

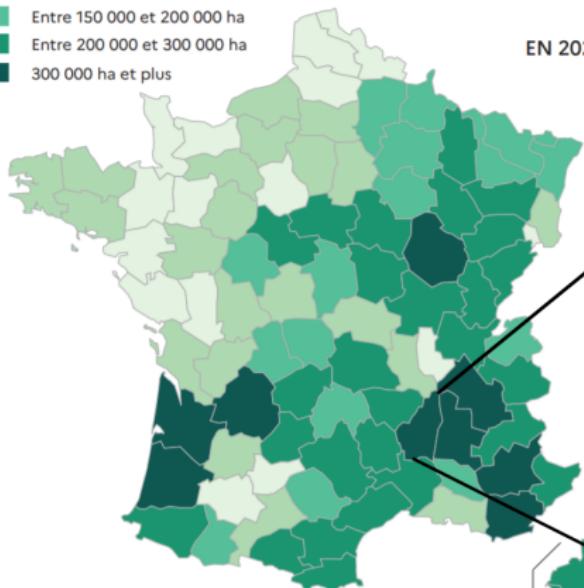
Turning point in forest productivity revealed from 40 years of forest inventory data

Lionel Herzog

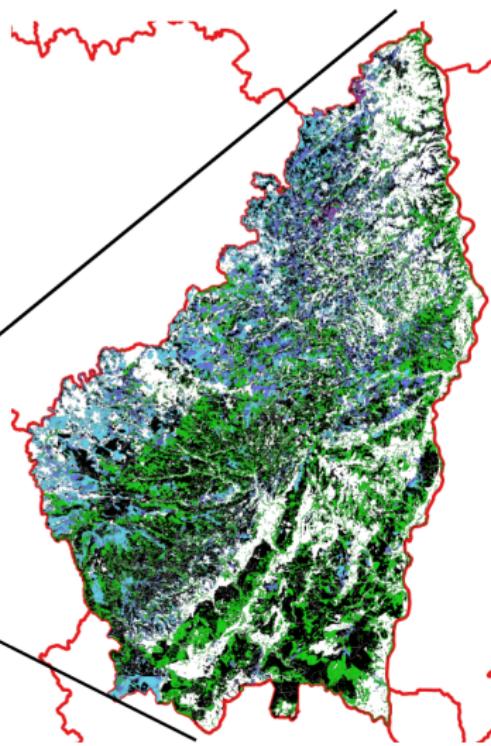
28/03/2023

Forest dynamics in the XXth century

- Moins de 100 000 ha
- Entre 100 000 et 150 000 ha
- Entre 150 000 et 200 000 ha
- Entre 200 000 et 300 000 ha
- 300 000 ha et plus



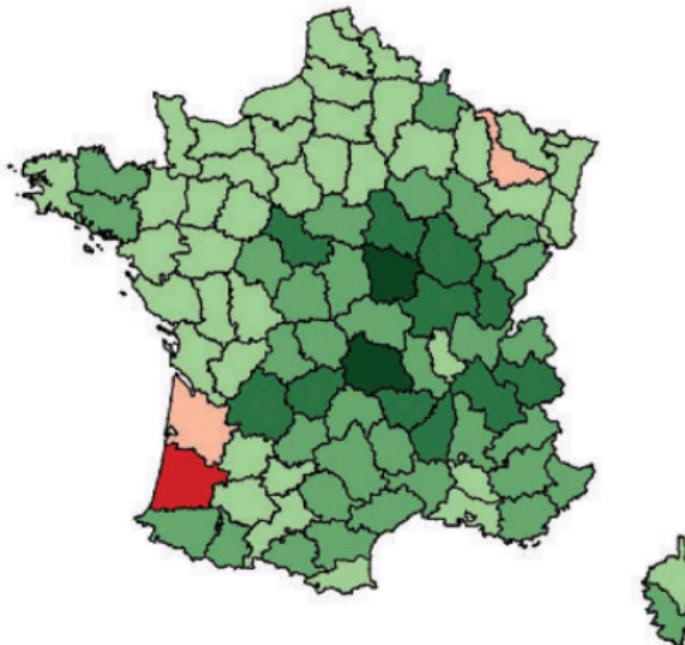
EN 2022



Data IGN, Mémonto IFN, BDForêt v2, BDCartoEM

- Since the beginning of the XXth century forest surface increased by 75% covering a third of France in 2022.

Forest dynamics in the XXth century



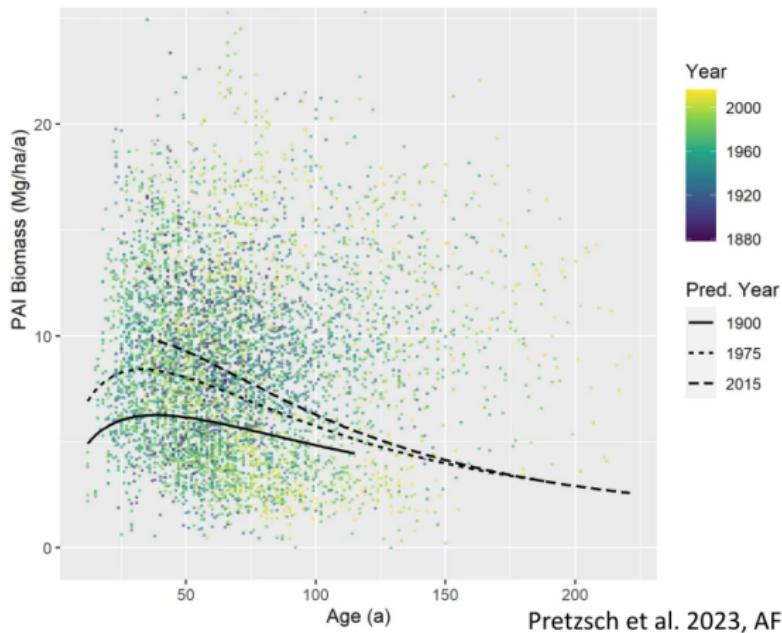
Variation de stock annualisée ($\times 10^3 \text{ m}^3$)

- inférieure à - 250
- de - 250 à 0
- de 0 à 250
- de 250 à 500
- de 500 à 750
- supérieure à 750

Denardou et al. 2017, RFF

- Since the beginning of the XXth century forest surface increased by 75% covering a third of France in 2022.
- Tree volume increased by 60% between 1975 and 2010

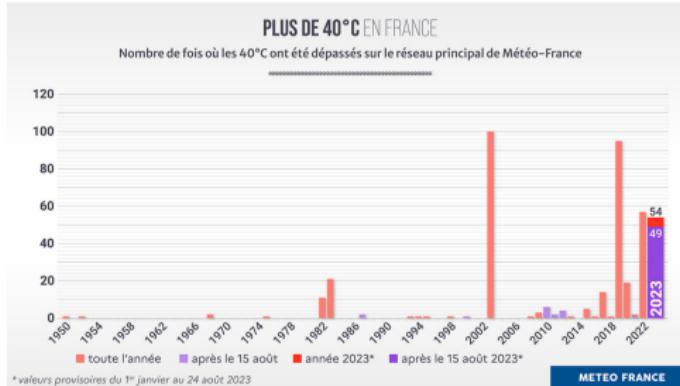
Forest dynamics in the XXth century



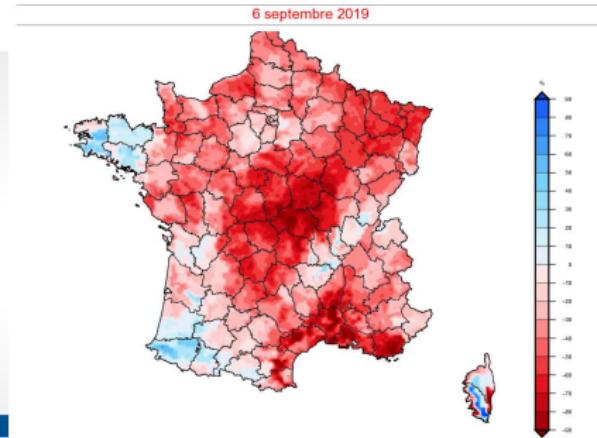
- Since the beginning of the XXth century forest surface increased by 75% covering a third of France in 2022.
- Tree volume increased by 60% between 1975 and 2010
- Forest productivity increased over the XXth century

(Forest) dynamics in the XXIst century

Données MétéoFrance

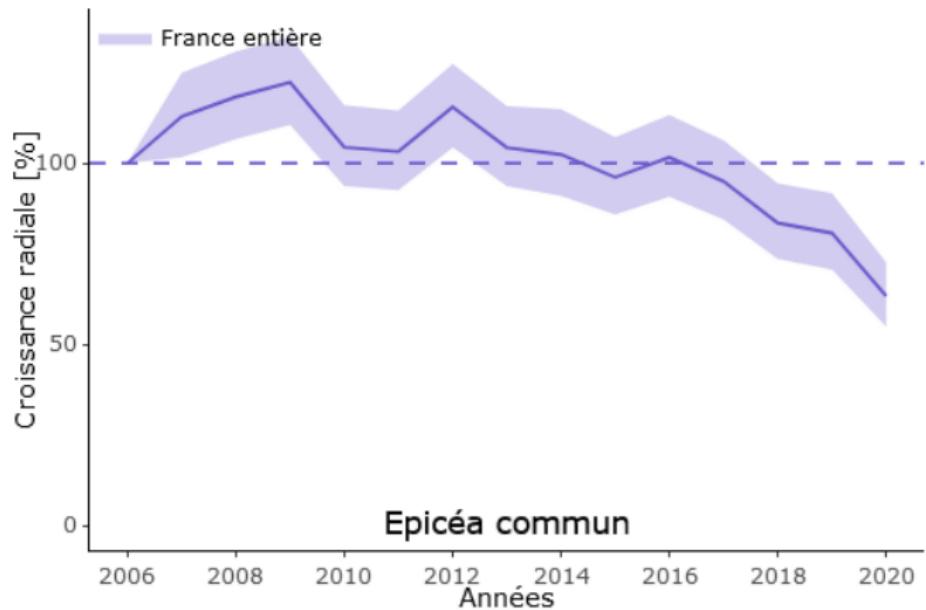


Ecart pondéré à la moyenne quotidienne de référence 1981-2010 de l'indice d'humidité des sols
France



- Increasing heat and water stress.

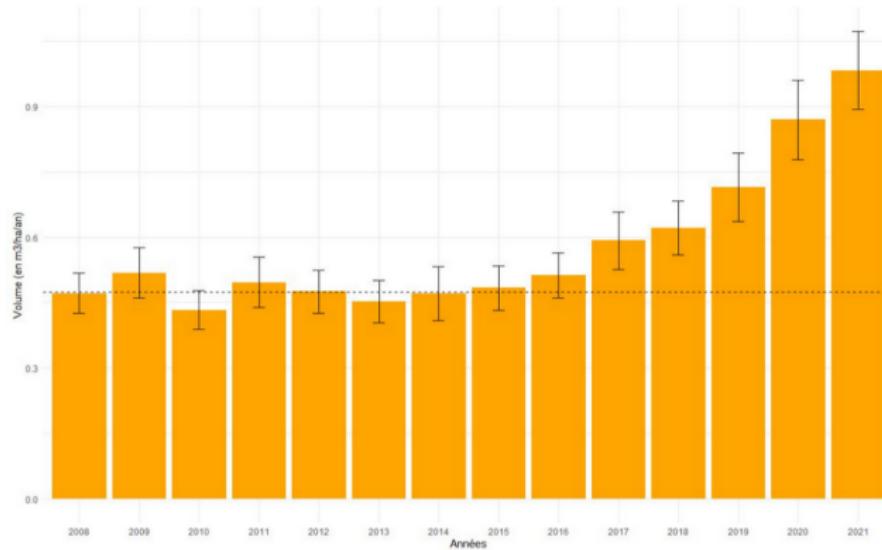
(Forest) dynamics in the XXIst century



inventif.ign.fr

- Increasing heat and water stress.
- Productivity declines already noted for some productive coniferous species

(Forest) dynamics in the XXIst century



foret.ign.fr, données IGN

- Increasing heat and water stress.
- Productivity declines already noted for some productive coniferous species
- Mortality increase caused by multiple factors

Study objectives

The aim of this work was to:

- Study regional variations in forest productivity trends
- Explore links between the productivity trends and climate changes

The National Forest Inventory



- Annual national inventory of forest ecosystems, around 7000 plots are measured on the ground yearly

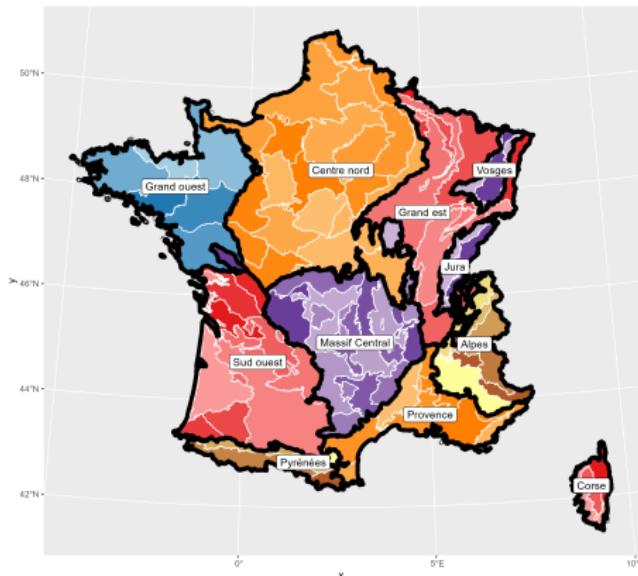
The National Forest Inventory



- Annual national inventory of forest ecosystems, around 7000 plots are measured on the ground yearly
- Numerous tree, floristic and environmental parameters are measured and estimated

Figure from Memento 2022 (IGN)

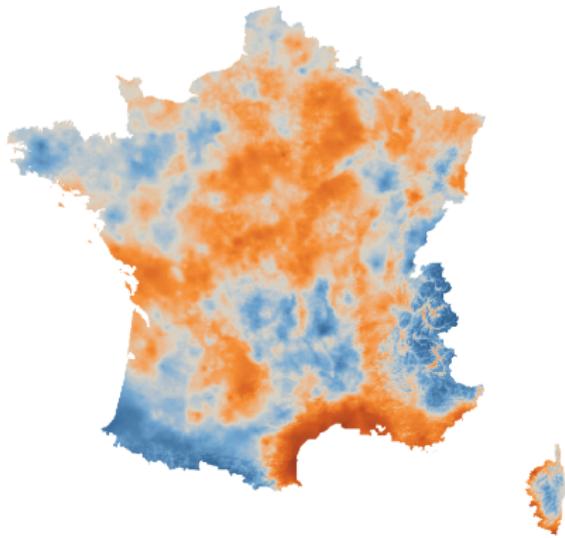
Sylvoécorégions



- 86 "Sylvoécorégions" are defined
- These regions form homogeneous and original environmental conditions and forest structure
- The forest inventory provides estimates at this spatial scale

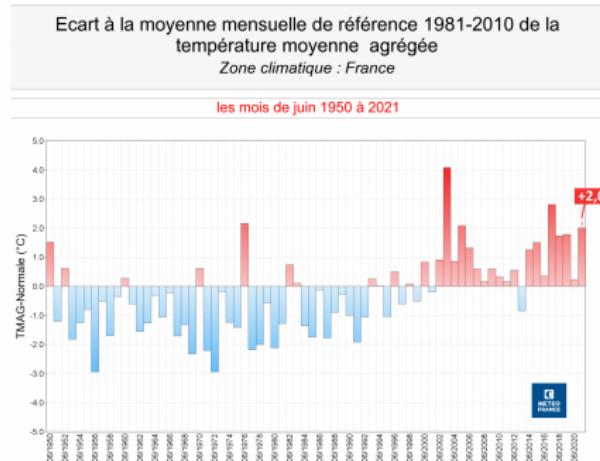
Climatic data

- Homogenized climatic series from meteorological station are used to interpolate temperature and soil water deficit on a 1km grid
- Parameters used: min, mean and max seasonal temperature (12 parameters) plus spring and summer (growth season) water deficit
- 30-year climate normals are computed to derive anomalies

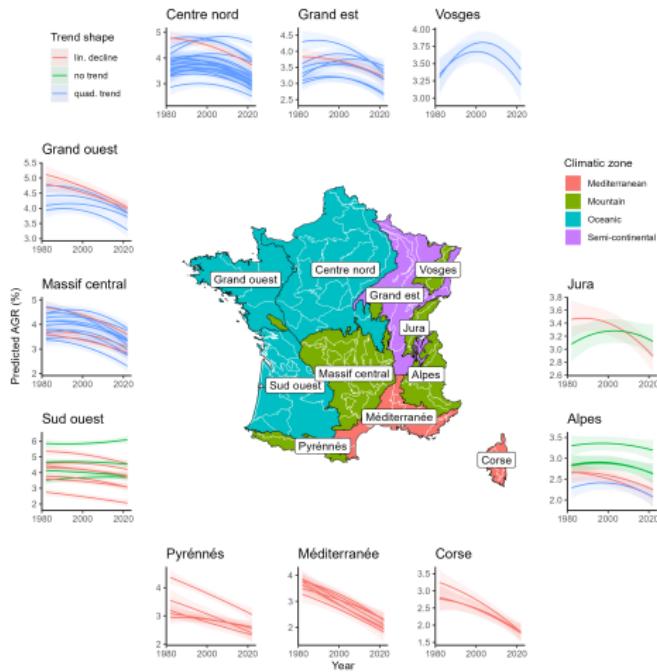


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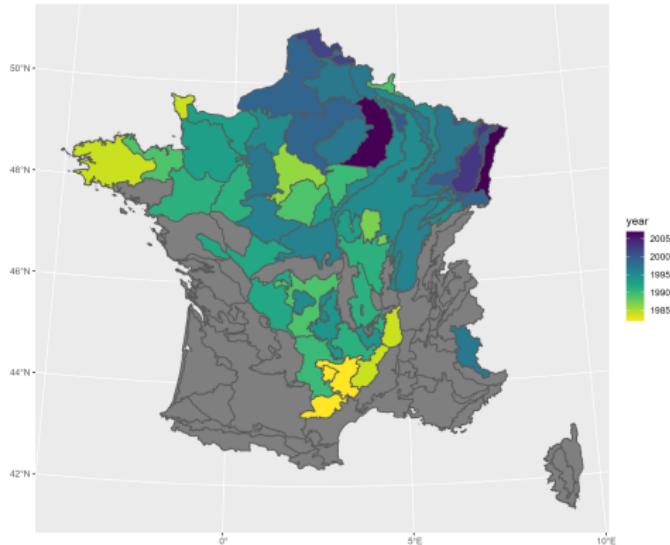


Results: regional variations in productivity trends



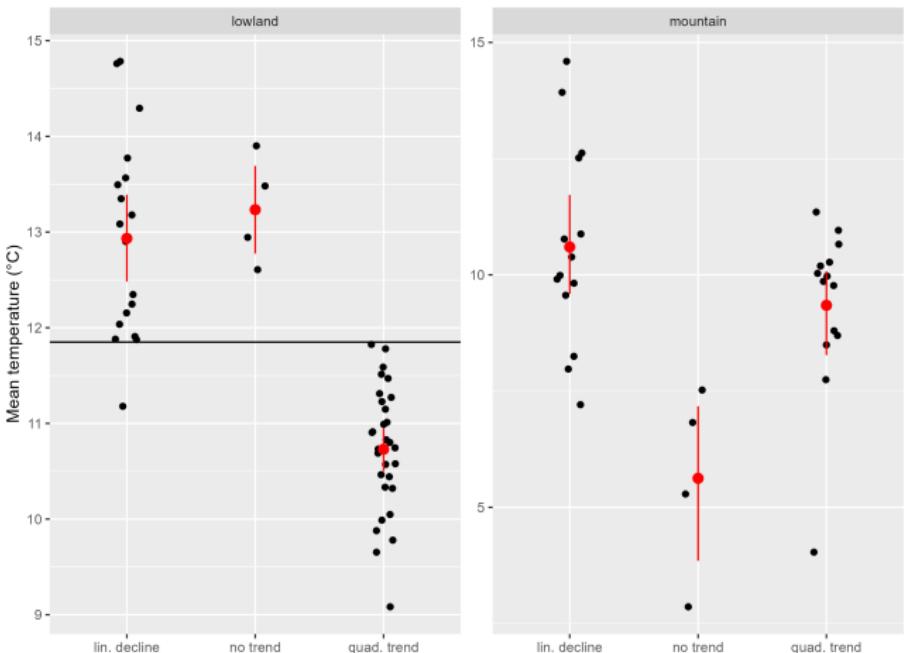
- Strong difference in shape of trends between Sylvoécorégions
- Regions in southern France present more negative linear trends, regions in northern France present more hump-shaped trends
- All but 8 regions had lower productivity at the end of the period compared to the beginning

Results: spatial variation in optimum



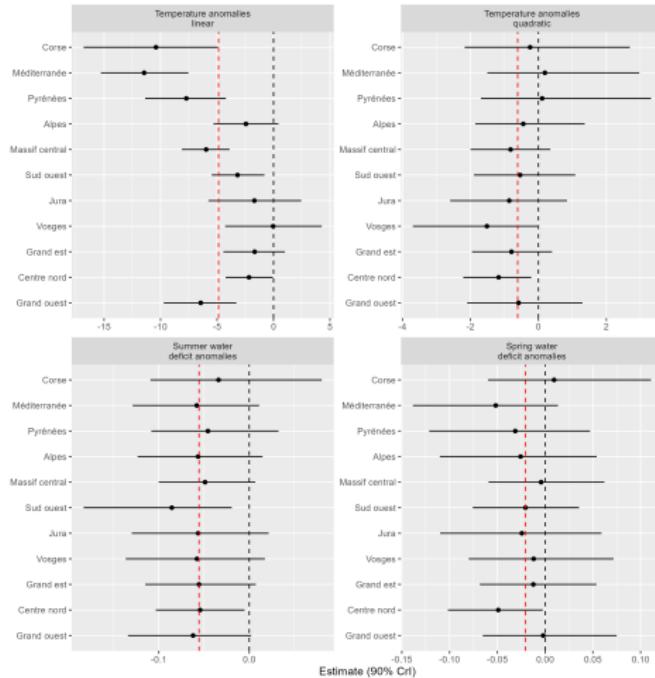
- Spatial gradient in the year when productivity reached the optimum
- Later optimum for regions in the north and east of France

Results: climate and trend shapes



- In lowland, a temperature threshold separate regions with linear declining trends and regions with hump-shaped trends
- In mountains, temperature does not appear to be a determinant of trend shape

Results: effect of temperature and water deficit anomalies



- Variable effect of temperature anomalies between the regions, stronger effect in southern France
- Stronger effect of summer compared to spring water deficit

Result summary

- ① Forest productivity showed variation in the shape of temporal trends over the last 40 years
- ② Despite these variations, almost all regions show productivity currently lower than level measured in 1980
- ③ Climate change, especially temperature anomalies, could reproduce the temporal trends
- ④ Temperature anomalies had variable effects between the regions with stronger effect in warmer regions
- ⑤ Water deficit changes had more constant effect across regions and summer water deficit had stronger effect than spring water deficit

Conclusions and implications

- ① The national forest inventory with its 40 years of representative and systematic data allow the study of productivity dynamics (digital twin?)
- ② The analysis revealed that there are regional variations in productivity dynamics, potentially due to different climatic and environmental conditions
- ③ The declines in productivity in almost all regions imply adaptation in forest management and carbon neutrality strategy

Thank you for your attention
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