Pre-announcement – Research position

Research scientist in *monitoring of climate change impacts on French and European forests*

Chargé de recherche du Développement Durable (CR2)

Institut National de l'Information Géographique et Forestière (IGN)

Laboratory of Forest Inventory (LIF)

Location – Nancy, France

Speciality: biometry, sampling, modelling, signal processing, climatic analyses

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1. Issues and justification of needs

Climate change has been affecting forests for several decades and results in the strengthening of thermal and water stress regimes, with a regional to continental extent (for example European heat wave of 2003), that weaken forest ecosystems, reduce their growth, or increase the frequency and intensity of dieback and mortality events. It is also manifested in an edifying way by major disturbances, still rare, but which have an immediate destructive effect on forests (storms of 1999, 2005 and 2009 in Europe, fires in the Nordic zone in 2018). These stresses and disturbances also form the ground for the emergence of pests, themselves favored by climate change (emblematic case of the spruce bark beetle). Their intensity depends on critical forest ecosystem attributes, including their species composition, their level of biomass capitalization, their structure, or their abiotic environment, at the origin of a variety of responses, the reading of which in time and space becomes complex and sometimes confuse in the literature, and remaining subservient to restricted geographical perimeters.

Strategic reaction to these events has led to the clarification of public policies for adapting forests to climate change, either at European level (European Forest Strategy - EFS, European Commission 2021) or at the national level (Roadmap for the adaptation of forests to climate change - FRAFCC, MAA 2020). A salient priority of these is the need for exploitation and adaptation of forest observation systems for delivering information able to support current

and future adaptation strategies. This need constitutes the first priority of the FRAFCC, for which the French national forest inventory system is one of the cornerstones (MAA 2020). It is also requested at the European level as a new integrated European forest observation and monitoring, in a context of imperfect outcome of the effort to harmonize European forest inventories (EFS 2021).

This context highlights the need for long-term research on the use and adaptation of the national forest inventory system for the purpose of an operational real-time spatio-temporal monitoring of the impacts of climate change on the French forests.

In terms of technical opportunities, i) the national forest inventory has been running since 1958 and covers a period when these impacts were not obvious, making it possible to quantify their extent over the long term, ii) this inventory is also one of the rare in the world to be systematic and annual on the national territory (since 2005), with that of the USA, Finland, and Sweden, making it possible to tackle the new problem of real-time forest monitoring, iii) the forest inventory cooperates with the Forest Health Department (MAA) to establish common protocols for assessing dieback, and is considering its combination with the systematic forest health monitoring network.

The French forests are also the most diversified in Europe in terms of forest habitats, species and climates, and intensity of management. This, on the **one hand reinforces the need for a unique national monitoring tool for these contexts with varied responses, and on the other hand offers the prospect of identifying, in French forests, the species, territories, and management practices offering tangible support points for incremental and informed adaptation policies**. In this latter situation, the monitoring tool envisioned can therefore go beyond the observation of the evolution or criticality of forest ecosystems, and reveal their causes and possible levers of action.

It is at IGN that these research developments are the most relevant in France, as this institute hosts the national forest inventory program, and the laboratory for this research - the Laboratory of Forest Inventory – with a solid expertise acquired since 2015 (see references). These bases enable to envision an ambitious research program, focusing at indicators (growth, decline, mortality, vulnerability to risks), forests contexts of analysis and scales, whereby initial works demonstrated the possibility of homogenizing inventories of different countries to establish continental responses. This research program should therefore contribute to the laboratory's ambition to create a European research cluster on these issues.

2. Research Axes

AXIS 1 – Development of an annualized national spatio-temporal monitoring system of the impacts of climate change on forests

Built upon existing bases, the objective is to develop a set of indicators of the impact of climate change on the fundamental demographic parameters of forests (volume growth, biomass sequestration, mortality), by developing information filters of the ordinary, environmental and biotic determinants of forest dynamics. Interactions with forest health attributes will also be researched, through collaboration with the DSF (Département Santé des Forêts). Taking advantage of the survey design of the inventory should enable the development of an annual mapping system and automatic updating of time series relating to the forest ecosystems of the territory based on signal filtering models. With regard to small forest estates, the systematic imperative of the approach may also lead to hybridize a multi-source-based mapping of these indicators, based on remote sensor information, to reach high-resolution predictive ecological mapping.

AXIS 2 – Development of trans-national monitoring approaches and contribution to the development of a European monitoring system

In the climatic and bioeconomic context, the European continental space is becoming a major issue for the deployment of forest monitoring systems. Recent work based on homogenizing trans-national inventories demonstrated its added value in monitoring and understanding the ongoing impacts of climate change. This approach will be continued and developed, on the basis of existing collaborations or to be posed across Europe, including the inventories of Switzerland, Germany, Austria, Italy and Romania, on the basis of identified research networks. The researcher will also involve in research on the development of a harmonized European forest monitoring framework. Aspects to focus on will be the design of spatio-temporal forest growth and mortality sampling plans, and inclusion of remote sensing information, to achieve these ends.

AXE 3 – Scientific foresight for the development of updated vulnerability indicators of forests to major disturbances

The objective here is to develop indicators of the vulnerability of forests to the major risks of storms and fires, based on models quantifying forest factors of this vulnerability, in a context where the spatial extension of French forests and their multi-decade capitalization contributes to its increase. This axis has a strong collaborative dimension with partner research institutes. It will take advantage of the historical databases of the forest inventory in which the damages of the most recent storms are identified, and also with the national database on forest fires. The finalized dimension of this research is the deployment of updated vulnerability indicators, supported by the current annual systematic inventory.

3. Missions

In addition to the research exposed higher, the transversal expertise gradually developed may be used within the institute: (i) to support upstream decisions in the operational sampling plan of the 'forest inventory, (ii) to support operational tests to implement this monitoring system, and (iii) for the transfer of technology to the various services concerned, with concern for the framework of the future IGN "Forest Observatory".

Defining the appropriate characteristics of the monitoring system requires the ability to collaborate with forestry research teams competent in the areas of: forest management, adaptation to climate change, biometrics and survey statistics, and risk analysis in a broad sense.

The researcher will also get involved in higher education at engineer or master level (IGN / ENSG, AgroParisTech) or at doctoral level (Université de Lorraine, Université Gustave Eiffel Marne-La-Vallée), for an around fifty hours per year to secure outreach and training in the field.

4. Profile

(i) transversal skills in forestry science, biometrics, climate change, and especially in forest inventory. An academic course gradually built around research teams using inventory data in different countries can be a significant asset,

(ii) interest in both applied research in information system engineering, and in fundamental understanding of the observed phenomena.

(iii) initial network of collaborations in the field of forest inventory, especially in Europe.

(iv) scientific contributions identified in the forest dynamics, climate change and monitoring communities.

(v) an ability to initiate and conduct a research project independently, to obtain contractual funding, to integrate broad collaborations, and an interactive and invested know-how.

(vi) a first experience and an interest in higher education.

Selected references

Ols C., Gschwantner T., Schadauer K., Bontemps J-D. 2021. Unexpected Negative Effect of Available Water Capacity Detected on Recent Conifer Forest Growth Trends Across Wide Environmental Gradients. Ecosystems, 1-18.

Ols C., Bontemps J-D. 2021. Pure and even-aged forestry of fast-growing conifers under climate change: on the need for a silvicultural paradigm shift. Environmental Research Letters 16, 024030

Ols C., Hervé J-C., Bontemps J-D. 2020. Recent growth trends of conifers across Western Europe are controlled by thermal and water constraints and favored by forest heterogeneity. Science of The Total Environment 742, 140453.

Taccoen A. Piedallu C., Seynave I., Gegout-Petit A., Bontemps J-D., Gégout J-C. 2019. Background mortality drivers of European tree species: climate change matters. Proceedings of the Royal Society B 286 (1900), 20190386

Charru M., Seynave I., Hervé J-C., Bertrand R., Bontemps JD. 2017. Recent growth changes in Western European forests are driven by climate warming and structured across tree species climatic habitats. Annals of Forest Science 74, 1-34.

Charru M., Seynave I., Hervé JC. Bontemps JD. 2014. Spatial patterns of historical growth changes in Norway spruce across western European mountains and the key effect of climate warming. Trees 28, 205-221.

Charru M., Seynave I., Morneau F., Bontemps JD. 2010. Recent changes in forest productivity: an analysis of national forest inventory data for common beech (Fagus sylvatica L.) in north-eastern France. Forest Ecology and Management 260, 864-874.