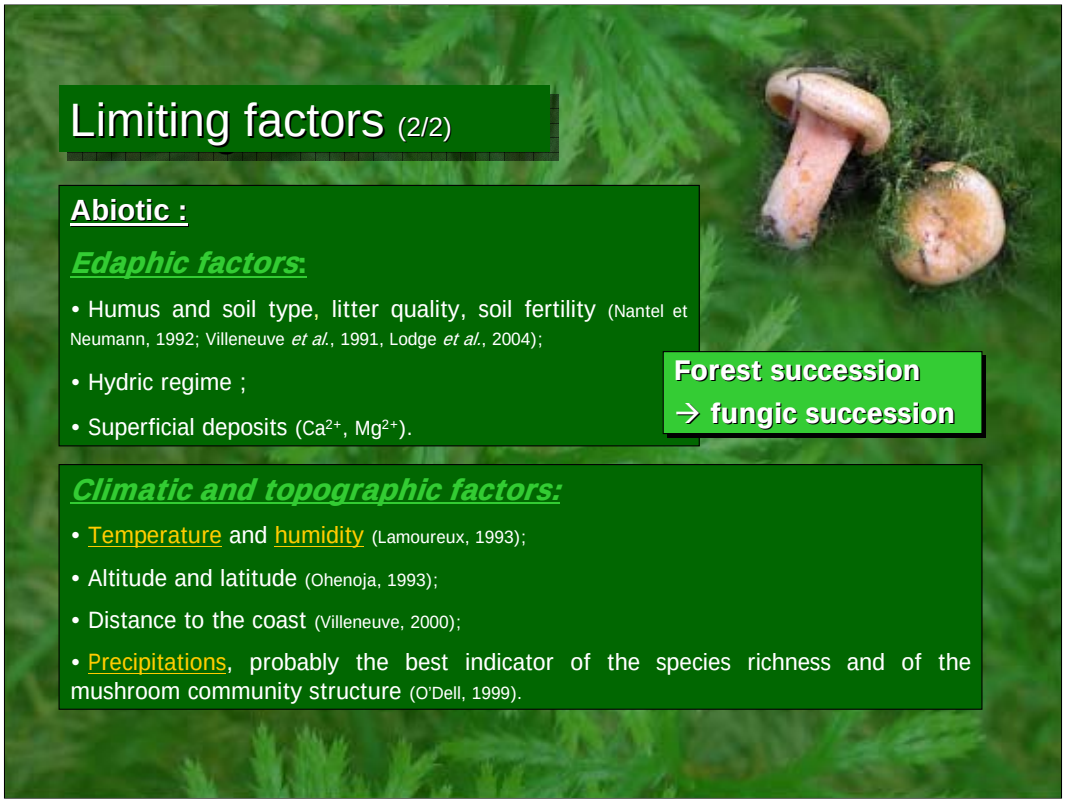
Then, the presence of a tree host, often very specific to a mushroom species, is fundamental for the presence of the fungi in a forest.

Consequently, as harvests must me done in natural environment, a good comprehension of fungi-forest relationships is essential to eventually be able to exploit the resource.

But the presence of a tree host does not assure that the mushroom will be present in a forest. In fact, all the ecological characteristics can influence the presence and productivity of fructifications, in each growth season.

Several studies have been done to identify what may causes the presence and productivity of fructifications, but conclusions of those studies are highly variable depending of the region it has been done. Nevertheless, recommendations about methods are still similar: regional studies would be essential to asses the potential of a territory and the surveys should be done at least during 3 growth season, preferably 5 seasons.

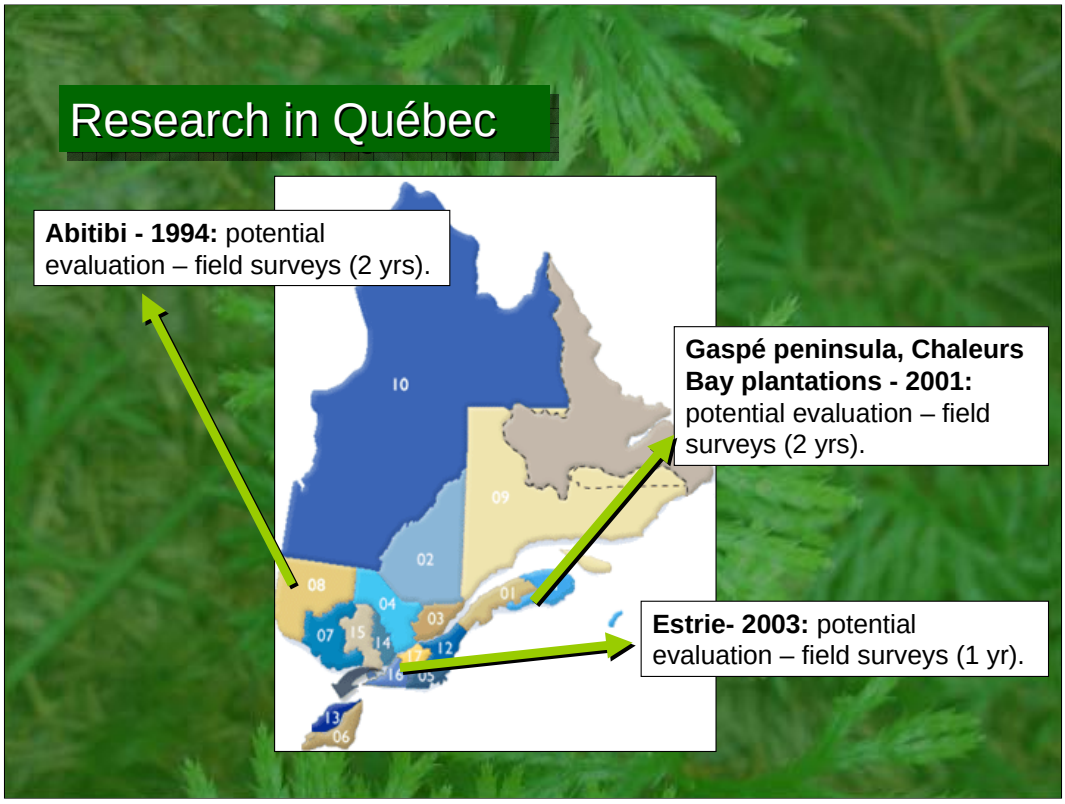
Among the factors that would play a role, here are the main biotic ones.



Abiotic factors , such as edaphic factors also play an important role. In fact, as the mushroom grows in the ground, some characteristics are to be considered to establish the relationship between the mushroom and its habitat. Per example, the very coveted Canadian matsutake, also called pine mushroom, grows generally with Jack pine, but it will be present only if there is a sand substrate.

A fungic succession can be observed as the forest succession goes on, because of changes in the structure and composition of plants, but also by changes in humus and soil characteristics.

Climatic factors are also very important and may often explain the interannual variations as the forest stand type is similar from one year to another. Temperature and humidity have often been identified as the main factors acting on the productivity of mushroom in natural environment. They are influenced by other factors such as altitude and latitude, distance to the coast, and the amount of precipitations.



In Quebec, very few searchers had the chance to conduct field studies to determine the relationship between edible mushrooms and their habitat. In fact, researches on the subject are so rare that we can mention every study done to this date.

In 1994, in Abitibi, a 2-yrs survey mostly conducted in Jack pine forests showed a variable, but interesting production in Jack pine stands. The survey method developed here has then been exported for studies in Estrie and Gaspé peninsula. Each of those field studies have brought some precious knowledge on edible species but have unfortunately been too short and lack survey intensity prior to establish any strong relationship between the species and their habitat.

Here are the objectives and hypotheses of the present study

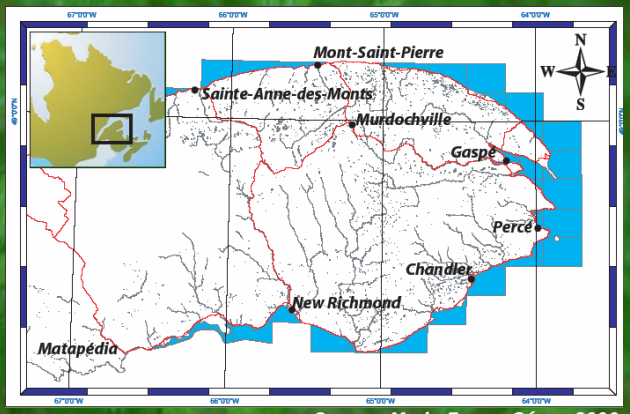
Methods

Study area

The administrative region of the **Gaspe peninsula** covers a territory of 20 272 km^2 (Gouvernement du Québec, 2005).

The growth season (>5ºC) , the amount of precipitations and the mean minimal and maximal temperatures vary greatly on the territory, due to the **altitude** and to the **maritime climate** (Environnement Canada, 2004).

→ A **great diversity of habitats**, partly due to the relief and to the diversity of the geology in place.



Source: *Marie-France Gévry, 2006.*

Forest stand types

Site selection:
-14 forest stand types representative of the territory and having a fungic potential.

Natural forest stands :

30 yrs	*(Fir)*	Spruce	Fir & Spruce	Coniferous & deciduous forest	*(Deciduous forest)*
50 yrs	Fir	Spruce	Fir & Spruce	Coniferous & deciduous forest	Deciduous forest
70 yrs and over	Fir	Spruce	Fir & Spruce	Coniferous & deciduous forest	

Plantations :

30 yrs	White spruce	Norway spruce	Jack pine

The site selection have been made in 2 two steps.

First, forest stand types of the Gapsé peninsula have been listed by importance, by age, and stands offering low fungic opportunities have been put apart with regard to the existent literature.

Then a validation on the field have been made, and 14 principal forest stand types were conserved. Two stand types appear to be in italic caracters because a characterisation a posteriori have add those stand types to the ones chosen.

Plantations were also selected to compare our results with other studies, especially the one that had been done in the south of the Gaspé peninsula in year 2000.

Surveys (1/2)

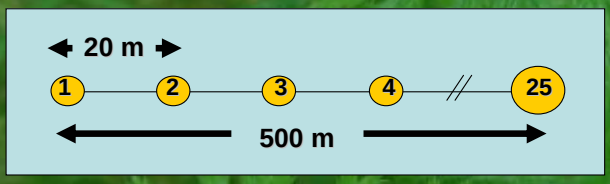
Inventory of permanent plots located systematically along 500 m-transects.

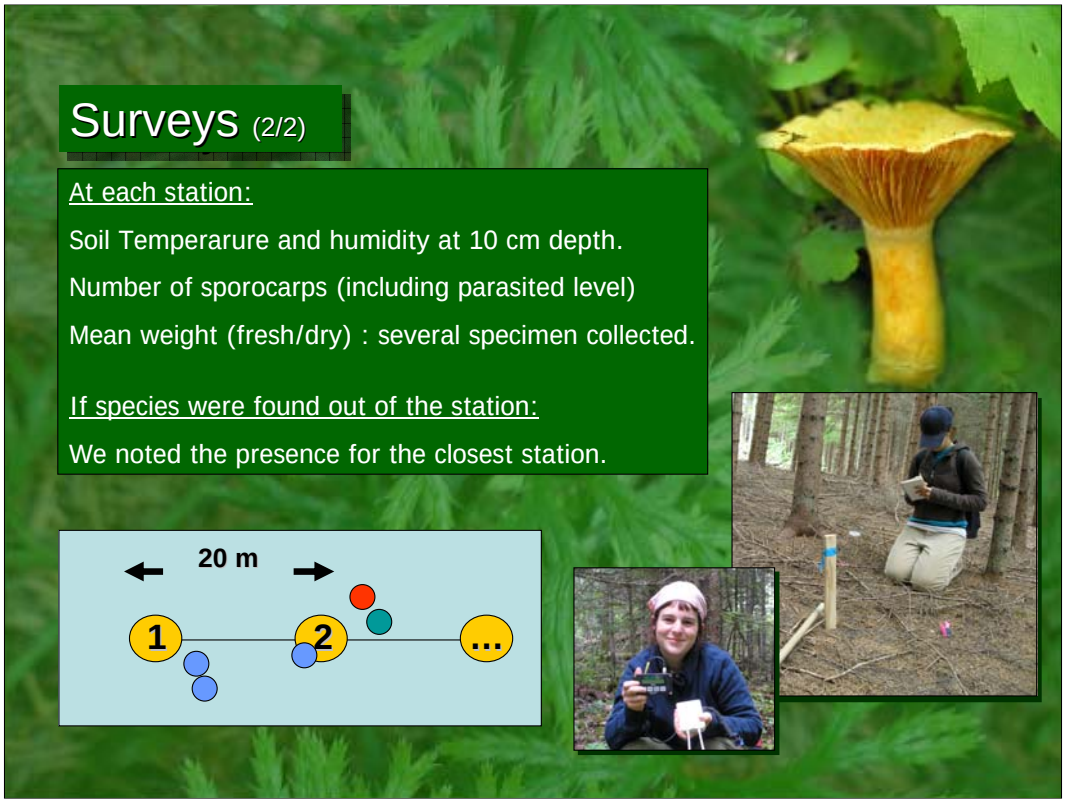
Advantages:

- facilitates the walk in the forest;
- is efficient when an exact habitat is unknown (Castellano *et al*., 1999);
- allows long term studies and phenologic observations;
- avoids cryptic species to be forget.

Total: 895 plots along 39 transects have been installed.

Surveys are conducted every 7 days, during 3 consecutive seasons of fructifications (2005 - 2006 - 2007).





Data were collected every week at each station. Soil and humidity temperature were measure using probes at 10 cm depth.

When mushrooms were present, we count them and identify the parasite level … which can vary between no-parasited to totally parasited.

Mean weight was done only on low parasited individuals. Fresh weight was first measured, and dried weight was measure after a 24 to 48 hours drying period in a dryer.

When species were found out of the station, we noted their presence for the closest station mentioning it was outside of it. Quantitative data were not possible here because no boundaries limit a specific area.

	Latin name	French name	English name
1	*Catathelasma ventricosum*	Armillaire ventru	Swollen-stalked Cat
2	*Leccinum atrostipitatum*	Bolet à pied noir	Black-stemmed Leccinum
3	*Boletus subglabripes*	Bolet à pied glabrescent	Glabrescent Boletus
4	*Boletus edulis*	Bolet comestible	King Bolete
5	*Lecinnum piceinum*	Bolet des épinettes	Spruce Bolete
6	*Leccinum auranticum*	Bolet orangé	Orange-capped Bolete
7	*Tricholoma magnivelare*	Champignon des pins	Canadian pine Mushroom
8	*Cantharelllus cibarius*	Chanterelle commune	Chanterelle
9	*Craterellus tubaeformis*	Chanterelle en tube	Trumpet Chanterelle
10	*Hypomyces lactifluorum*	Dermatose des russules	Lobster Mushroom
11	*Sarcodon squamosum*	Hydne squamuleux	Turtle Mushroom
12	*Hydnum umbilicatum*	Hydne ombiliqué	Umbilicate hydnum
13	*Hydnum repandum*	Hydne sinué /Pied de mouton	Hedgehog mushroom
14	*Lactarius deterrimus*	Lactaire des épinettes	Orange-latex milky
15	*Lactarius thyinos*	Lactaire du thuya	Orange ring milkcap
16	*Rozites caperata*	Pholiote ridée	Gypsy mushroom
17	*Suillus cavipes*	Bolet à pied creux	Hollow-stemmed boletus

Here are the species we are looking for. They are listed respectively in their Latin, French and English name.

You may recognize some of them like boletes, chanterelles, pine mushroom, hedgehog mushroom and milky mushrooms. But there are also other ones that are very good to, believe me I have taste them all!

Morels does not figure in the list because they appears earlier in the season. Only species that starts sprouting in mid-summer are considered here.

Ecological caracteristics

Stand caracteristics observed:

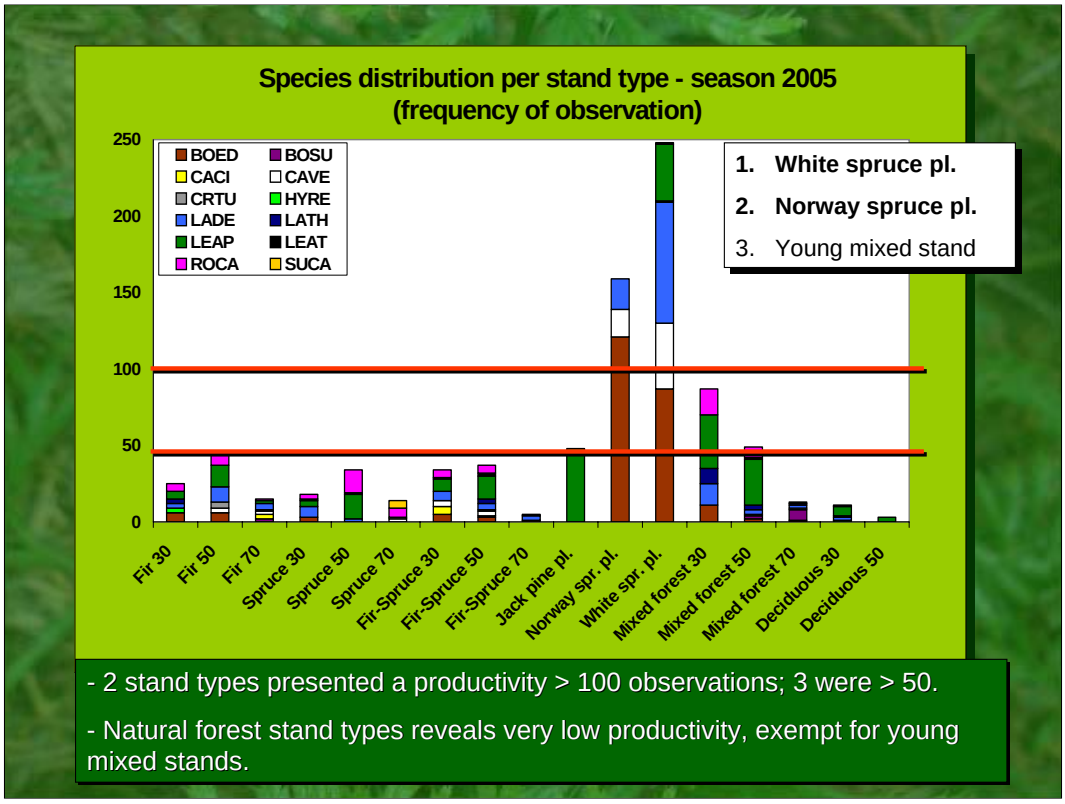
- Canopy cover and plant cover at 0,5 m;
- Basal area;
- Plant species in place :
  - arbustive (sp.);
  - herbaceous (sp., %);
  - mousses (%);
  - lichens (%).
- Obstruction level of logs and branches on the ground;
- Stand age every 100 m along the transect.

- Edaphic and topographic parameters:
  - hydric regime;
  - slope (including position, aspect);
  - soil texture;
  - humus: decomposition, origin, type and thickness (Saucier, 1998);
  - litter thickness;
  - pH;
  - altitude.

In order to identify the fungi-forest relationship, ecological characteristics have been described at every station.

Edaphic factors were measures as well.

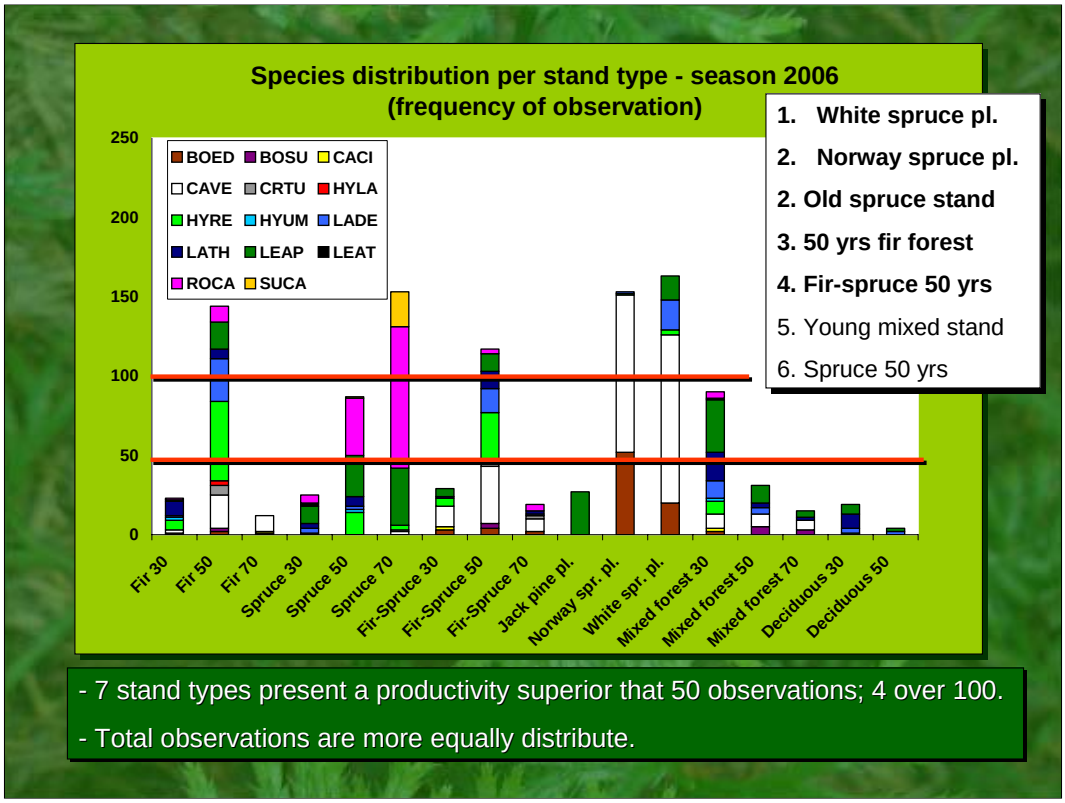
So we will have a look now on some preliminary results. I will first show you results concerning productivity per stand type and then we will have a look on the productivity per species.



During the seasons surveyed, the majority of observations were noted out of the plots.

So the results here included also the one noted out of the station and are presented as the number of observations by forest stand types, without consideration of the abundance of mushroom seen each time.

For season 2005, only 2 stand types had more than 100 observations, and 3 were above 50. The most productive stands were white spruce and Norway spruce plantations. Young mixed forests did pretty well too, but all other natural forest stand had a very low production of fructification.



For season 2006, the total number of observations were more equally distributed among the stand types. We can see that 4 stand types scores above 100 and 7 scores higher than 50.

White spruce and Norway spruce plantations are still the most productive stands followed by old spruce stands. 50 yrs -coniferous stands scores better than in 2005 too and the species were similar for those sites. The symbiosis opportunities may be similar for those sites.

	2005 nb.obs/station		2006 nb.obs/station	
Fir 30	3,57	1	3,29	1
White Sp. pl.	3,31	2	2,17	4
Norway sp. pl.	3,12	3	3,00	2
Mixed 30	2,56	4	2,65	3
Deciduous30	0,92	5	1,58	7
Fir-spr. 30	0,85	6	0,73	11
Jack Pine	0,72	7	0,40	14
Spruce 30	0,53	8	0,74	10
Fir 50	0,52	9	1,62	6
Mixed 50	0,49	10	0,31	16
Fir-spr.50	0,44	11	1,38	8
Mixed 70	0,43	12	0,50	12
Fir 70	0,43	13	0,34	15
Spruce 50	0,41	14	1,06	9
Spruce 70	0,19	15	2,04	5
Fir-spruce70	0,13	16	0,49	13
Deciduous 50	0,07	17	0,10	17

High productivity for White Spruce and Norway spruce plantations, and for 30 yrs-old forest stands in both years; productivity increased for coniferous stand.

As the number of stations is not equal for all forest stand types, we can also have a look on the ratio of observations per stand type to asses the productivity per stand type. The highest productivity goes to the 30 yrs old- fir stand. The ratio is also very high for the White spruce and Norway spruce plantation, as well as for the young mixed stand. All the first ranks are occupied by 30 yrs-old stands, as all the plantations were 30 yrs-old.

We can see a better production of fructification for 50-70 yrs spruce stands in 2006 compare to 2005. In general, forest stand types revealed an higher production in 2006, but some stands had produce less, jack pine plantation per exemple. It can be explain by low production of Spruce boletes last season.

Forest stand type	Richness		.+/-
	2005	2006	
Mixed forest 30	5	11	6
Fir 50	6	11	5
Spruce 50	4	9	5
Spruce 30	5	8	3
Spruce 70	4	7	3
Fir-Spruce 70	3	6	3
Fir 30	6	8	2
Fir-Spruce 50	9	10	1
Jack pine pl.	1	2	1
Norway spr. pl.	3	4	1
Deciduous 30	5	6	1
Deciduous 50	1	2	1
Fir-Spruce 30	7	7	0
White spr. pl.	6	6	0
Mixed forest 50	8	7	-1
Mixed forest 70	6	5	-1
Fir 70	7	3	-4

- Richness has increased for most of the stands, with a increase mean of 1,52.

- Plantations showed similar specific richness.

- Only 3 stands showed a lower richness due to less boletes in the sites.

Here we can have a look on the specific richness between stands, and by year. Richness has increased for most of the stands, with a mean of 1,52.

Plantations showed very similar richness, which is not very high because the symbiosis possibilities are constraint to only one host.

Only 3 stands showed lower richness due principally to a lowest presence of boletes species in those sites.

Species rank per season

	2005	2006
Cata. ventricosum	4	1
Lecc. piceinum/aur.	2	2
Rozites caperata	5	3
Hydnum repandum	12	4
Lactarius deterrimus	3	5
Boletus aff. edulis	1	6
Lactarius thyinos	6	7
Suillus cavipes	11	8
Boletus subglabripes	7	9
Crat. tubaeformis	9	9
Hydnum umbilicatum	N/A	10
Cantharellus cibarius	8	11
Hypo. lactifluorum	N/A	12
Lecc. atrostipitatum	10	12

Frequency/ species per year

	2005	2006	+/- (%)
Hydnum repandum	4	121	2925
Suillus cavipes	5	23	360
Cata. ventricosum	77	320	315,6
Lactarius thyinos	23	70	204,3
Rozites caperata	74	152	105,4
Crat. tubaeformis	7	13	85,7
Boletus subglabripes	12	13	8,3
Hypo. lactifluorum	0	3	0
Hydnum umbilicatum	0	6	0
Cantharellus cibarius	5	5	0
Lecc. piceinum/aur.	224	205	-8,5
Lactarius deterrimus	159	89	-44
Lecc. atrostipitatum	7	3	-57,1
Boletus aff. edulis	246	88	-64,2
Total	**843**	**1111**	**31,79**

Now lets have a look on the species itself. At the left, we can see the rank occupied by each species by year and at the right we see the percentage of augmentation for each species in 2006.

In 2005, Boletus aff. edulis, or king bolete, has been the most common species observed with 246 observations. This species only ranked 6th in 2006 as its abundance has decrease of more than 60%.

Catathelasma ventricosum, or Swollen-Stalked cat mushroom, was the more abundant species in 2006, its abundance was more than 3 time the number of observations of 2005.

Rare species found in 2005, such as Suillus cavipes and Hydnum repandum where more common in 2006, especially that last one that was clearly more frequent.

We also found species in 2006 that have not appear in 2005, such as the Umbilicate hydnum and the famous Lobster mushroom.

The total production was more than 30% better in 2006 compare to 2005. Even though if some species had a similar production, most of them showed a very different production if we look to the last column of the second table in general.

What may have causes such results?

First suspect: the climate

Mean temperature (C), Gaspe city

	2005	2006
June	14	16
July	18	17.7
August	17	14.8
Sept	13.2	11.4

Total precipitations (mm), Gaspe city

	2005	2006
June	47	88.2
July	28.2	50.6
August	90	43.4
Sept	93.2	109

Summer 2005 as been warmer, but had lower precipitations.

Summer 2006 was warmer in June, had similar temperature in July and then was cooler. Great amount of precipitation were observed in June and July but low precipitation in August seems to have suddently « broke » the season.

The first suspect would be the climate.

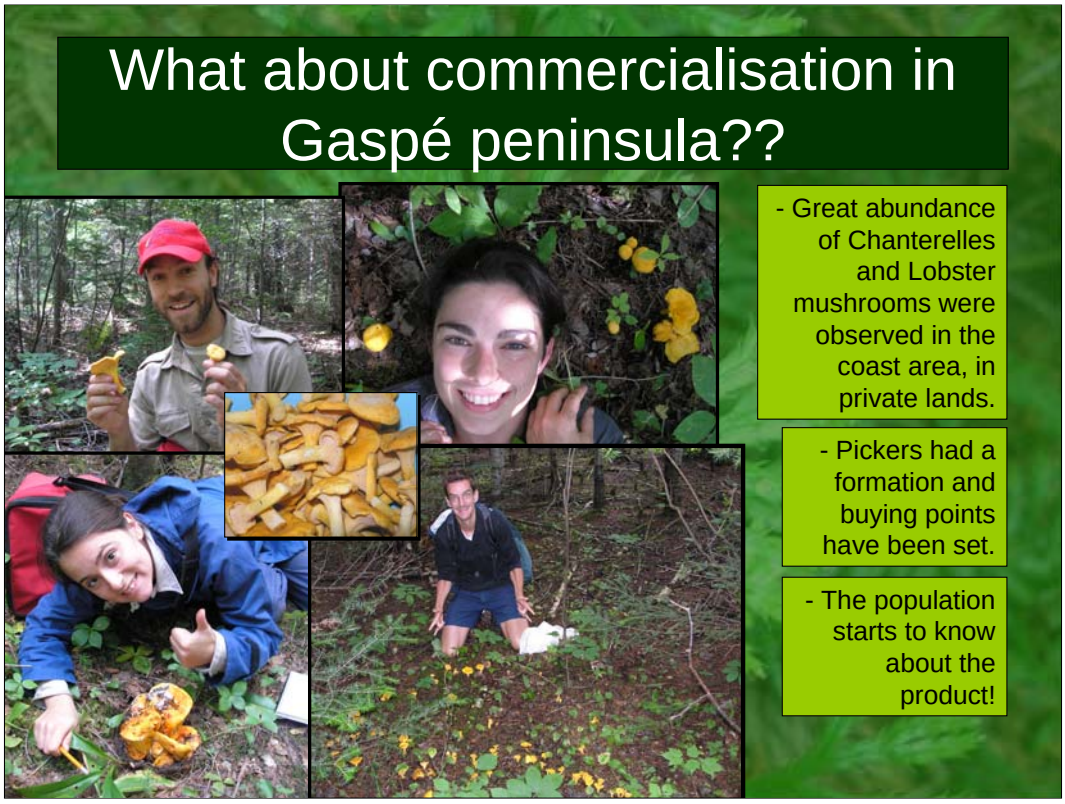
Effectively, the 2 seasons surveyed were very different.
except for august.

In 2006, temperature

may explain great abundance of mid-summer species such as hedgehog mushroom or chanterelle. Species such as the king bolete were not as abundant as in 2005 probably because the precipitations were not suffisant in the autumn.

To this date, we cannot tell exactly what may be the causes of the sprouting of edible forest mushroom in the Gaspé peninsula. Further multivariate analysis including more ecological variables will be done eventually and some tendencies may appears.

The 3rd season will also contribute to determined which one of the factors influence the most the productivity in the stands.



To conclude, don t you think there is a market for mushroom in Gaspé peninsula? Of course, there would be. In fact, it already started.

Last summer, several sessions of mushroom identification have been organised all over the Gaspé peninsula and buying points have been set up. Several mushroom species were collected and the population starts slowly to learn more about this mysterious product. So all it needs now is good weather. Lets hope that climate changes will gives us more precipitations!

Chanterelle would be one of the mushroom that could be easily commercialised because it is easily recognisable in forest, and it had the advantage to be beautiful too. I have not monitored much of this species in my site because the production was limited to the coastal area, generally private lands. Those sites where unfortunately not selected because they are more often “homemade” managed. But it is to mention that the abundance of chanterelle has been very impressive in 2006, according to abundant precipitations in july. The Same observations were made for the Lobster mushroom.

I want to sincerely thanks all the people that helped me on the field. And also a huge thanks to the myco-group of Rimouski, that had helped me in my identifications.


Questions ?