The fate of forest ecosystems in the Anthropocene

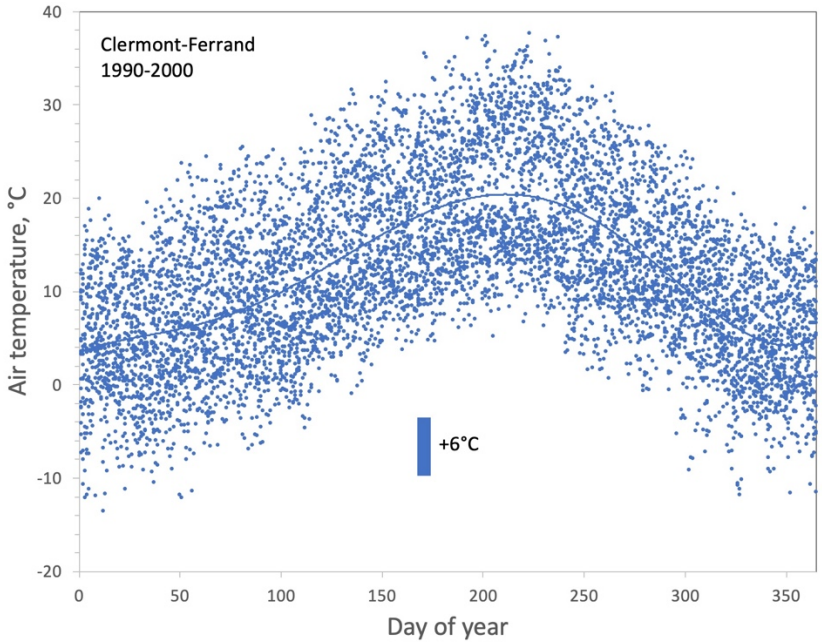
Hervé Cochard

Université Clermont Auvergne, INRAE, PIAF, 63000 Clermont-Ferrand, France.
herve.cochard@inrae.fr

I have realized, when I recently gave lectures or conferences, that people have a misperception of what a few degrees of global warming can mean, especially for forest ecosystems. I also wonder whether this may contribute to the general lack of awareness of the scale of the climate crisis that is looming? My objective is to present some very simple illustrations, but I think striking, to make this little +6°C more tangible and demonstrate how deadly for our forest ecosystems it will be.

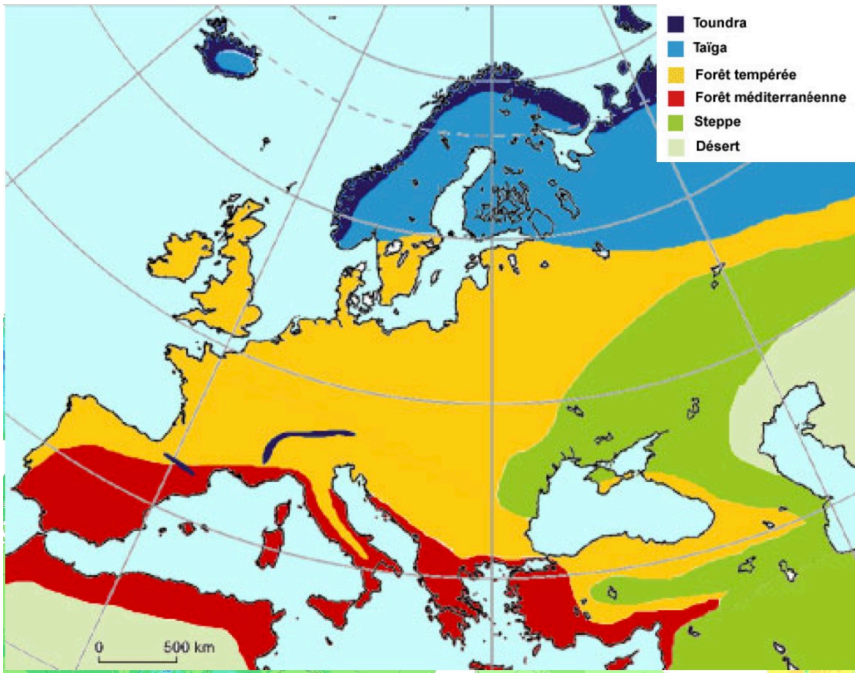
First of all, a little reminder: if we continue our current way of life, the "business as usual" scenario, what climatologists call the RCP8.5, corresponding to a radiative forcing of +8.5 W/m^2 by 2100, we must expect global warming of at least +5°C by the end of this century (the latest simulations are at +7°C...). This radiative forcing is undoubtedly linked to human emissions (direct or indirect) of greenhouse gases (CO2, methane, etc.).

For most people, +6°C doesn't say much because it's not a very tangible variation. People are sensitive to daily or seasonal variations in temperature and these are much higher as illustrated in the figure below. So, +6°C increase in average temperature may seem rather anecdotal.

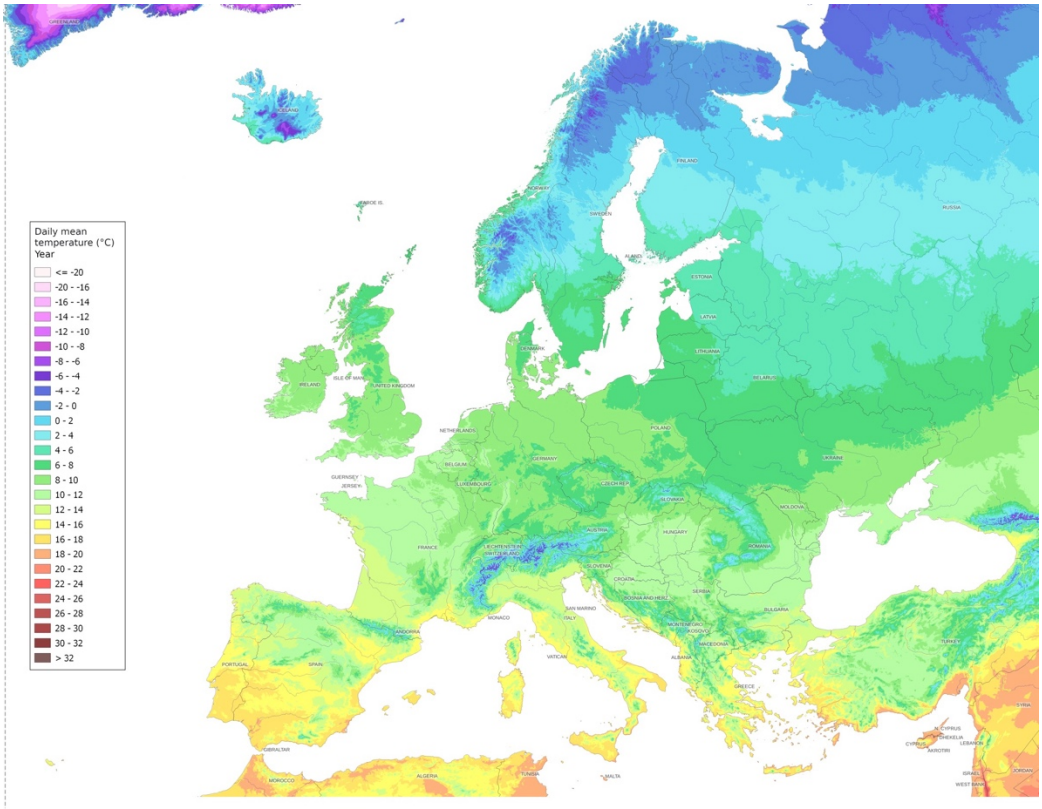


In fact, from the point of view of vegetation and biogeography in general, this variation is just colossal. Let me demonstrate it to you...

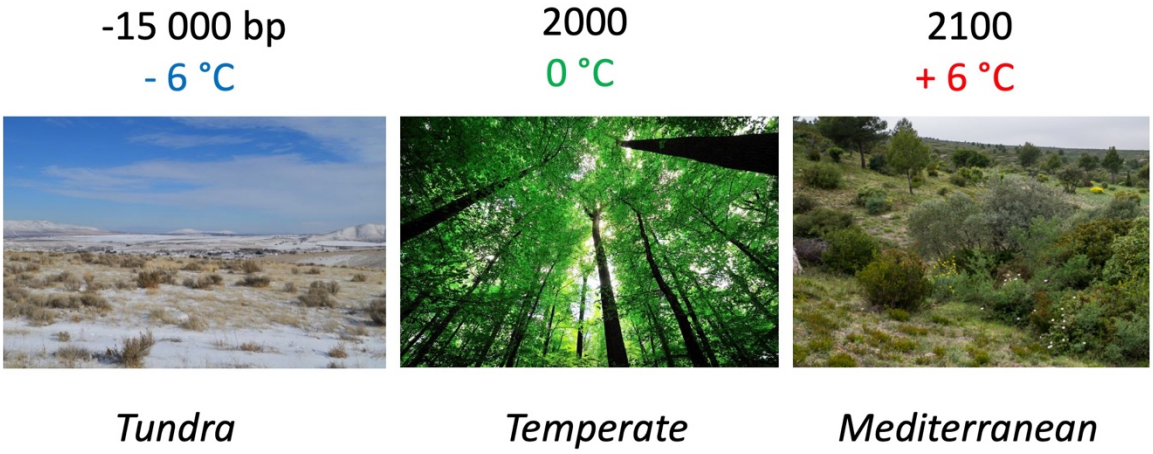
First of all, here is a simplified map of the different "biomes" of my little corner of the planet showing a latitudinal gradient of the vegetation.



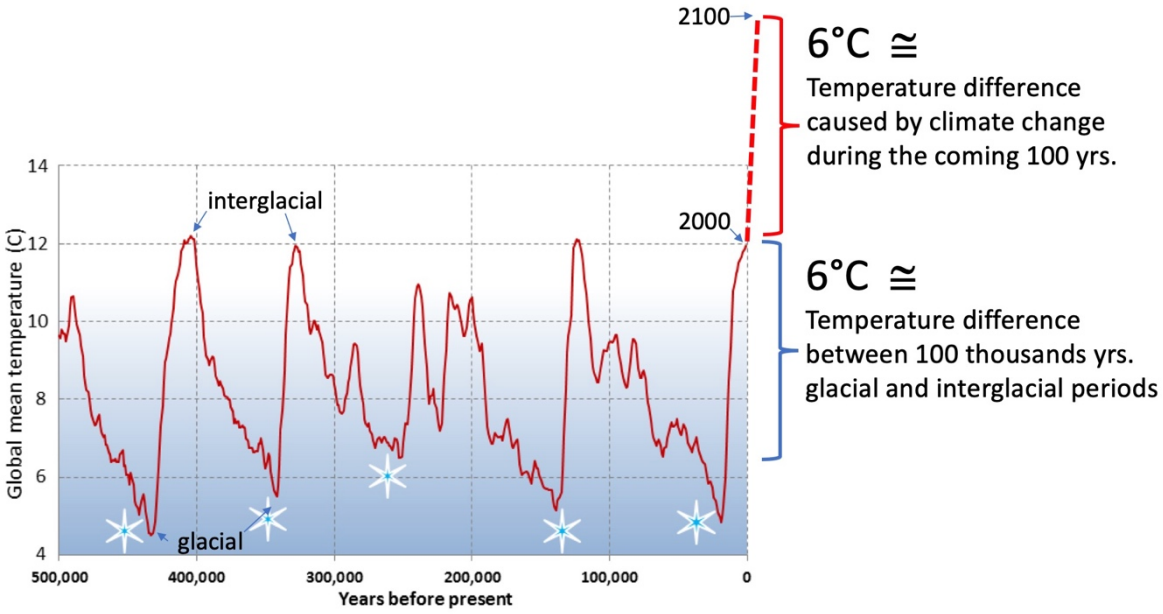
Biogeographers have long demonstrated that the climatic variable that first determines this distribution is temperature. Precipitation and soil types are also important, but here it is mainly temperature that models vegetation types on a large scale, as this mapping of mean annual temperatures in this region shows:



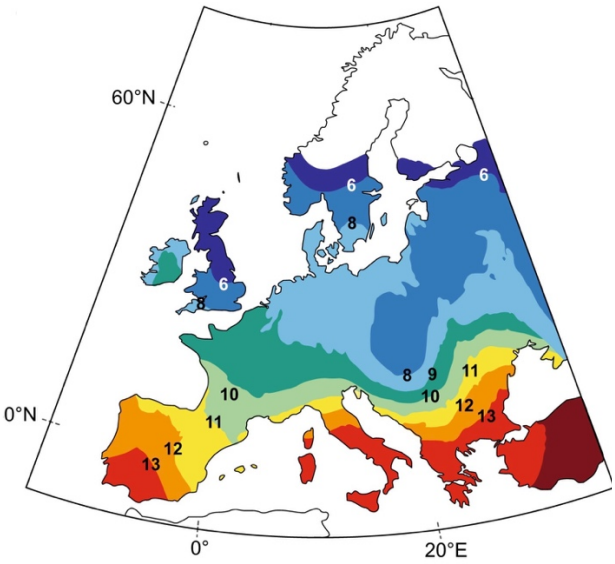
But the important point to look at here is the order of magnitude of variation of these temperatures on this map. The difference in average annual temperature between a temperate climate and a Mediterranean climate is of the order of 6°C, as is the difference between a temperate climate and a boreal climate. In other words, if we increase the temperature by 6°C, we can expect to see Mediterranean-type vegetation replace a temperate forest, or a boreal forest become a temperate forest.



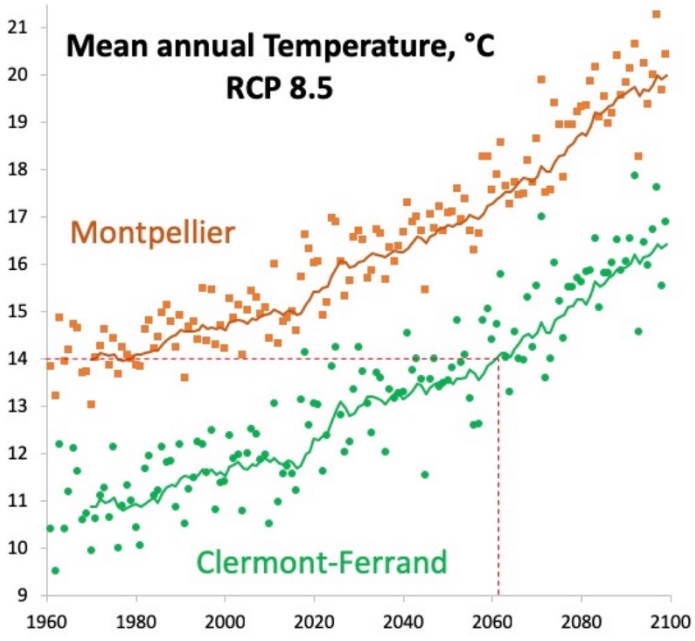
Paleontologists have known this for a long time. During the Quaternary, there were successive waves of glaciation, one every 100,000 years or so. In France, boreal-type vegetation (tundra) occupied the plains during the ice ages. We are currently in an interglacial period characterized by its temperate vegetation. Paleoclimatologists can reconstruct the climates of the past and tell us that the variations in average temperatures between an ice age and an interglacial period are also only a few degrees (about 6 to simplify), which is entirely consistent with the current layering of vegetation.



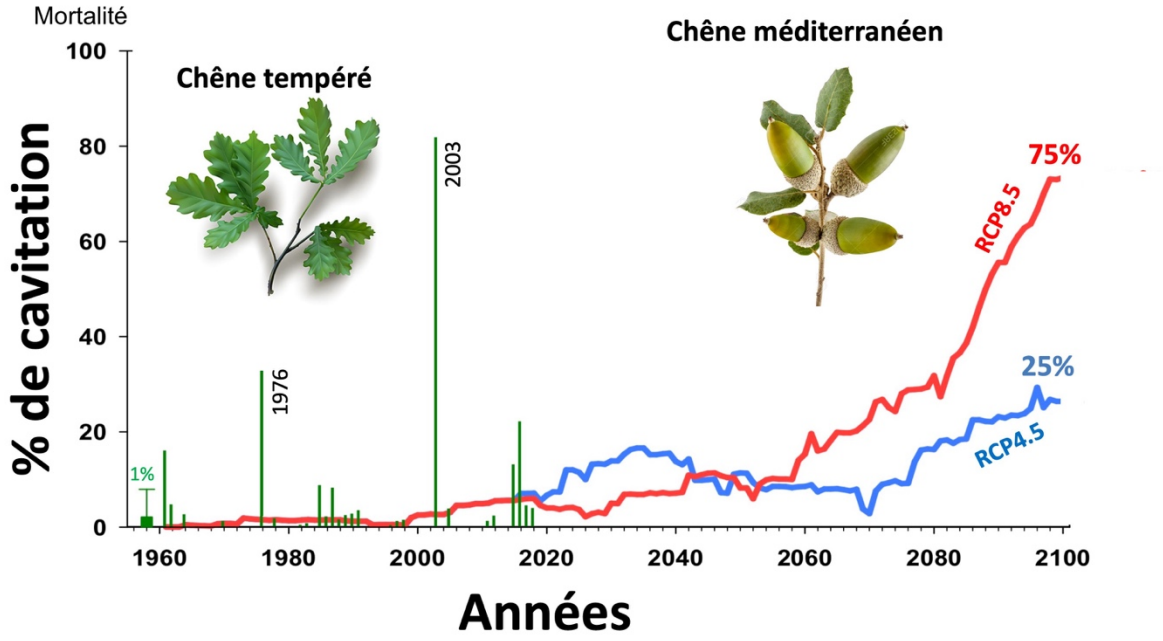
We can therefore conclude, with a high degree of certainty, that we will eventually have Mediterranean-type vegetation in the Paris basin, and desert vegetation in the south if the average temperature rises by 6°C. But there is a small problem... It will have taken a few thousand years for the climate to warm up and for the temperate forest to settle since the last glaciation (Holocene), because the trees naturally migrate only a few hundred meters a year. Here is an example for the Oak that shows its progressive migration towards the North during the Holocene (in 1000 year increments).



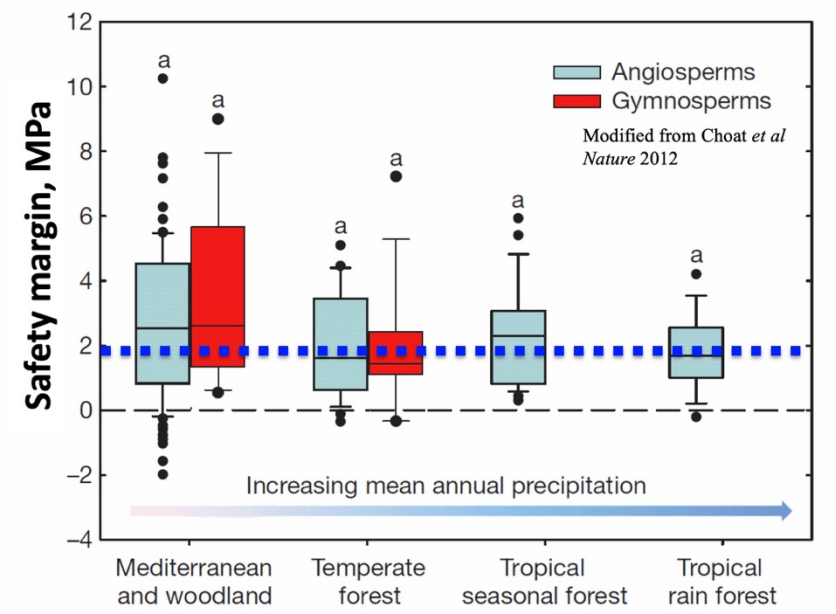
The small problem is that global warming during the Anthropocene will be very rapid, 6°C in only one century! Climate simulations show us that if we continue the RCP8.5 scenario we will have in 2060 in Clermont-Ferrand the average temperature of Montpellier and that during this period of time the Mediterranean forest will have naturally migrated northwards by only a few tens of km.



Vegetation models also show us that climate change is of such magnitude and speed that trees will probably not have time to adapt or acclimatize to these new climatic conditions. In other words, the mortality rate will increase considerably to reach almost zero chances of survival by the end of the century for the species currently present in our forests. Our models show that only Mediterranean vegetation species are physiologically adapted to the climate we will have in 2100 in central France.



The problem is therefore simple: by the end of the century, the spontaneous species of trees that currently populate our forests will die out and the species potentially adapted to these future conditions will not have had time to settle naturally (we are starting to talk about assisted migration to help them a little!). We have also shown that this scenario is global and that it is likely to impact all the forest biomes of the planet as there is a global convergence of forest vulnerability to drought.



We will therefore have to get used to seeing natural forests that are increasingly dying out, with an increase in the risk of fire. The oldest trees will probably be the first to be affected, leaving more open environments conducive to the establishment of shrubby bushes.

To conclude, behind this small +6°C is therefore a major and global modification of our natural ecosystems. The only solution to avoid this catastrophic scenario is well known: drastically reduce our greenhouse gas emissions, which means drastically changing our lifestyles. It is up to each of us to set an example to follow!