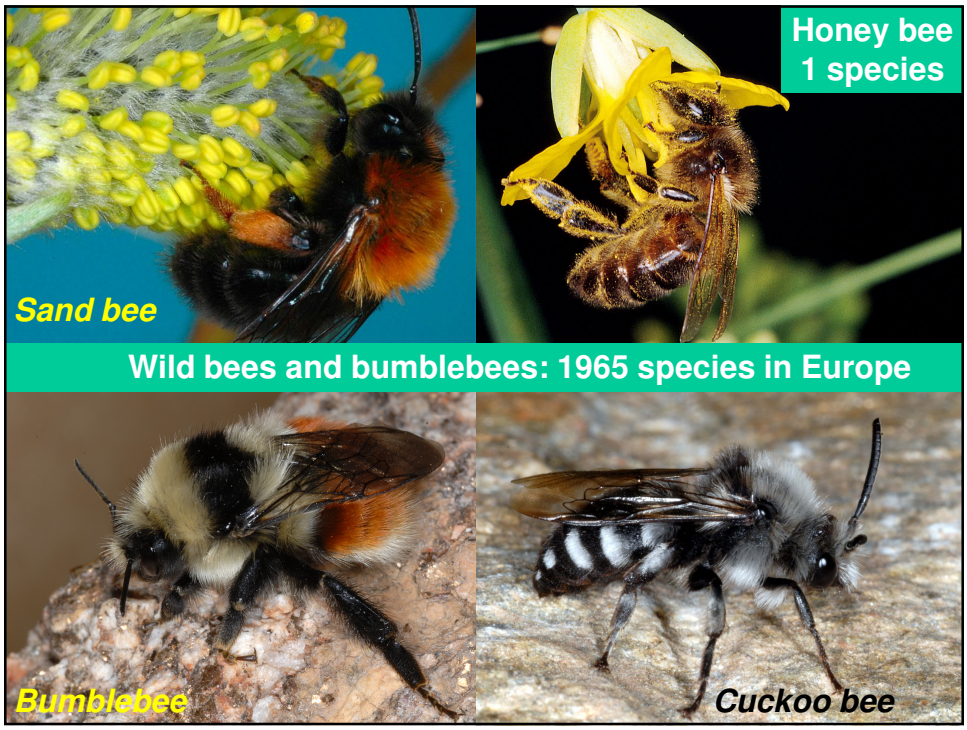
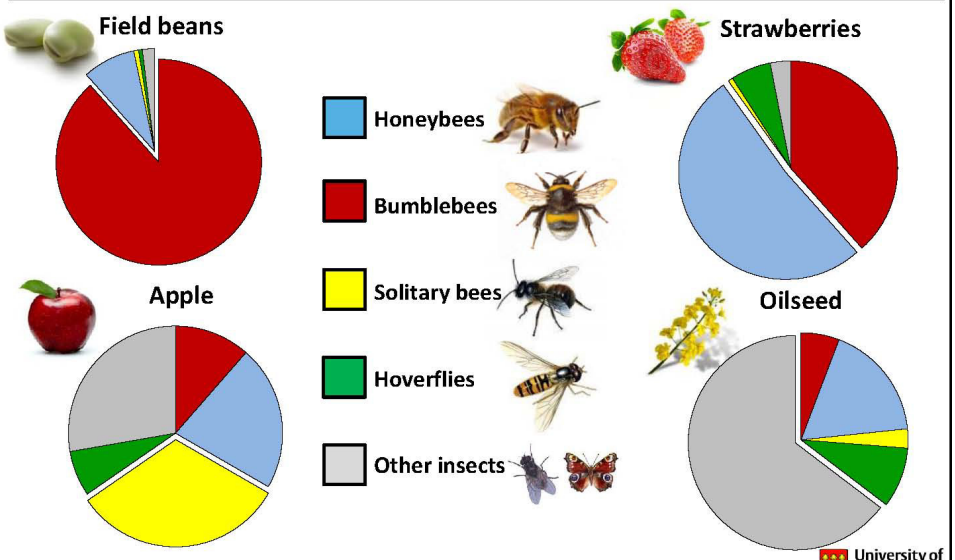
How does climate change affects bumblebee diversity?

by P Rasmont, B Martinet, M Franzén, A Harpke, J Kerr, T Lecocq, D Michez, SG Potts, SPM Roberts, O Schweiger

7.IX.2016
Cluj



Each crop is different (UK)



POSHBEE, ANSES, 31 May 2016 Garratt et al. 2014 **Biol. Con.**; Garratt et al. 2014 **JPE**

University of Reading

Each pollinator is different

STEP

Apples

Solitary bees

€10,400/ha

Honey bees

€1,800/ha

Bumblebees

€4,600/ha

Hoverflies

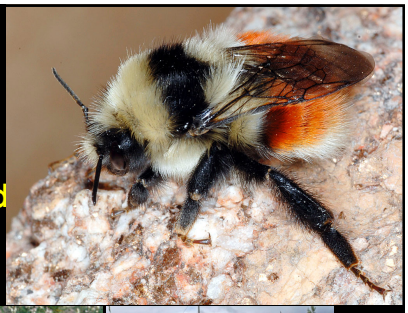
€415/ha

POSHBEE, ANSES, 31 May 2016 Garratt et al. 2014 **Biol. Con.**

University of Reading

Bumblebees (*Bombus* spp.)

All highly social.
68 species in Europe.
Very abundant.
Only pollinator insects in Boreal and Arctic biomes, e.g. in N. Scandinavia and in N. Russia




Silene acaulis


Hedysarum alpinum


Astragalus alpinus


Pedicularis lapponica

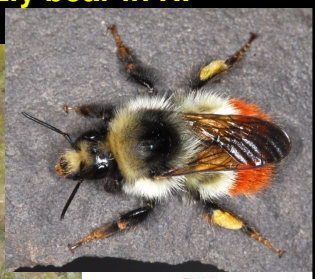

Salix lapponum


Bartsia alpina


Arctostaphylos uva urs

Blueberries (*Vaccinium* spp.) and roots of Arctic sainfoin *Hedysarum alpinum* are main food of grizzly bear in N. Alaska, as also in traditional life of Inuits.


Grizzly bear digging for sainfoin roots (photo PR)



2010-2015

FP7 STEP project

Status and Trends of European Pollinators

16 EC countries, 21 labs

Thanks to this very important project, we gathered 3.2 millions data about European wild bee species

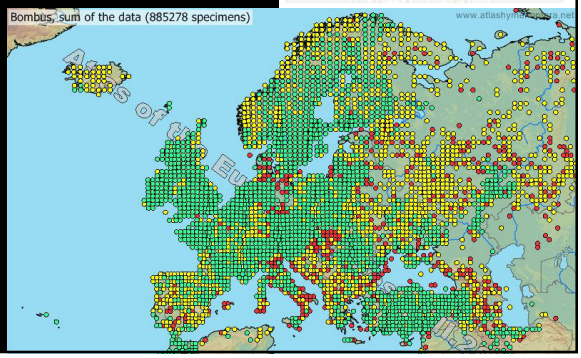
2010-2015

FP7 STEP project

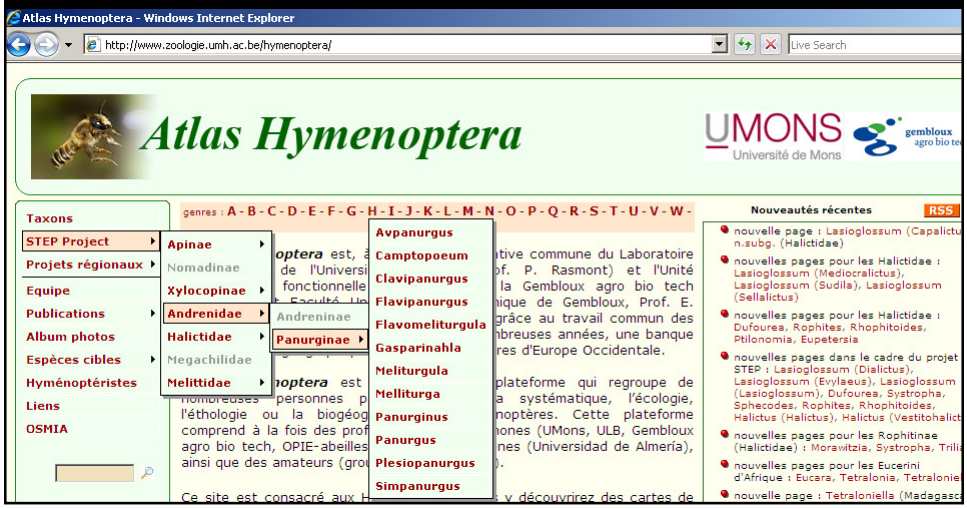
Status and Trends of European Pollinators

This project allowed so to elaborate full mapping of more than 2000 European species, to produce the first IUCN Red List of European Bees. We have been able to assess the fate of the European wild bees and bumblebees.

2011	1 391 538	data
2013	2 232 396	data
2015	**3 277 936**	**data**

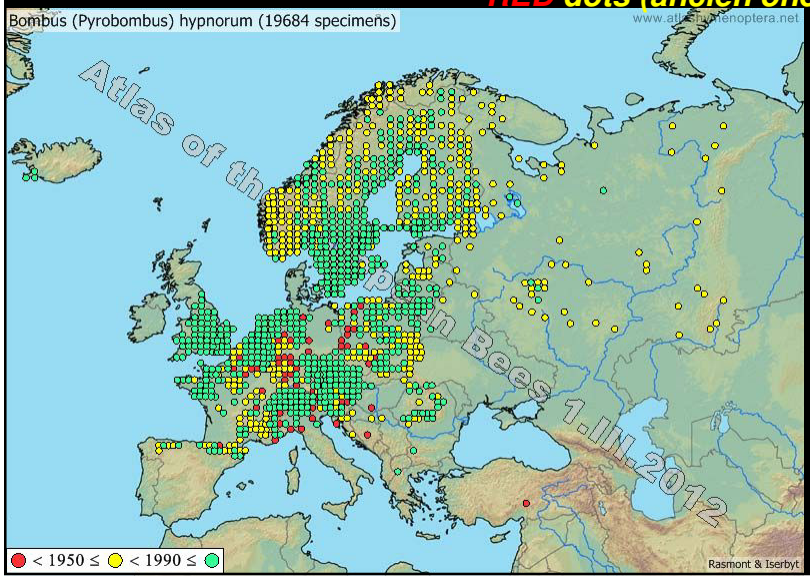


All maps are on the website Atlas Hymenoptera
***see** http://www.atlashymenoptera.net/*
*and follow the menu "**STEP** "*
*or simply search for "**Atlas Hymenoptera**" on google*

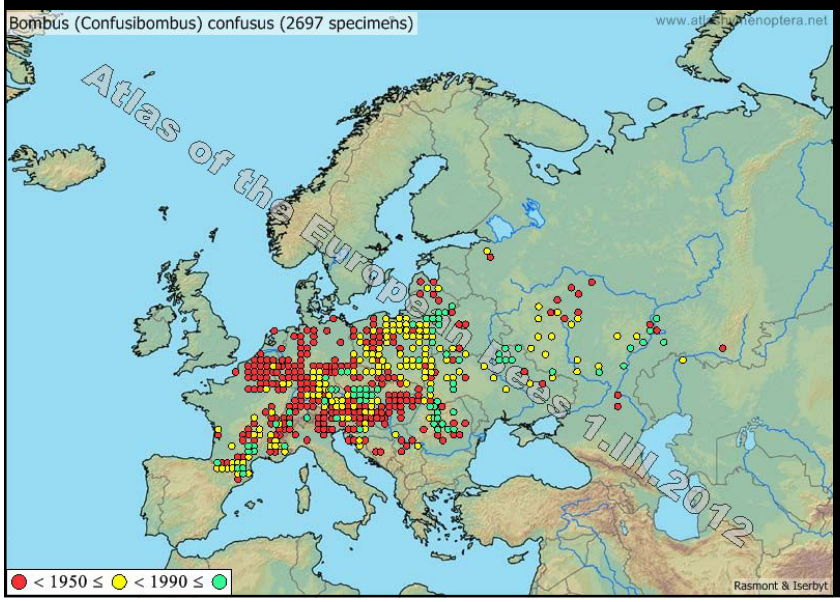


Maps allow to assess the "health" of each species.

This is a species in good health: more GREEN dots (recent observations), than RED dots (ancien ones)



This is a species that is clearly threatened: much more RED (ancien) dots than GREEN (recent) ones.



Redlist of European bees 2015

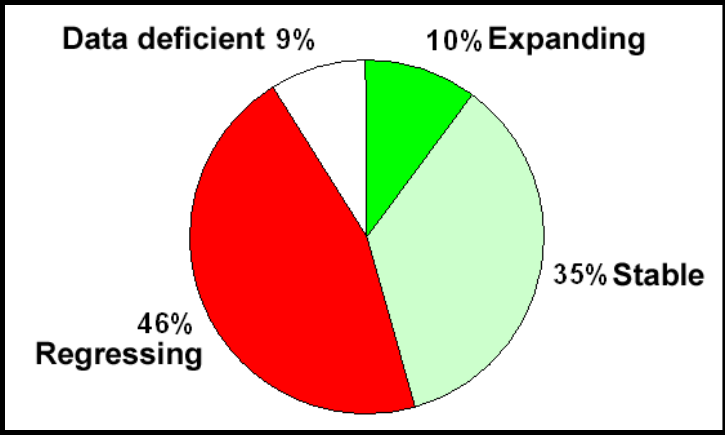
1965 species

The most diversified groups assessed by IUCN in Europe !

Redlist of European bees 2015

To summarize the bumblebees situation as assessed in 2015

Redlist European Bees, Genus *Bombus* (Bumblebees)



The surprise is the main role played by climatic factors in this regression process, while we expected factors as pesticides, resources availability or landscape changes

We have now several evidence about climate impact:
- follow-up of selected mountain areas

- measures of heat-stress resistance in heat waves

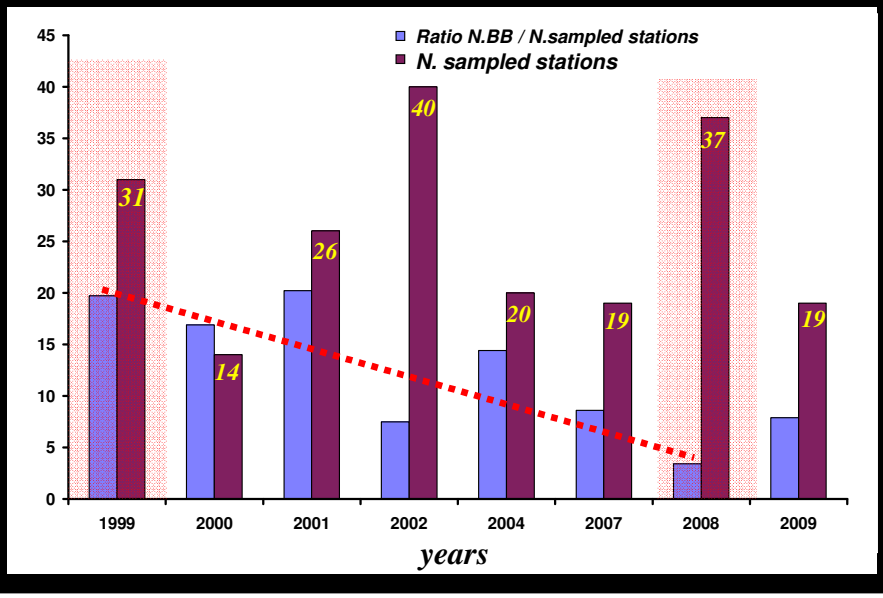
- impact of wild fires

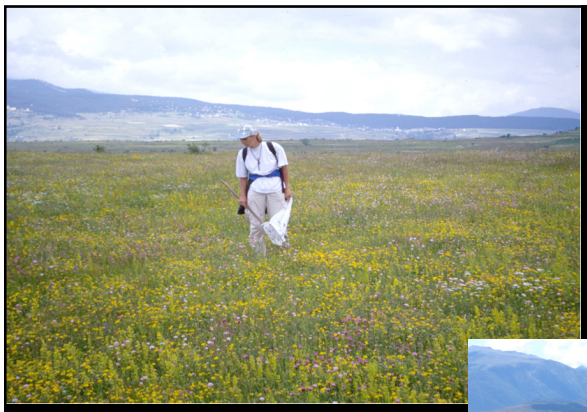
- modelling of climatic envelope in climate warming

- meta-analysis of data from Europe and N. America

- experiment on social disruption of colonies related to heat stress
...

Follow-up of global abundance of the bumblebees in a Pyrenean area during 10 years





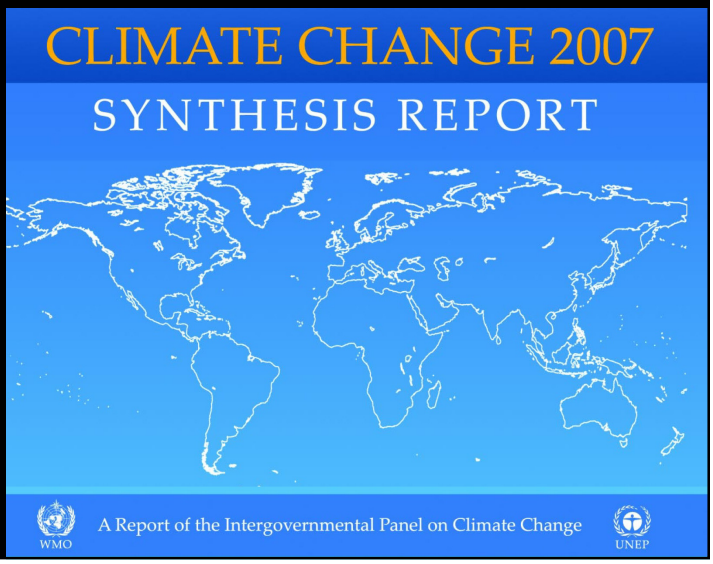
1999 : a cold and wet year, with a high abundance of bumblebees.

Iserbyt & Rasmont, 2012

Bumblebees are 4 times more abundant in cold and wet years

2005 : a hot and dry year, with a very low abundance of bumblebees.

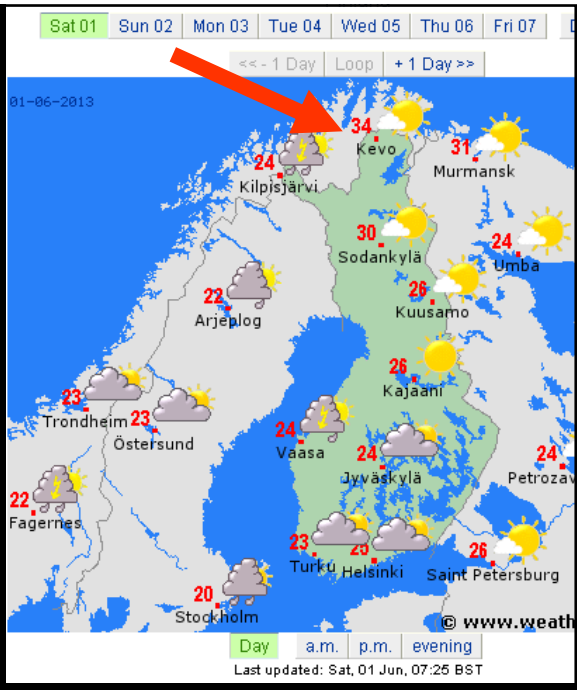
The IPCC estimation for the 20°century : +0.74°C (1906-2005). **This deals with mean temperatures only.** ***However, populations appears mostly impacted by extreme events, as*** **heat waves.**



Exemple:

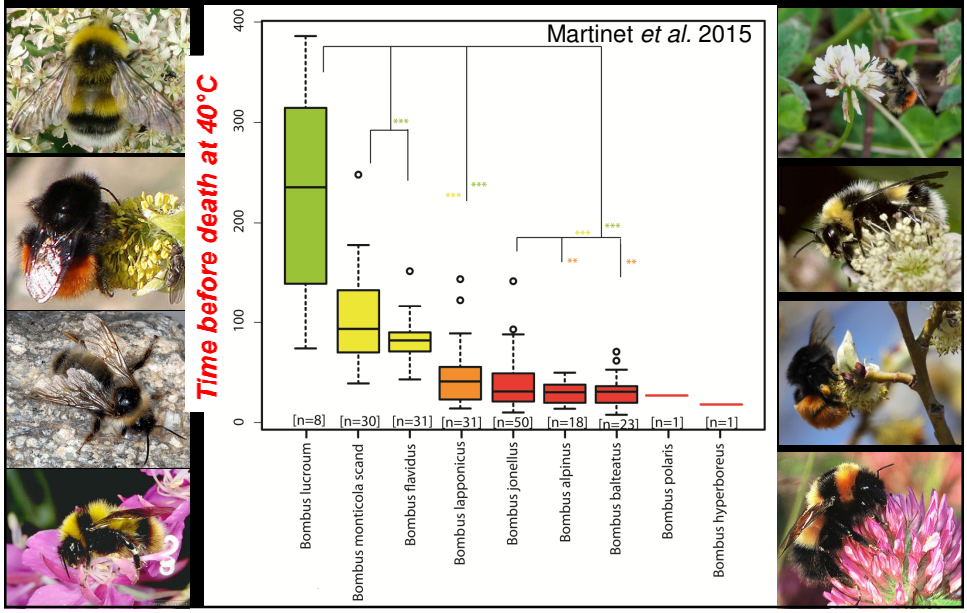
Kevo, Finnish Arctic June 1st 2013, early spring.

During one full week the temperature crossed 30°C reaching 34°C, instead of the normal 14°C maximum of the location.

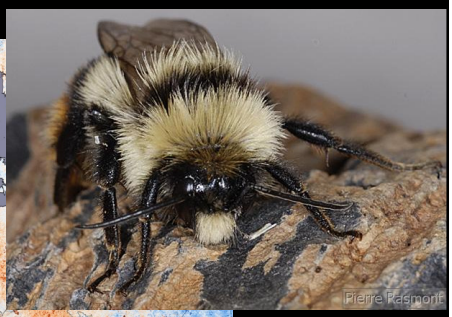


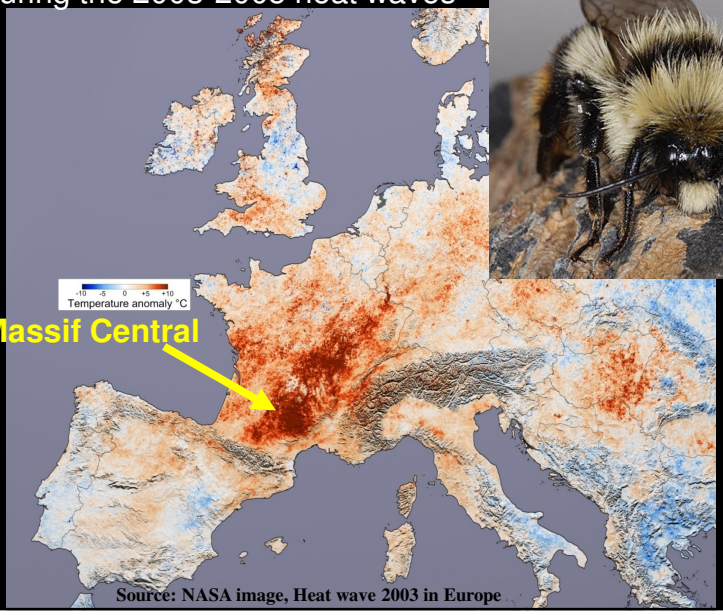
Such event strongly affect vegetation, as in this heathland (Brora, Scotland, 2009)

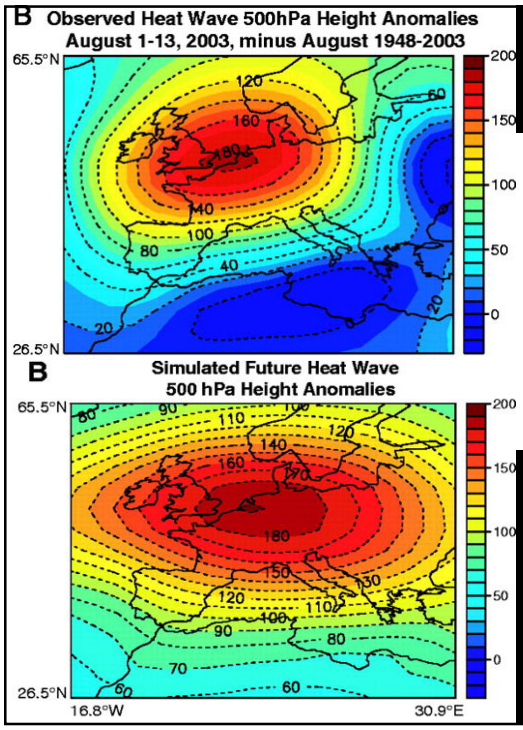
We measured the Impact of heat stress on bumblee species



The very last populations of *Bombus cullumanus* have been extirpated from its last locations in Massif Central during the 2003-2005 heat waves







Actual frequency of heat waves 1948-2003

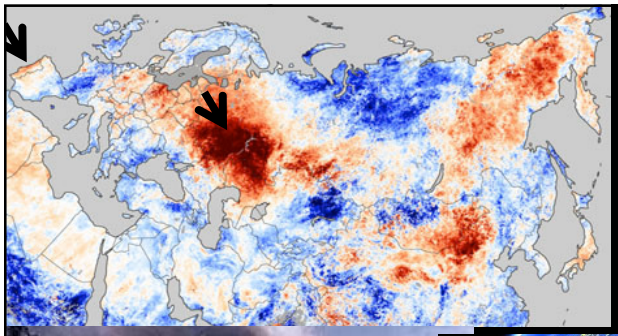
More Intense, More Frequent, and Longer Lasting Heat Waves in the 21st Century

Gerald A. Meehl* and Claudia Tebaldi

A global coupled climate model shows that there is a distinct geographic pattern to future changes in heat waves. Model results for areas of Europe and North America, associated with the severe heat waves in Chicago in 1995 and Paris in 2003, show that future heat waves in these areas will become more intense, more frequent, and longer lasting in the second half of the 21st century. Observations and the model show that present-day heat waves over Europe and North America coincide with a specific atmospheric circulation pattern that is intensified by ongoing increases in greenhouse gases, indicating that it will produce more severe heat waves in those regions in the future.

The future is worrying !

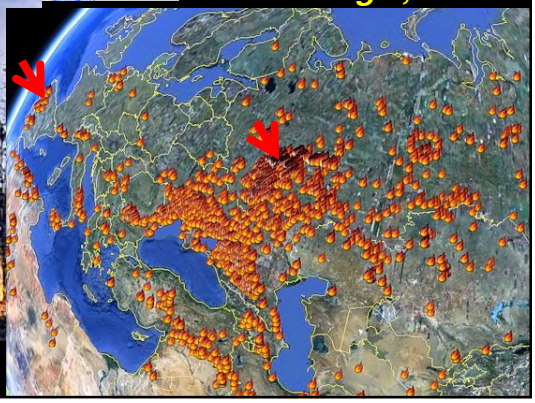
Modelized frequency of heat waves in the Future



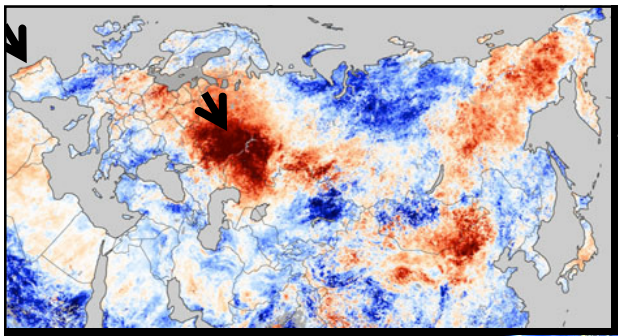
WILD FIRES

Heat wave from July 20—27, 2010, Source: NASA image

Wild fires in Russia and Portugal, 2010



http://jotman.blogspot.be/2010/08/map-of-fire-situation-in-russia.html



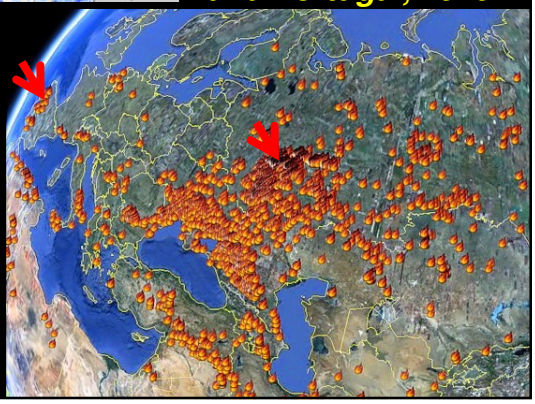
WILD FIRES

Heat wave from July 20—27, 2010, Source: NASA image

Wild fires in Russia and Portugal, 2010

Wild fires have been identified as a major risk for a bunch of southern wild bee species. It could also impact boreal ones

Nieto et al. 2015
Lazarina et al. 2016



http://jotman.blogspot.be/2010/08/map-of-fire-situation-in-russia.html

Rasmont *et al.* 2015 (Book, Pensoft, Sofia) and PDF Open access

STEP

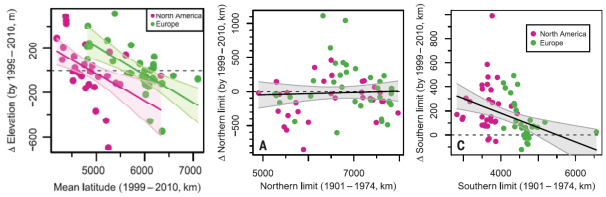
CANPOLIN
CANADIAN POLLINATION INITIATIVE

Science
AAAS

Climate change impacts on bumblebees converge across continents

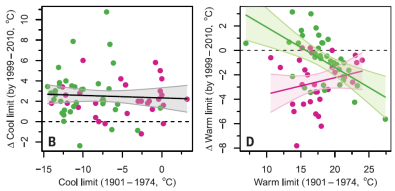
J. T. Kerr, A. Pindar, P. Galpern, L. Packer, S. G. Potts, S. M. Roberts, P. Rasmont, O. Schweiger, S. R. Colla, L. L. Richardson, D. L. Wagner, L. F. Gall, D. S. Sikes, A. Pantoja.

Long-term observations across Europe and North America over 110 years.



Found cross-continentally consistent trends in :

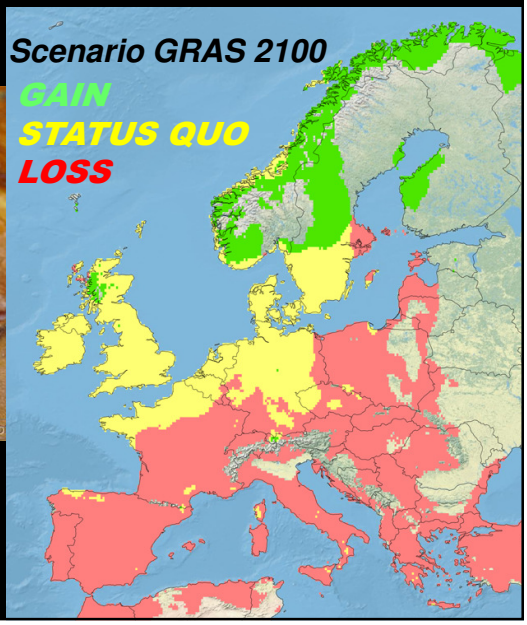
- ***range losses from southern range limits;***
- ***shifts to higher elevations among southern species.***



Kerr *et al.* 2015, *Science*

With climate change, most species distributions will shift toward the North….

Bombus terrestris



Rasmont *et al.* 2015

While most northern species will very likely vanish…

Bombus hyperboreus

Rasmont *et al.* 2015

A very small number of species will take advantage of climate change to expand their distribution….

Bombus argillaceus

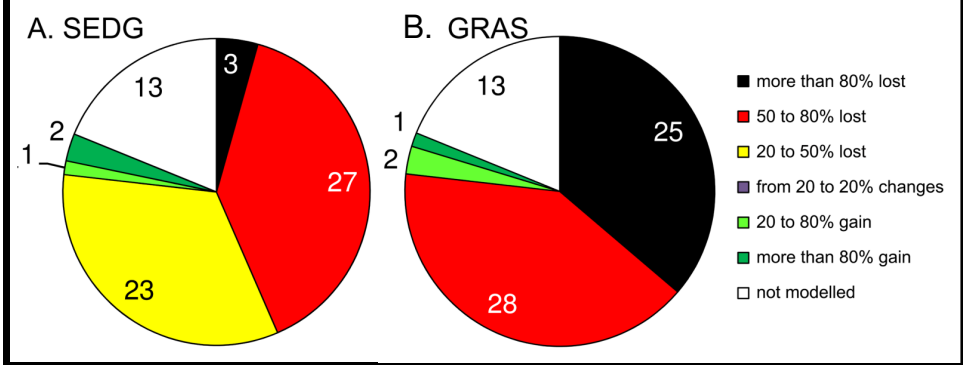
Rasmont *et al.* 2015

To summarize the situation…

In any cases, the projection appears dramatic.

At best **At worst**

Rasmont *et al.* 2015



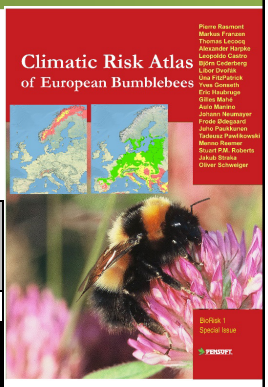
Projected fate of European bumblebee species in 2100

Climatic Risk Atlas of European Bumblebees

City surroundings

STEP

City	Present Actual sp. Nb	2100 % remaining Best	2100 % remaining Worst
Narvik	23	117.1	100.0
Stockholm	26	29.0	3.2
Berlin	16	37.9	17.2
London	25	39.1	17.4
Brussels	**29**	**41.7**	**8.3**
Paris	18	50.0	10.0
Bordeaux	5	37.5	0.0
Mont-Louis	35	104.8	73.8
Granada	9	25.0	**2.5**
...	...	...	...
Median	23	46.23	**10.3**



Rasmont *et al.* 2015

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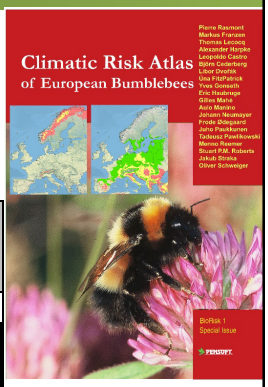
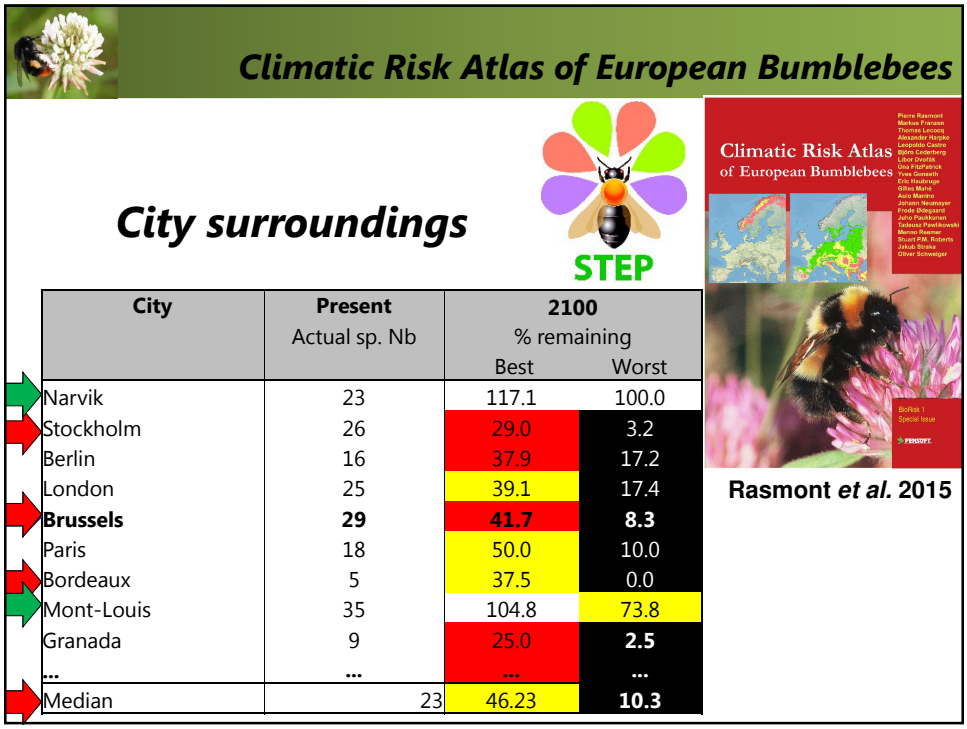


Rasmont *et al.* 2015



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...	...	...	...
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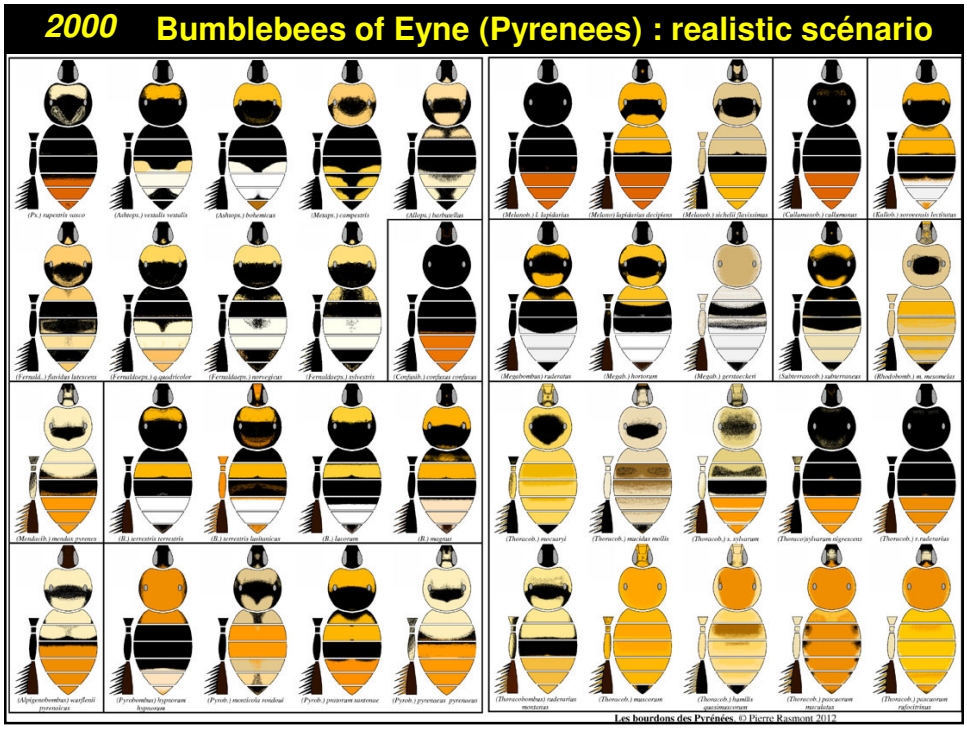
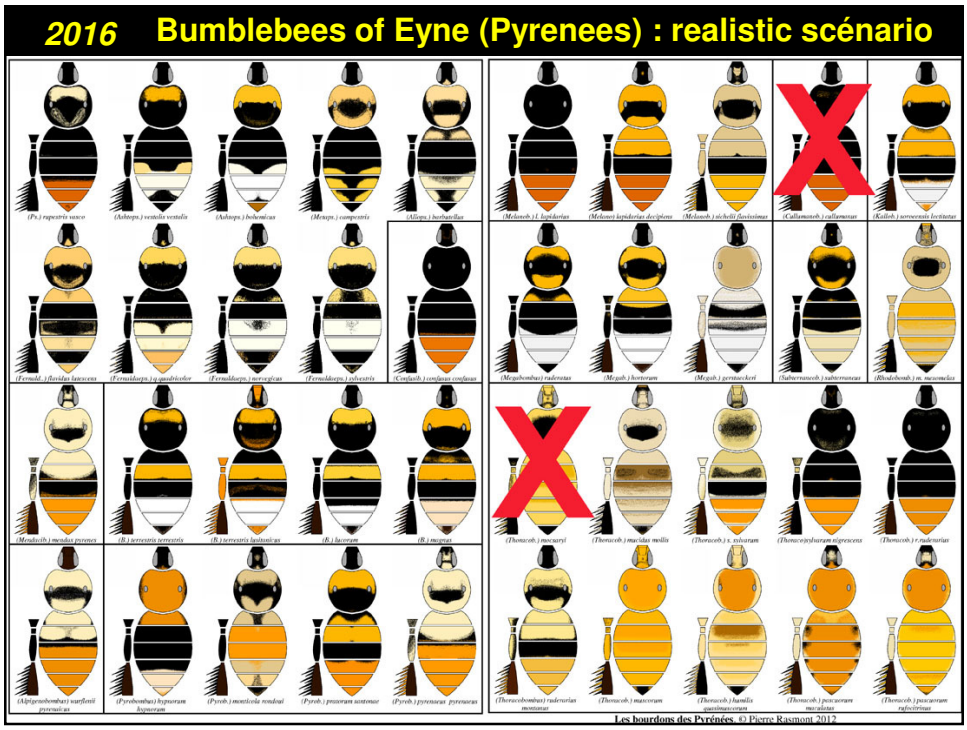
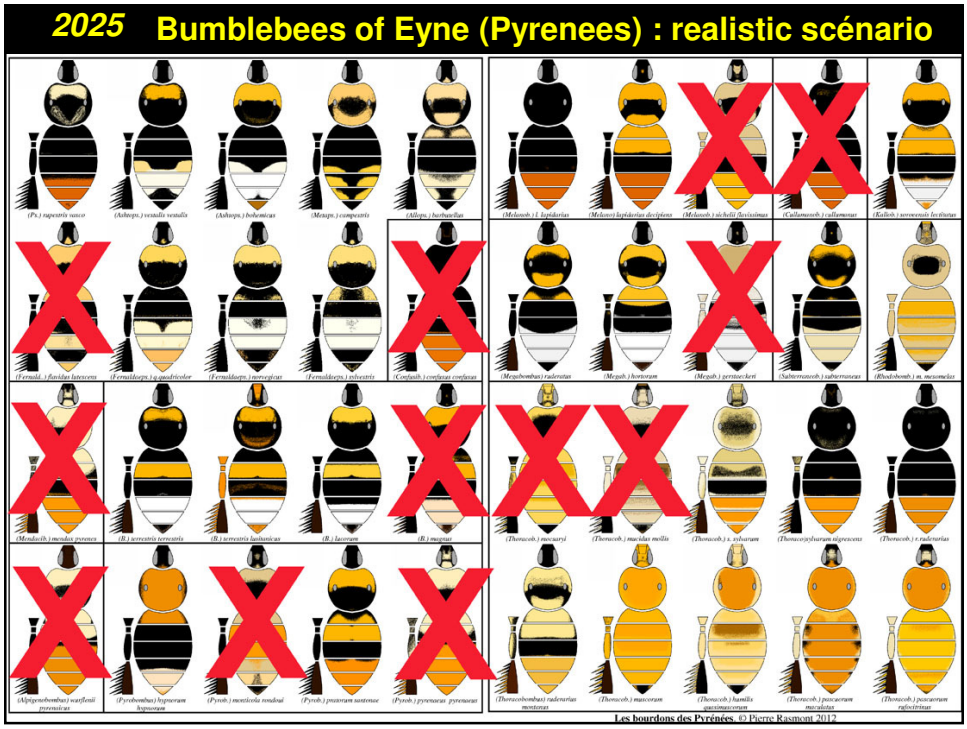
Rasmont *et al.* 2015

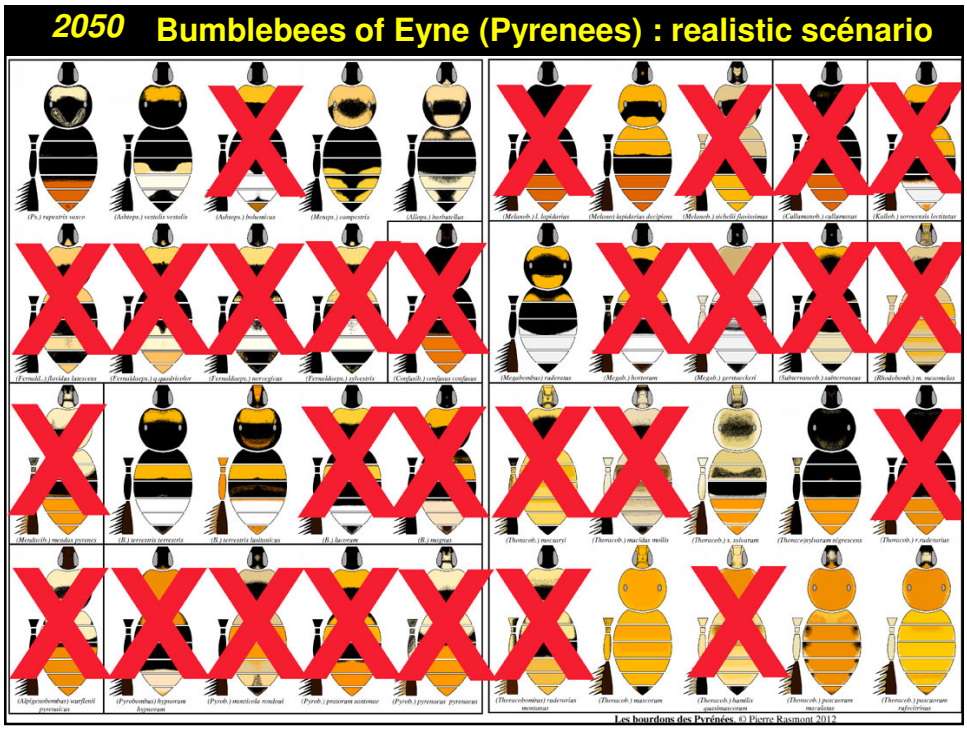
Example of scenario:

What could be the dynamics of bumblebees regression in SW France in the next decades ?

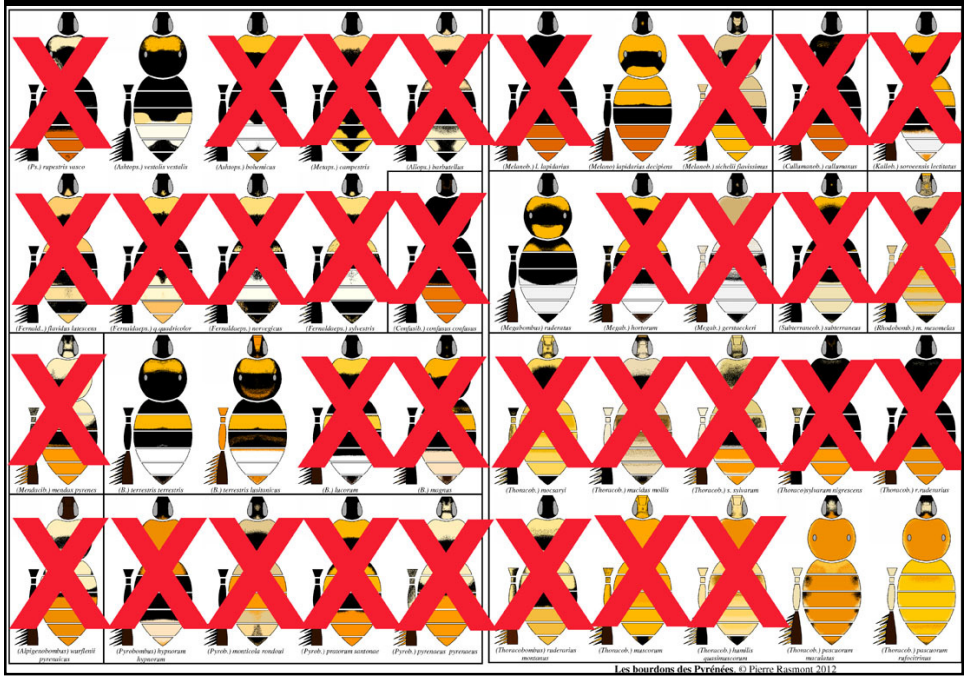

2000 Bumblebees of Eyne (Pyrenees) : realistic scénario
Les bourdons des Pyrénées. © Pierre Rasmont 2012


2016 Bumblebees of Eyne (Pyrenees) : realistic scénario
Les bourdons des Pyrénées. © Pierre Rasmont 2012


2025 Bumblebees of Eyne (Pyrenees) : realistic scénario
Les bourdons des Pyrénées. © Pierre Rasmont 2012

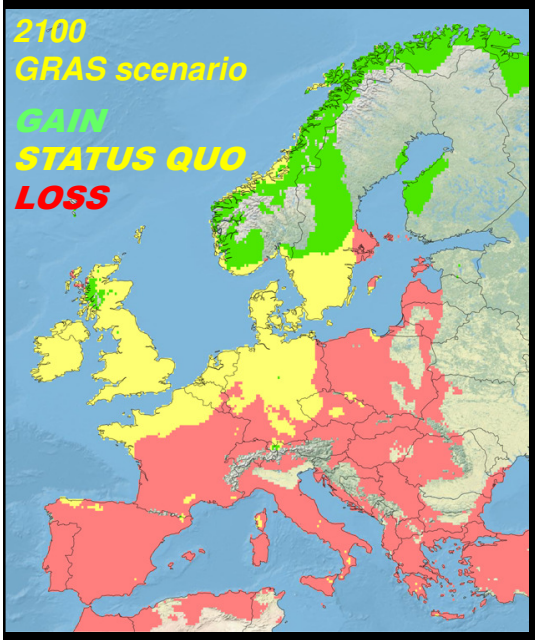

2050 Bumblebees of Eyne (Pyrenees) : realistic scénario
Les bourdons des Pyrénées. © Pierre Rasmont 2012

2080 Bumblebees of Eyne (Pyrenees) : realistic scénario



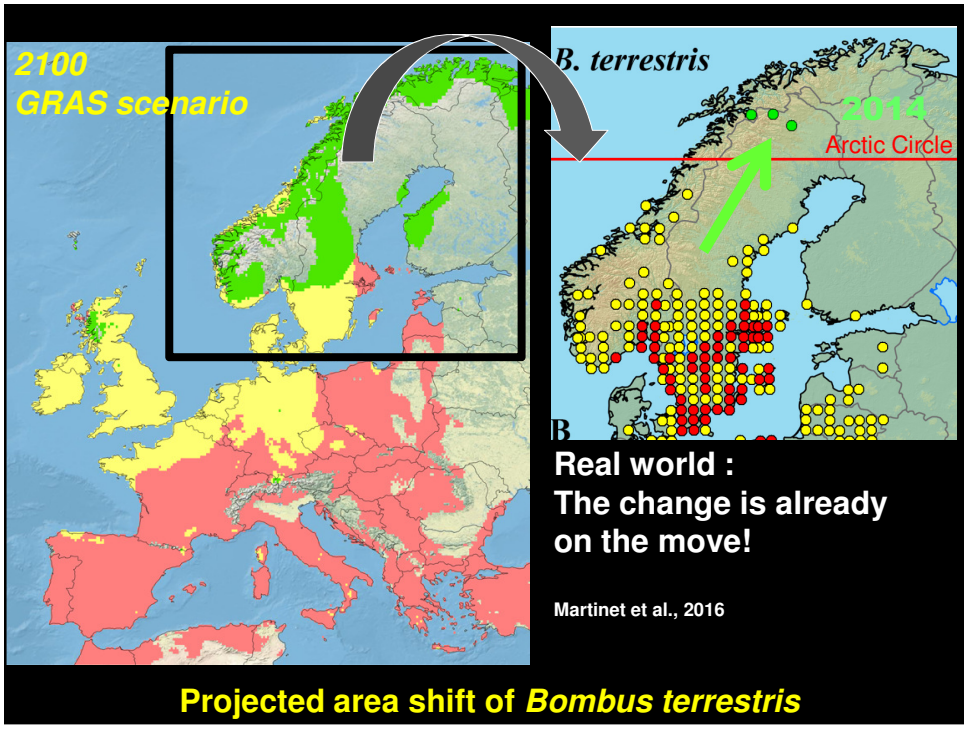
2100 GRAS scenario

GAIN
STATUS QUO
LOSS



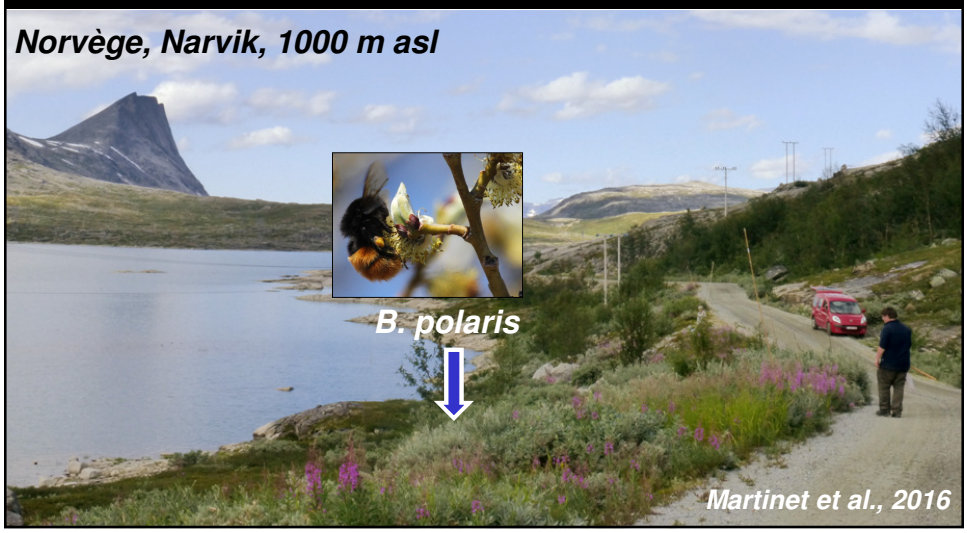
Modelled scenario

Projected area shift of *Bombus terrestris*

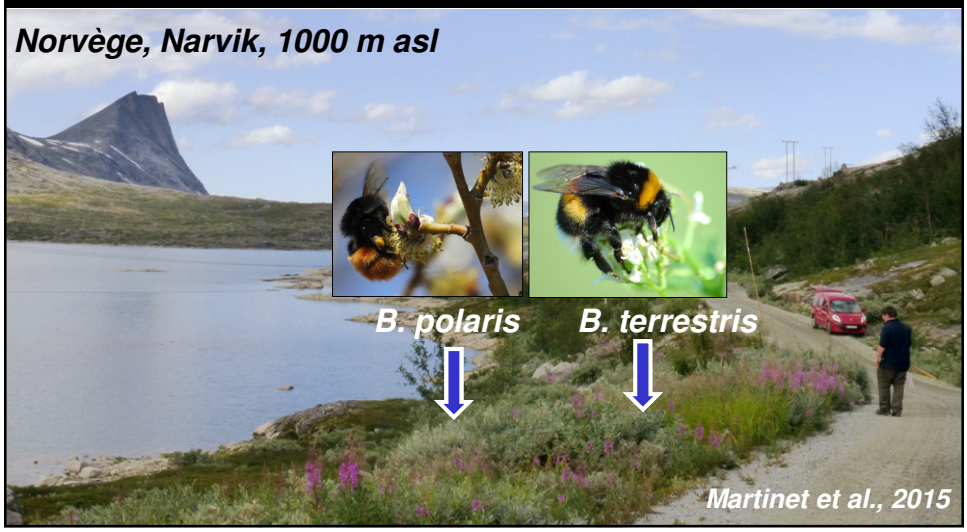


Projected area shift of *Bombus terrestris*

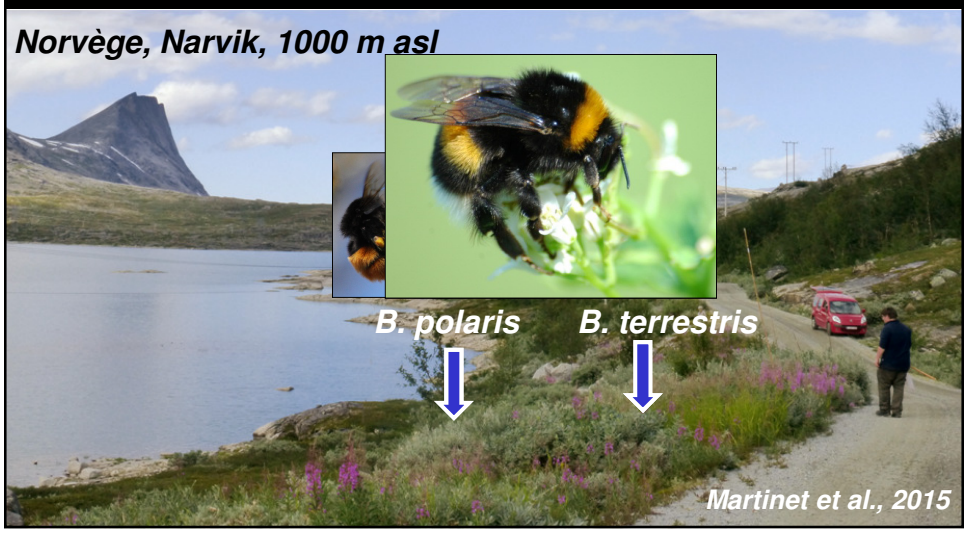
Competition between arctic wildlife and new southern species



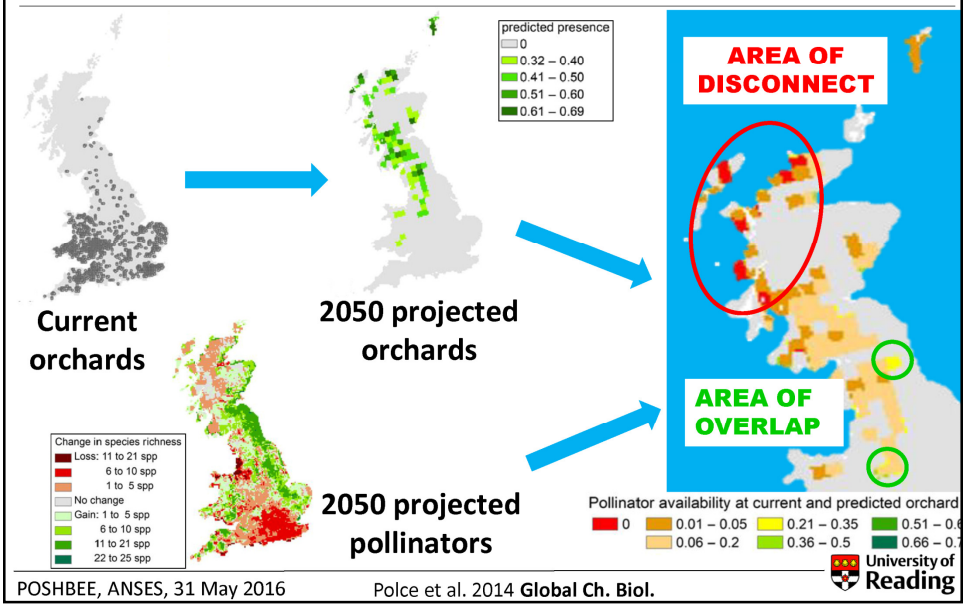
Competition between arctic wildlife and new southern species



Competition between arctic wildlife and new southern species



Orchards under climate change



POSHBEE, ANSES, 31 May 2016 Polce et al. 2014 **Global Ch. Biol.**

We should reassess our present "Nature Conservation paradigm", mainly based on sanctuarising Natural Areas.

It should be replaced by a dynamic paradigm, with two very different concerns:

- <u>Trailing edge conservation</u>

How to maximize the survival of non-moving species in their original areas ?

- <u>Leading edge conservation</u>

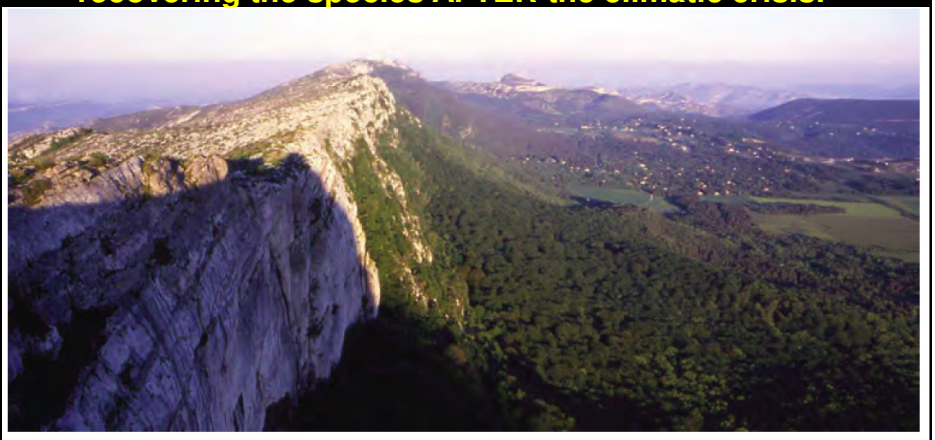
How to manage the move of species toward their new areas ?

The trailing edge conservation

is likey not very different from the present policy.

However, it should focuse on microclimatic areas.

Such areas could play a "Noah's Arch" role for recovering the species AFTER the climatic crisis.



As it is presently the case for the Mediterranean beech forest from « Sainte Baume », near Marseille.

This unique beech forest (*Fagus sylvatica*) survives there since thousands of years sheltered by a high clift.

Beside some isolated populations of several bumblebees like *Bombus pratorum* and *B. humilis*, the Sainte Baume forest is the ultimate refuge in France of the brown carpenter bee *Xylocopa cantabrita*.

The leading edge conservation

Should DEEPLY questions our present management of "invasive taxa".

While most of our present bumblebee species will disappear from temperate countries they are projected to be replaced by high dispersal species from Balkan or Near-Orient

Bombus argillaceus Bombus haematurus Bombus niveatus

The leading edge conservation

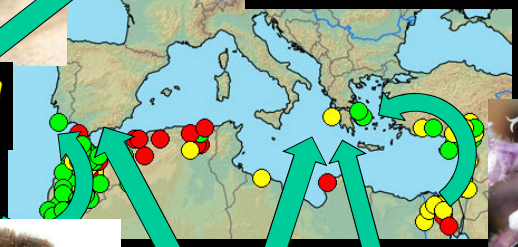
Should DEEPLY questions our present management of "invasive species".

In the real world Southern species are already arriving !

Large Carpenter bee *Xylocopa pubescens*, arriving from Africa and presently invading Greece.

X. virginica USA

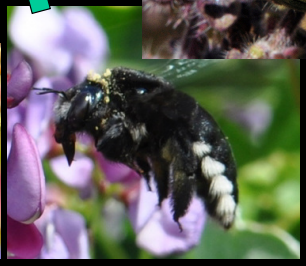
5 new carpenter bees for Europe doubling their former species number



Xylocopa pubescens N.Orient

X. amedaei N.Africa

X. caffra C.Africa



X. nigrita S.Africa

How do arrive all these new incomers ?
By natural way , flying their own way?

Or by human transportation ?

***CSCL-Globe*, the largest container ship in the world**

How do arrive all these new incomers ?
By natural way , flying their own way?
Or by human transportation ?

Does it really matter ?

in ALL CASES our wild bee fauna will be CONSIDERABLY changed in a very near future !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Thanks for
your attention