



Improving the Effectiveness of Forest-based Research Results France Report June 14, 2017

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French forests include those of metropolitan France on the one hand and those of the overseas territories on the other. Metropolitan France belongs to four biogeographical regions (Atlantic, Alpine, Continental and Mediterranean). This diversity provides a richness of natural landscapes, tree species, forest ecosystems, silvicultural systems, goods and services, and their value chains.

With 17 to 18 million hectares, the wooded lands of metropolitan France are amongst the largest in Europe. Forests themselves cover more than 16 million hectares, about 30% of the land; 95% of them are available for wood supply. They have been used intensively until the beginning of the XIXth century but since this transition period, their area has almost doubled. This extension is largely due to natural colonisation but also to afforestation programmes: With reforestation against forest degradation, about 13% of forest area has been planted (over the period 2008-2012).

French metropolitan forests are diverse, not only biogeographically but also institutionally. Over one fourth of these belong to about seventeen thousand public institutions (state-owned forests, community forests...). The other three quarters are private, mainly non industrial holdings distributed among 3.3 million owners; two thirds of these private owners are individual persons or households and more than fifty percent of them are retired. In this context, public policies play an important role in stimulating sustainable forest management through regulations, incentives and technical assistance.

1. Short description of the role of forestry in the national economy

(extracted from Peyron, 2016 in: Maaf, IGN, 2016)

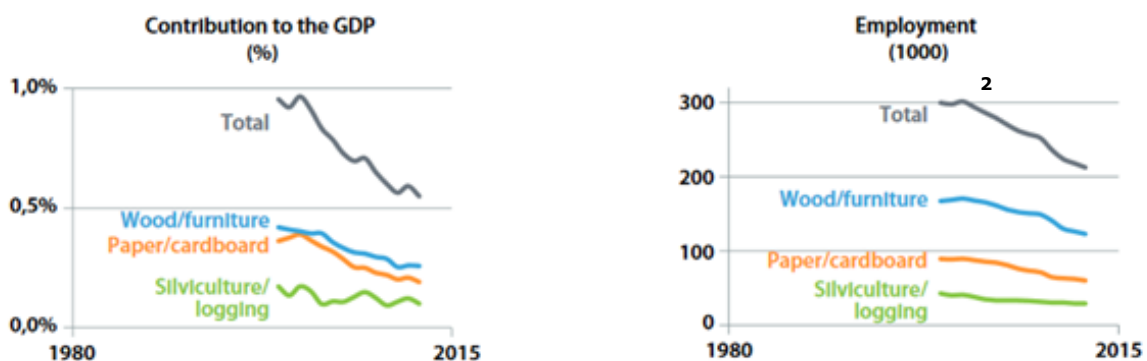
According to the summary of trends included in the 2015 edition of indicators for the sustainable management of French metropolitan forests (Peyron, 2016 in: Maaf, IGN, 2016), raw timber harvesting remained globally constant since 1980, with however an upturn at the end of the 1980s and the effects of the 1999 and 2009 storms. It varies according to the species, rising for conifers (+0.6% per year) and dropping for broadleaved species (1.3 % per year). Harvesting of industrial timber and marketed fuelwood increased regularly until 2007 (+0.5% per year and +2.7% per year, respectively), before becoming variable due to the 2009 storm for the industrial timber and to an increased demand of renewable energy (around +15% of fuelwood per year since 2007).

Figure 1 (source: Peyron, 2016 in: Maaf, IGN, 2016)



Again according to the summary of trends, the added value of the French forest sector has been decreasing in recent years (Peyron, 2016 in: Maaf, IGN, 2016). Furthermore, the primary (natural resources) and secondary (industry) sectors have been losing ground compared to the services sector. In 2012, the Forest-Wood sector contributed only to 0.55% of the gross domestic product (GDP) against 0.95% in 1999. Total direct employment of the forest-timber sector declined by nearly 30% in the same period (i.e. an average reduction of 3% per year for the various economic sectors), with a slightly lower reduction for the woodworking/furniture branch. **The Forest-Wood sector represents thus around 0.83% of the active population¹ and generates 0.55% of the gross domestic product (Peyron, 2016 in: Maaf, IGN, 2016).**

Figure 2 (source: Peyron, 2016 in: Maaf, IGN, 2016)

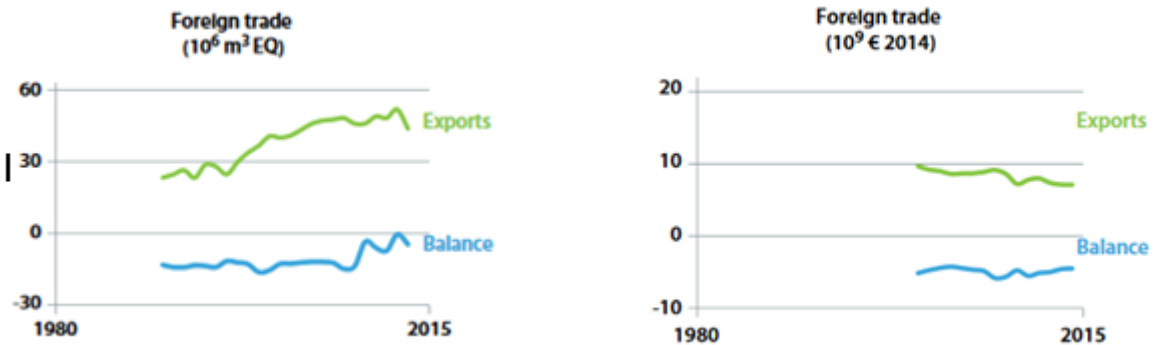


¹ without accounting for forest owners managing their own forest

² total direct and indirect employment in the forest-based sector currently represents more than 400 000 jobs

Finally, **the foreign trade deficit of the Forest-Wood sector has remained globally stable over the last fifteen years**, despite fluctuations dependent on the general economic and the forestry contexts (mainly climate accidents). **This deficit fluctuated between 4 and 6 billion Euros 2014**. Presently, this deficit is firstly explained by furniture (45% in 2014 against 27% in 2000) and therefore related to high added-value products. It is still significant but has declined radically in the paper sector (23% in 2014 against 56% in 2000). It is growing in the construction and building sectors (14% in 2014 against 3% in 2000) and remains stable in the sawing industry (around 12 or 13%) (Peyron, 2016 in: Maaf, IGN, 2016).

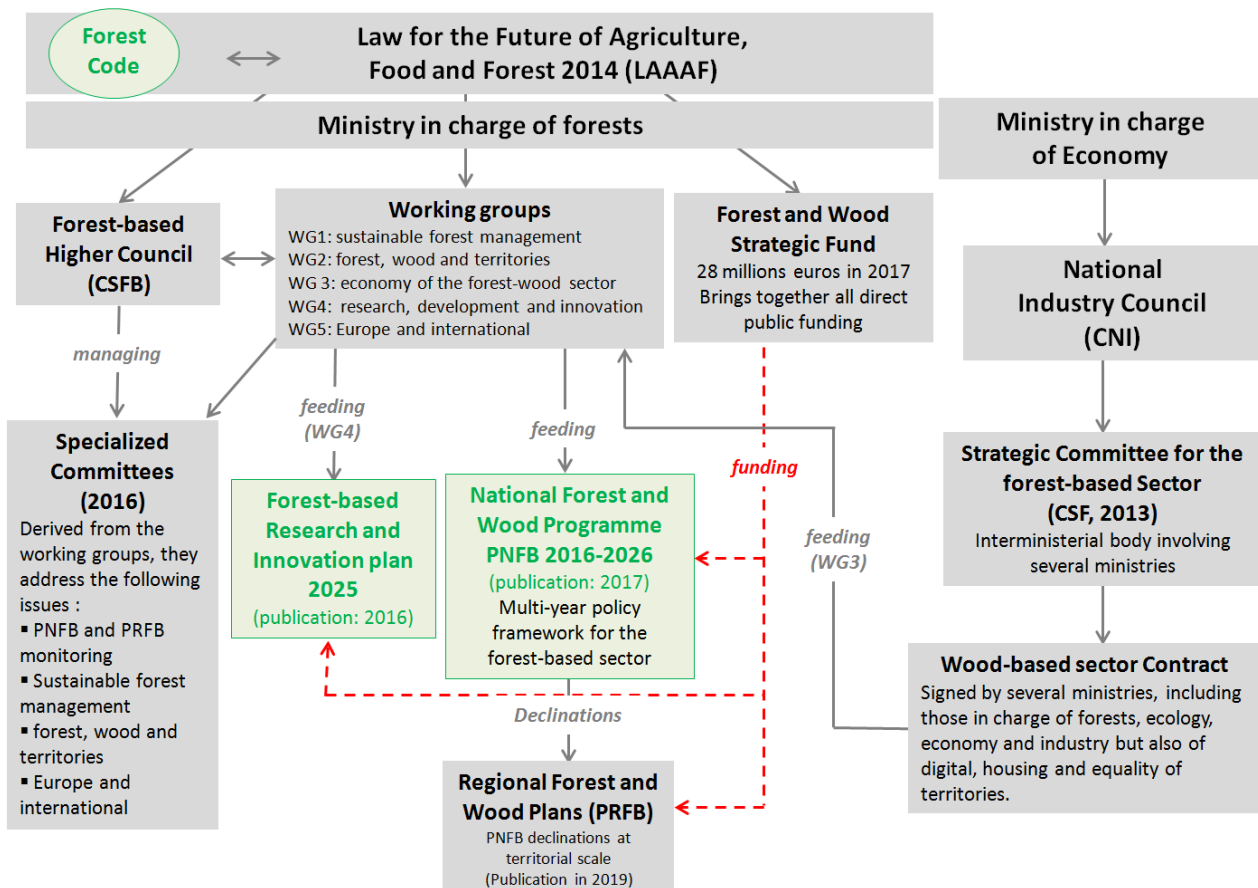
Figure 3 (source: Peyron, 2016)



2. Science-practice interaction in policy documents

At the national scale, the forest-based sector is steered by several public policy processes. Before going through three main policy documents, namely the French forest code, the French National Forest and Wood Programme and the French forest-based Research and Innovation plan, here is a simplified diagram showing their integration into the National policy landscape.

Figure 4: simplified governance of the French forest-based sector at the national level, 2017



This figure shows especially that forest industries and products were the subject of a strategic approach prior to the renovation of the former National forest programme (2006-2015), as a result of the recognition of the Wood-based industry as a strategic sector monitored by the National Council of Industry. This resulted in a Wood-based sector strategic contract published in 2013, with which the National forest and wood programme (2016-2026) drawn up in 2015 (and formalized in 2017 in an agreement).

a. Science-practice interactions in the French Forest Code (Article L152-1, 2014)

The French Forest Code is a collection of legislative and regulatory articles related to the forest management and operations activities and to the protection of forests and human societies depending on them. Nevertheless, one article located in the first book ("Common provisions to all woods and forests") of the Code is specifically dedicated to Research. This article provides a framework for the organization of applied and fundamental research on forests and timber (Chapter 2 of Title V). It specifies that :

- "Applied research on forests and Wood contributes to the sustainable management of forests, strengthens the competitiveness of the value chain and harvesting practices, adds value to forest products and meets the social expectations;
- Applied research is based on fundamental research. It is conducted in public or private organizations and institutions of higher education, and with the help of technical institutes. It is subject to periodic evaluations;
- The public research organizations carry out a mission of permanent expertise for public authorities, particularly in the field of sustainable management of metropolitan and overseas forests;
- The competent administrative authority of the State shall, after obtaining the opinion of the French forest-based higher Council (CSFB), define the methods of co-ordination of research programmes relating to forestry and forest-based products. It ensures the adaptation of research activities to the objectives of forest policies".

This article shows especially that research activities are seen as a way to add value to forests activities. Renamed and renovated by the Law for the Future of Agriculture, Food and Forest (LAAAF, 2014), the CSFB includes representatives of administrations, local authorities, forest owners, producer organizations, professional forest managers, forestry experts and other stakeholders of the forest-based sector.

b. Science-practice interactions in the National Forest and Wood Programme 2016-2026

The **National Forest and Wood Programme (PNFB)** is the national framework of forest policy which stems from the French national law on the future of agriculture, food and forest. It has been officially adopted in 2017. Hence, this programme sets guidelines for forest policy, in public and private forests, in metropolitan France and overseas territories, for a period of ten years (2016-2026). It is divided into the four following main objectives :

- **OBJECTIVE A: increase the harvesting of wood in France while at the same time ensuring forest stands renewal.** French forests are currently under

harvested and have been constantly expanding over the last century. Improved management will help develop the economy of the forestry & wood sector and prepare for the future ;

- **OBJECTIVE B: take fully into account what the general public expects from forests.** Forests are both a place for recreation and a space for preservation of the biodiversity. It is also a source of territorial employment and economic wealth. Lastly, forests provide wood for material and energy production. This means that it is important to raise the awareness of the general public through communication on forestry issues, particularly by means of educational initiatives. The national programme will be adapted to fit each French region by being rolled out as a series of Regional Forest and Wood Programmes (PRFB). The PNFB provides for involvement of regional government bodies in local, sustainable projects;
- **OBJECTIVE C: address climate change.** Climate change and increasing risks are major concerns for French forests and their sustainable management, Forest fires are responsible for large damages in the Southern regions but are rather under control to the exception of large drought conditions. Destructive wind storms have hit France several times in the last two decades. The levels of insect populations and diseases are supposed to increase in the future. **Woodland has a major role to play in absorbing carbon, thereby reducing greenhouse gases.** Climate change will also have a direct impact on forests and their biodiversity;
- **OBJECTIVE D: develop synergies between forestry and industry.** While France has one of the world's most attractive national hardwood forests (oak, beech, poplar, etc.) and ranks as the second-biggest producer of sawn hardwood in Europe, the Forest-Wood sector contributed only to 0.55% to the gross domestic product (GDP) and the balance of trade remain negative. Matching actual market needs with products coming from French forests is therefore a major issue.

To define these strategic objectives, actors of the forest-wood sector have been consulted through the implementation of Working Groups (WG) on "sustainable forest management" (WG1), "forest-wood and territories" (WG2), "economy of the forest-wood sector"(WG3), "research, development and innovation" (WG4) and "Europe and international" (WG5). Three transversal action types can be distinguished here to highlight the expected contribution of the research and development community to the PNFB objectives (see more information in table in appendix 1):

- **Developing observation and monitoring.** Research and development initiatives in this area are particularly expected to address climate change and biodiversity related issues;
- **Developing knowledge and providing tools to support management choices and public policies.** Many research actions are pointed out here to support stakeholders in the forest based sector. They are expected to contribute to almost all PNFB objectives, like for instance: developing silvicultural models integrating various types of scenarios, creating a research and development coordination to select and preserve genetic resources, enhancing hardwood material properties and associated transformation processes, integrating research results into forestry professional education, improving the appropriation of biodiversity-related knowledge by forest managers et policy makers,...

- **Other actions to promote interactions between scientists and other Forest-Wood stakeholders.** This action type focus on initiatives specifically oriented to strengthen the links between the researchers and the practitioners, at the national and European scale such as: building Research and Development partnerships across countries sharing common issues (hardwood promotion, genetic material selection and preservation,...), mapping research, development and innovation capacities to identify potential gaps and overlaps, sharing information between different type of actors,...

Furthermore, one of the 15 key actions of the PNFB concerns the development and implementation of an ambitious plan for research and innovation for the forest-based sector.

c. Science-practice interactions in the forest-based Research and Innovation plan 2025

The French forest-based Research and Innovation plan 2025 was developed in close connection with the PNFB and the CSFB, in order to reinforce the Research-Development-Innovation (RDI) continuum. It is the result of individual and collective consultations conducted among a large panel of forest-Wood actors. Through 13 projects and 29 associated actions, the RDI plan addresses three key and complementary priorities:

- **to improve performance in all parts of the sector through cross-cutting approaches:** this priority is expected to contribute in particular to the objectives B (meet public expectations) and D (develop synergies between forestry and industry) of the PNFB through system approaches. Many initiatives contained in this part of the plan could contribute to the three PNFB transversal action types (see above) and therefore to the reinforcement of interactions between science and practice such as: the creation of networks and resources in the field of social and economic sciences, the establishment of a forest sector employment and training observatory, the development of living labs (i.e. innovative networks based on open innovation philosophy), of platforms dedicated to data and knowledge sharing,...
- **to develop uses for wood in a future bioeconomic context:** research projects and actions are mainly expected here to contribute to market development wood products, stimulating industrial renewal and encouraging sustainable uses for wood. This second priority includes a list of innovations coming both from the National Forest-Wood Programme (PNFB) and the Strategic Committee for the Sector (National Council for Industry). The interaction between Science and practice is mainly addressed here through the modernization of tools and processes for the industrial actors such as: developing demonstrators, enhancing large size roundwood processing, open innovation (fablab, living lab)...
- **to adapt forests and prepare forest resources for the future:** this is a core priority for the objective C of the PNFB (Adapt to climate change) but also for the other objectives of the plan in so far as they requires all the initiation of major changes in forests. National forest R&D network and long term research programs have already been initiated to advance knowledge and provide the scientific basis for developing forest adaptation measures towards climate change and other risks. This part concentrates many expectations related in particular to monitoring activities, remote sensing technologies, precision forestry, adapted Forest Reproductive Material,...

This plan also includes an analysis of RDI mechanisms and funding instruments in the sector, supplemented by recommendations. Most of them requires or relies on the enhancement of interactions between science and practice (see section 5 below) and on an increased level of funding for the RDI continuum.

3. Research and Innovation capacities in relevant fields

(mainly based or extracted from Carnus J.-M. and Richter A., 2015)

Forest and forestry are characterized in France by a great diversity of tree species and ecological conditions (from boreal to tropical), ownership status (public and private), forest type and uses (industrial, social, ...), management regimes (from short rotation coppice to protected areas), regulation and public policies and socio-economic actors.

Forest research approaches are therefore multiple amongst French research organizations and universities involved in scientific fields related to forests and forestry. Within the framework of the National Forest Program, the working group on "Research, Development, Innovation" produced a report in 2015 giving among other things a picture of the French Research-Development-Innovation capacities for the Forest and Wood sector. In this report, French research is divided into three categories:

- **Category 1: fundamental or academic research**, mainly based on unresolved scientific questions put forward by the scientific community itself;
- **Category 2: finalized research**, rather driven by questions designed to meet the needs of a business sector or the society ;
- **Category 3: applied research (technological, industrial or socio-economic)** aimed at developing a product that will be sold on the market or put at the service of society.

Research activities of an institution rarely correspond to a single category. Thus, this classification aims to describe the French diversified landscape of research and development in this field.

Table 2: Distribution of main Research and Development organizations by type of research

Type of organization	Main Research and Development organizations			
<i>Fundamental or academic research</i>	CNRS IRD Other Universities	INRA AgroParisTech	IRSTEA MNHN CIRAD	~ 3% of scientific publications
<i>Finalized research</i>	~ 50% of scientific publications	~ 30% of scientific publications	~ 17% of scientific publications	IGN ONF- R&D CNPF - IDF FCBA
<i>Applied (technological or industrial) research</i>				

There are no official data to assess the current total number of people working in the field of forest research but informal estimations have been made in 2015 by the working group "Research, Development, Innovation" to give an order of magnitude of the human resources involved in the public sector of forest research and development. The given

estimates in the following table mainly come from extrapolations based on publications and expert statements. Therefore, these results should be considered with caution.

Table 3: research capacities estimates of research capacity in major forestry research organizations (in France and by fields of Research and development, as full time person per year in 2015)

	<i>Universities and other higher education establishment (AgroParisTech, MNHN,...)</i>	<i>INRA</i>	<i>CNRS</i>	<i>CIRAD</i>	<i>IRSTEA</i>	<i>FCBA</i>	<i>IRD</i>	<i>CNPF - IDF</i>	<i>ONF</i>	<i>IGN</i>	<i>Other</i>	Σ
Total number of human resources involved in forest research*	940	340	160	120	100	90	50	50	30	10	110	2 000
<i>Including Ecology and silviculture</i>	620	250	120	60	80	55	45	48	29	10	80	1 400 (70%)
<i>Including wood sciences and technology*</i>	300	75	35	50	10	30	1	0	0	0	30	530 (26%)
<i>Including Economy, statistics, society and policy *</i>	20	15	5	7	10	5	5	2	1	0	0	70 (4%)

* *Researchers, permanent engineers, PhD student, postdocs, contractual personnel*

a. Current state of global Forest research

Even in the absence of precise knowledge about the number of people working in the field of forest research, the members of the working group used a bibliometric approach (quantitative analysis of publications) to apprehend the place of France at international and European level and its characteristics:

With 4,8 % of the world publications, the French forest research ("forest" and "wood" topics combined), rose to the 8th position, behind the United States, Canada, Germany, Brazil, Japan, The United Kingdom and Australia, and before the European Nordic countries, Spain and Italy.

In all European countries, most research activities focus on the environmental, ecological and biological forest ecosystem aspects as well as on forest trees (covering, in particular, major issues including the effects of climate change). Indeed, research activities related to silviculture and forest management occur less frequently. Thus, France ranges between countries strongly involved in the field of ecological sciences like the United Kingdom and countries most involved in research on forest management and operations like Germany, Sweden and Finland.

Machinery and logging are among the less R&D developed topics in France. More generally, research related to social and economic sciences remain poorly addressed, even if efforts have been made in the recent years.

In France, INRA ranks first with 26 % of national publications, followed by CNRS (14%), CIRAD (9 %), IRD (5 %), MNHN (5 %), AgroParisTech (3,7%), Irstea (3,4%) and CEA (2,2%). The relative modest scores of institutions generally associated with the "forest" subject (INRA in particular) are due to the high scientific production of university laboratories: 24 universities contribute together to 47 % of publications, often as co-

publications with the research organizations mentioned above. The scattering of these laboratories, added to the fact that it is mostly academic research, explains their relatively low visibility in the forest world. One half of university production is concentrated in four universities: Lorraine (7.5% of the national total), Aix-Marseille and Montpellier (4-5% each) and Toulouse 3%.

The only R&D and technological research organizations that reach 1% of publications are the ONF and FCBA. These modest scores are due to the lower priority given by these organizations in terms of scientific publications, but also to the modest number of research staff involved.

b. Current state of research in wood sciences

In Europe and around the world, research related to the wood sciences represents only 6% of research related to materials, 8 times less than metals, 5 times less than polymers, and also less than ceramics or concrete. From this point of view, French public research on wood sciences ("wood" or "timber") is quite well positioned at the international level (better than other materials) and on the rise since many years, in particular thanks to state incentives initiated since the 1980s and involving in particular the universities and the CNRS (totally absent before 1975). Furthermore, since 2012, the GDR Bois, an extensive research group specifically dedicated to the wood sciences improved significantly the visibility and effectiveness of French research in this field, at national and international level. However, a strong disconnection remains between academic research and the business world in this field. The furniture industry seems in particular to be neglected compared to the packaging sector (carton for drinking) which is more visible in scientific publications. The construction sector (and related fields of study) mobilize at least half of total research effort in this field.

c. Current state of technological and industrial research

Also on the basis of the working group analysis, there are a large number of stakeholders in the field of industrial and technological research for the wood sector (Industrial Technological Centers, Technological Resource Centers, etc.), including the private research carried out by large companies. The visibility on the work - even collective ones - remains limited due to the confidentiality most often requested by industrial players.

Table 4: main players involved in the wood industrial and technological research

<i>Organization</i>	<i>Status</i>	<i>Sector of activity</i>	<i>Total workforce</i>	<i>Total workforce in the forest-based sector</i>
FCBA	Technological institute for industry (CTI)	Forest, cellulose, construction sector and furniture industry	340	340
The Pulp and Paper Research & Technical Centre (CTP)	Technological institute for industry (CTI)	Pulp, Paper, Packaging industry	130	130
The Scientific and Technical Centre for Construction (CSTB)	State-owned industrial and commercial establishment (in French, EPIC)	Construction sector	900	5
The technological institute NOBATEK	technological resources center	Construction sector	50	5
The Regional Center of innovation and technology transfer (CRITT) Bois Epinal	association	Construction sector	15	15

The Regional Center of innovation and technology transfer (CRITT) Bois Rodez	association	Construction sector	5	5
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The number of patents registered in the forestry-timber sector can be considered as low. About 90 patents were registered in 2014, 60% of which are related to the construction sector. There are very few breakthrough innovations: the new products or processes rely indeed mainly on incremental innovations. An important part of the technological and industrial research is now oriented towards wood in construction and new uses of wood components (green chemistry). New developments and innovations are structured around the competitiveness industry clusters (mainly the XYLOFUTUR cluster, the only one dedicated to the forest-wood sector and Fibres-ENERGIEVIE).

4. How the interaction is arranged in the country

a. Interactions inside the main forest management bodies

In France, the RDI departments of the two main forest management organizations (ONF and CNPF) play of course an important role in the development of interactions between science and practitioners (forest managers) :

- In public forests (25 % of the French forested areas), the RDI department of the National Forests Office (ONF R&D) comprises about 30 people. Very keen to adapt forests to climate changes, they work on many projects based on observation, monitoring, research and experimentation activities. These studies are carried out in partnership with many organizations especially those involved in research and development related activities (INRA, FCBA, IGN, ...). Through the publication of a quarterly magazine (*Rendez-vous Technique*), the ONF disseminates research results to the forest manager community (to share knowledge, experiences and know-how but also new efficient methods and tools).
- Dedicated to the private forests (75 % of the French forested areas), the RDI department of the National Center for Forest Owners (CNPF IDF) comprises about 50 people. They develop in particular silvicultural models that are adapted to the technical, economic and human realities of the private forest owners. The IDF organizes and leads some working groups on specialized topics (irregular treatments, regular treatments of the main social broadleaved trees, etc.). It also acts as the umbrella organization for the Centers for forest technical studies (CETEF), which include 65 silvicultural associations developing technical and economic experiments, inviting foresters to share their silvicultural concerns, ...The IDF experts identify needs and draw up specifications for solutions, then analyse the forest research literature, study the documentation, develop some adaptations and innovations, set up experiments in close collaboration with their partners, ...To disseminate results more broadly, they publish their own magazine (*Forêt entreprise*) as well as some technical or general guides and software applications. Finally, they also conduct training courses and sessions adapted to specific needs.

Among the publications playing a significant role regarding these interactions between different categories of actors, let's mention also the *Revue Forestière Française* (RFF), an AgroParisTech publication mainly dedicated to temperate forest (and its related subjects such as natural environments, wood, fauna and flora). This publication disseminates scientific and technical information aiming at building effective links between research

and practice, administration and management, progress and dissemination of knowledge. Also at the interface of research and development, let's mention *Bois et forêts des Tropiques*, a CIRAD quarterly publication entirely dedicated to the forestry sciences and techniques in tropical regions and *L'IF*, the IGN quarterly newsletter which is fully dedicated to the sustainable management of French metropolitan forests.

b. Interface bodies and other initiatives

Beside these management organizations, specific bodies like **GIP ECOFOR** (a public interest group dedicated to forest ecosystems) provides in France overall R&D coordination at national level between the organisations involved in forest research and development and also a science-policy interface. Here are few examples of transversal initiatives led by the GIP ECOFOR and other organisms to strengthen the links between researchers and practitioners:

- **SEHS Network (led by GIP ECOFOR, since 2011)**: the Economic, Human and Social Sciences Network aims to create and maintain links between researchers and research teams that work on a timely or permanent basis on forest, wood industry and other forest uses. Its objectives are to develop collaborations, mainly between researchers, to stimulate research, in particular by encouraging the practice of multi-disciplinarity within the SHS disciplines (also with the life sciences) and to bring scientific developments closer to social expectations. To feed these objectives, scientific events are organized on transversal topics (Forest Values, Forest and Territories...) and a weekly newsletter is published;
- **GIS COOP (led by INRA, since 1994)**: INRA and six other forest management, development or research organizations (ONF, AgroParisTech, FCBA, IRSTEA, ...) have decided to pool their resources and expertise under the Ministry of Forestry. They have created a Scientific Interest Group (GIS) "data cooperative on forest stand growth". One of the main objectives of the GIS Coop is to **collect data** among 800 plots and **make them accessible to research and technical operators** through a common database; there are also specific GIS dedicated to the development of some forest tree species such as Maritime Pine (GIS Pin Maritime) or Poplar (GIS Peuplier).
- **GDR BOIS (created in 2012, by CNRS)**: this research group dedicated to the wood sciences aims to increase the national visibility of research, to develop training and serve as a link to international networks involved in wood sciences. Financially supported by several institutions (CNRS, the Ministry of Culture and Communication, INRA, Labex and sponsors), it gathers about 600 people (including 450 permanent staff) coming from CNRS and other bodies such as INRA, CIRAD, Ministry of culture, universities, engineering schools, FCBA, etc.
- **RMT AFORCE (led by CNPF-IDF, since 2008)**: foresters and researchers have also joined their efforts to create AFORCE, a Mixed Technological Network (RMT) devoted to the adaptation of forests to climate change. AFORCE is a network bringing together the actors of research, development, management, education and training. Its objective is to **coordinate actions to adapt forests to climate change and provide managers with decision-making tools**;
- **Interface jobs (implemented by INRA)**: to promote the **transfer of research results**, INRA created an innovative tool based on the time limited (2-4 years) recruitment of engineers or academics coming from development bodies (such as CNPF, ONF, IGN,...) to work on specific research projects and

return after that to their home organism. Even if this type of initiative seems to be a powerful way to improve connections with practitioners, a limited number of people benefit from it.

- **Collective expertise, foresight and panel studies:** many exchanges between scientists and policy makers are organised in France through collective scientific and technical expertise and panel studies. A formalized methodology makes it possible to formulate the questions that arise for decision makers in a well-defined field, and then to look for the elements of response existing in scientific publications or grey literature. The synthesis of these elements expresses not only the main lessons available, but also the gaps in knowledge that will have to be addressed in the future.

More operational, industrial and technological research and innovation are rather coordinated by technical centres such as FCBA or forest industry clusters. French research organisations are also very active nationally and internationally in coordinating or supporting forest-related networks interacting with practitioners (i.e. EFI Atlantic for planted forests), research infrastructures and collaborative projects.

c. Incentive instruments developed by the French State to increase the interactions between science and practice : a brief overview

Currently in France, the Forest-based sector is "eligible" to many multi-sectoral funding schemes. However, almost no funding flow is specifically dedicated to the Forest-based sector, even less for RDI, and most of the time, no sectorial accounting exists either, which makes it difficult to carry out follow-up exercises. Nevertheless, a Forest and Wood Strategic Fund has been created by law in 2014 to support investment and innovation in this specific sector. The total annual budget of this fund is 28 million Euros in 2017 of which 15 million Euros are dedicated to research and innovation

Among the transversal public incentives developed in France to increase the interactions between science and practice, the third wave of the French national programme called "Investments for the Future" (PIA 3) was launched beginning of 2017. Initiated in 2010, it aims to support research and innovative projects, essentially through grants and loans. All sectors are eligible, among which the Forest-based sector. The grants are distributed through four different public operators which are managing the associated calls of project proposals : the French National Research Agency (ANR), the French Environment and Energy Management Agency (ADEME), the public investment bank Bpifrance and the Caisse des Dépôts and Consignations (CDC).

In this context, large-scale projects has already been selected and initiated in the Forest-based sector such as ADIVBOIS (around 6 million Euros of grant, 2015-2018), a short-term operation aiming to the construction of high-rise buildings or XYLOFOREST ("Forest-Wood-Fiber-Biomass of the Future"), an Innovation Platform aiming to provide the research laboratories with high-level equipment (around 10 million Euros of grant, 2011-2019).

Furthermore, under the third edition of the PIA, actions are developed at the landscape scale in close cooperation with the French regions. More broadly, regional authorities (mainly regions but also departments and municipalities) also support research and innovative projects, either alone or in complementarity with other bodies such as the Bpifrance (48 territorial delegations). Since 2009, this bank is also managing the Single Inter-Ministry Fund (FUI), which is essentially dedicated to "collaborative" R & D projects (involving, for example, large companies, SMEs and laboratories) supported by competitiveness clusters.

Innovation in the forest-based sector is also supported at national scale through other mechanisms such as the research tax credit (CIR) granted to enterprises that carry out RDI activities : the total amount of the CIR was estimated around 54 million Euros in 2015 (see the Research and Innovation plan 2025).

Table 5: summarizing public funding of Research, Development and Innovation in the forest-wood sector in 2015, as defined in the Research and Innovation plan 2025 (D'Amecourt *et al.*, 2016)

<i>Type of funding</i>	<i>M€ - Order of magnitude in 2015</i>
Europe (H2020, Structural Funds and Cohesion Fund FEDER, FAEDER...)	5
State - sectoral (Ministries...)	10,3 (28 in 2017)
State - public establishments (INRA, IRSTEA...)	110
State - non sectoral (ADEME, ANR, BPI, PIA, FUI....) : direct payments	22
State - research tax credit	54
Regions	4
Total	206

About the main public bodies involved in the closer connection of science and practice, the **French National Research Agency (ANR)** is a funding agency of public research created in 2005. The main activity of this agency is to fund scientific or technological research projects through competitive calls for proposals (AAP). In 2013, it was estimated that ANR accounted for about 8 to 10 % of the total public research budget, about 50 % when considering the total funding allocated through incentive calls for proposals.

Promoting technical innovation and transfer of technology, as well as public-private partnerships, is part of its mission. To support projects carried out in partnership with the socio-economic world and having a direct economic impact, the ANR has developed an instrument called "Collaborative Research Projects - Enterprises" (PRCE). In addition to this instrument, the agency also proposes specific instruments, which are the subject to dedicated calls for projects:

- The **LabCom instrument** allows the creation of joint laboratories between research organizations and small or mid-sized companies (continuously open call);
- The **Industrial Chairs instrument** stimulates the creation of academic chairs co-funded with companies (dedicated calls);
- ANR manages also the **Institut Carnot** label on behalf of the Ministry of Research, which aims to develop contractual research between public research structures and the socio-economic world. In order to guarantee the real leverage effect of this programme, an associate programme called "Valorization-Institut Carnot" is also supported and managed by ANR on behalf of the State, within the "investments for the future".

Moreover, ANR cooperates with the French competitiveness clusters in order to enhance the adequacy between the research outputs and the socio-economic needs. therefore, it would be useful, in a near future, to acquire a global vision of all forest-based projects funded by ANR through these different tools but and also through other agencies such as

the **French Environment and Energy Management Agency** (ADEME) which also contributes to the development of interactions between science and practice, especially through the management of a fund dedicated to renewable heat and the launch of targeted calls for proposals.

d. Other interactions through informal processes

Finally, interactions between Forest-Wood scientists, forest managers and decision makers occur also through multiple other ways, like for instance:

- through the **consultations** related to policy processes, like the PNFB 2016-2026 and the Research and Innovation plan 2025;
- through **scientific or steering committees and scientific events** held within forest national research programs like those coordinated by the GIP ECOFOR on biodiversity (BGF for "Biodiversity, Forest management and Public policies") or climatic change (GICC for "Management and Impacts of Climate Change");
- through **working groups** supporting multiple national or regional initiatives, for instance within the development of observatories, which aim to promote and disseminate data available on transversal environmental issues³, or the management of natural parks:

Despite all these initiatives, interactions between the researchers and practitioners are perceived as relatively weak, as shown by the SWOT analysis⁴ conducted by the working group on "Research, Development, Innovation" (Carnus, 2015). In recent years, researchers benefiting of state subsidies are more and more often encouraged to associate Forest managers to their activities, from the beginning (co-construction of the objectives) and all along the project life. The decision-maker invites them also to formulate recommendations, but this remains a delicate exercise that most researchers have difficulties to achieve.

5. How the impacts of scientific results are being assessed

In France, the methods currently available to assess the impacts of public research are not fully satisfying. Most of them are designed to evaluate specific projects or programmes. They seldom look into the impact of an institution. Generally, they assess economic impacts and fail to take into account other impacts.

Measuring the global socio-economic impacts of scientific results (i.e., beyond the impacts of scientific results on research) is a relatively new field of interests in France. However, it is gradually integrated into the strategy of research bodies like INRA and CIRAD. These organisations see it as an opportunity to increase or consolidate their competitiveness, as well as to meet national and European public policies.

These actions are especially supported by the French national research alliance for the environment (ALLENVI), which aims to program and coordinate the French environmental

³ for example, the national observatory on the effects of global warming (ONERC) formulates recommendations concerning adaptive measures to limit the impacts of climate change using indicators and the expertise of the IPCC in France ; The French National Biodiversity Observatory published every year a set of indicators related to forest ecosystems,...

⁴ Strengths, Weaknesses Opportunities, Threats Analysis

science strategy, or by the French Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPESCT).

a. Assessing the socio-economic impacts of the agronomic public research at INRA: the ASPIRA project (2011-2014)

In 2014, INRA published a first report analysing the **political, health, territorial-social, environmental and economic impacts of agronomic public research**. This three-year study relied on the analysis of 30 standardized cases, including five fully and one partly focused on forest research:

Table 4: project cases related to forest ecosystems within the study of INRA on socio-economic impacts of public agronomic research

TITLE	DESCRIPTION
CAPIS	Modeling platform of forest growth and dynamics
PIN MARITIME	Genetic improvement of maritime pine
FIRE PARADOX	An integrated European Project on forest fire management
AMENDEMENT FRT	Limestone modification against forest dieback
PROCESSIONAIRE	Protecting trees and humans against the pine processionary caterpillar
INFOSOL	French soil information system

Three complementary analytical tools were used to analyze the impacts of these cases:

- **A chronology**, to understand the processes generating impacts over time and to identify mobilized resources (most often, they accumulated over a long time period);
- **An impact pathway** describing the research work, the circulation of knowledge outside the academic sphere, its transformation and use by socio-economic actors;
- and finally, **an Impact vector** involving a descriptive table showing the different aspects of the impacts (based on documentation and interviews), and a radar diagram to visualize them based on qualitative or quantitative evaluations, depending on the information available. The magnitude of each aspect of the impact was expressed through an ordinal scale ranging from 1 (very low impacts) to 5 (very strong impacts). Only the strongest (rated above 4) were then analyzed thoroughly and eventually quantified.

As no robust methodology, nor generic metric could be identified in the literature to apprehend the impact of research on public policies (Cozzens and Snoek, 2010), INRA developed its own methodology⁵. Regarding the economic impacts, INRA adopted conversely a classical approach based on the evaluation of the economic surplus.

Among the 30 cases, strong impacts (scores of 4 and 5) were the most frequent in the economic dimension, followed by the environmental and political dimensions. The social-territorial and health impacts were less represented, which, according to INRA, probably reflects reality rather than a sampling bias. It is interesting to underline that these results were not exactly the same when focussing only on forest related projects. Indeed,

⁵ based on the analysis of the mechanisms generating impacts and the relative weight of policies concerned

economic impacts seemed to be weaker, when the environmental dimension was the most developed.

Table 5: detail of the assessment of the economic, environmental, health, political and social-territorial impacts of forest research projects led by INRA

	Economic impacts	Environmental impacts	health impacts	Political impacts	Territorial-Social impacts
CAP SIS	3	4	1	2	1
PIN MARITIME	3	3	1	1	3
FIRE PARADOX	1	1	1	2	1
AMENDEMENT FRT	2	4	2	1	1
PROCESSIONAIRE	1	3	5	1	1
INFOSOL	1	3	1	4	4

Here are three examples illustrating different types of impacts highlighted in the forestry projects:

- **About the environmental impact:** the **Capsis** forest modeling platform, which houses models, tools and knowledge, simulates and compares forest production scenarios. According to INRA, the National Forests Office has **incorporated the results of Capsis into forest management guides**. In addition, since 2009, Capsis has been used by the Quebec authorities to plan harvesting operations in public forests, thus limiting overexploitation;
- **About the health impact:** through the accumulation of knowledge on the life cycle of the **pine processionary caterpillar**, an allergenic and invasive species, this project led to the development of solutions based on biological control rather than pesticides. INRA specifies that **these new technologies were patented and licensed by two start-ups and implemented on more than 50 000 hectares of forest since 1992**. They contributed to the national effort to reduce pesticides. Between 2009 and 2012, the share of chemical treatments used to fight this pest decreased by 8%;
- **About the political and territorial impacts:** created in 2001 by a Scientific interest group dedicated to the soils (GIS Sol), the **INFOSOL** unit has developed at national scale a large soil information system comprising data related to their physical, chemical and biological properties. This system ensures the centralization and permanent capitalization of all soil data in France, and offers a centralized access to data (30,000 samples). **A great diversity of territorial public policies benefit from this data, especially those involved in local planning, groundwater management or agricultural zoning (Disadvantaged Agricultural Areas)**. Furthermore, 21% of requests came from research offices to support their activity;

More generally, INRA has drawn several conclusions, including the following ones :

- First of all, the case studies **reflect the multidimensional nature of the generated impacts**. Indeed, 79 % of the cases affect more than one dimension, each case affecting on average 2.2 dimensions. The outputs are also multiple: they can be academic (publications, conferences ...), technical (embedded in software, marketable products ...or intangible like processes, know-how, training, expertise,...), organizational (database, collections),...
- Second, the production of impacts is the result of **long-term investments in research and partnerships other than scientific ones** for the production of

knowledge. If the research identified in the different case studies is long (14 years on average), they rely on even older skills and infrastructures;

- Then, in a large majority of cases, INRA has contributed to the production of fundamental or academic knowledge, the researchers of the institute being most often among the international scientific leaders in their field. **But the cases generating high-intensity impacts (scores of 4 and 5) also require more finalized research, producing knowledge easier to access for the socio-economic actors⁶ ;**
- Finally, the analysis shows that the partners most likely to participate in the research phase are not necessarily the best in the other phases of the impact pathway. **As a result, granting exclusive rights in the upstream phases can limit the downstream diffusion potential.**

b. a replication of this methodology among other research organizations

Cirad, a French agricultural research and international cooperation organization working for the sustainable development of tropical and Mediterranean regions, has recently built an impact evaluation methodology toolbox named ImpresS, using a range of participatory tools. During 2015, ImpresS has been applied to 13 case studies, representing the diversity of its activities around the world. In the long run, ImpresS is intended to boost the “impact culture” of all Cirad researchers and teams, just like the approach developed by INRA.

6. Challenges and development needs

a. An increase in Science-Practice interactions in the forest-based sector through existing or innovative funding instruments

There are many tools to finance RDI within the forest-wood sector, but few are fully specific to this sector. Generally modest, these funds could be better rationalized and, for some, increased. As pointed out in the French forest-based Research and Innovation plan 2025, the overall public efforts in favour of Research, Development and Innovation represent quite a small share of the total value created by the forest-based sector: less than 1% of the total added value. The recommendations presented in the Plan highlight some challenges and development needs. Most of them rely on the improvement of interactions between science and practice:

- **to entrust the competitiveness centres** (“Xylofutur”, “Fibres Energie Vie”, *etc.*) **with the task of assisting companies in obtaining European funding;**
- **to entrust a public actor** (e.g. GIP-ECOFOR) **or a main technological institute** (e.g. FCBA) **with an integrated view to carry out an in-depth study of RDI capacities and funding in the forest-based sector;**
- to **increase State subsidies** distributed through the public investment bank Bpifrance (around €4.4 million in 2015) **to support innovation in the forest-based sector;**

⁶ High impact were generally observed when INRA was involved in the downstream part of the project, i.e. in the demonstration and validation stages.

- **to endow the forest-based sector with a funding instrument to target development and innovation actions in upstream forestry;**
- **to increase research activities on timber construction components and materials** in Public Scientific and Technical Research Establishments (EPST) such as CNRS, INRA, IRSTEA and IRD, in higher education institutions and industrial technical centres;
- **to simplify and accelerate the certification process for products with a low carbon footprint** (including wood products) **to facilitate and foster innovation;**
- **to federate, structure and increase research in wood chemistry;**
- **to support and accelerate the development of methodologies to evaluate ecosystem services and study the implementation of regulatory and fiscal provisions that will ensure long-term payment for these services;**
- to develop a research action on innovative mechanisms likely to **attract new funding in the forest-based sector**, especially in upstream forestry (e.g. in the form of a University Chair);
- to **study the potential and feasibility of innovative funding instruments that could give new impetus to the wood market**, while contributing to price transparency and securing supplies for industry;

b. New ideas to stimulate Science-Practice interactions

One major barrier to fruitful exchanges between science and policy or practices is due to the large scope of decision making in comparison with the narrower scientific systems, even when the latter are connected in interdisciplinary approaches. Scientific developments are often oriented towards greater precision of models and specialization and more rarely or hardly toward integration and broadening the scope of approaches.

- A first idea would be to break down a practical question into elementary disciplinary components that scientists could deal with in order to provide partial answers before integrating them into a global response. However, this approach is interesting in theory but does not allow satisfactory treatment of possible interactions between components.
- Another idea is based on modeling as a common method of research. One can envisage to rely on two parallel approaches that feed one another progressively and tend to converge. On the one hand, it is a question of developing a simple model for the decision-makers' policy framework, based on a rudimentary but comprehensive description of the components of the system to be managed, developed in part with expert opinions. On the other hand, scientists rely on sophisticated models that they typically try to interconnect to better cover decision makers' scope. Under these conditions, the simple model can benefit from the existence of sophisticated models to be improved. Conversely, it constitutes a draft of the result to be obtained. It shows the gaps left by the sophisticated models in the field to be covered. It also highlights where research and improvement efforts should be concentrated.

- Among all other options, foresight approaches (particularly at territorial level) and open innovation processes (living labs, public-private partnerships,...) could also be considered as possible ways to foster interactions between research and practice.

c. An increase in Science-Practice interactions through the development of a dedicated think-tank at European level

A new COST action would be useful to enlarge and follow up on science-policy-practice interactions in forestry. At this stage, several arguments could justify the implementation of this type of action :

- the challenge to adapt forest and forestry to a changing world where it gains an increasing weight (climate change, biodiversity, need for renewable resources, natural assets, recreational areas, healthy activities,...);
- the necessity to consider the right system (forests only, forests and wood uses, forests and tourism,...) for a fair and wise decision (in terms of research, this means more interdisciplinary research);
- the need for multicriteria (biophysical and socio-economic) evaluations (this means more transdisciplinary research);
- the difficulty to consider long term to analyse the situation;
- the opportunity to better mobilize research and to imagine new types of research strengthening science-policy-practice interface;
- the consequences to be drawn from the way science should be financed and evaluated;
- the consequences to be drawn from how decisions should be made and evaluated;
- the development of open innovation process should be taken into consideration.

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List of main acronyms

ADEME - French Environment and Energy Management Agency
AgroParisTech - Paris Institute of technology for life, food and environmental sciences
ANR - French National Research Agency
ALLENVI - French National Research Alliance for the Environment
ASPIRA - Evaluating impact of public agricultural research
BGF - National research programme on biodiversity, forest management and public policies
CETEF - Centers for forest technical studies
CNI - National Industry Council
CNPF IDF - RDI department of the National Center for Forest Owners
CNRS - French National Center for Scientific Research
CSFB - Strategic committee for the forest-based sector
EPST - Public Scientific and Technical Research Establishments
FCBA - Private research and innovation institute for the French forest-based sector.
FSFB - Forest and Wood Strategic Fund
GDR SCIENCES DU BOIS - Research Group dedicated to wood sciences
GICC - National research programme on management and impacts of climate change
GIP ECOFOR - Public interest group dedicated to forest ecosystems
GIS COOP - Scientific Interest Group "data cooperative on forest stands growth"
IGN - French National Institute of Geographic and Forestry Information
INRA - French National Institute for Agricultural Research
IRD - French National Research Institute for Sustainable Development
IRSTEA - National Research Institute of Science and Technology for Environment and Agriculture
LAAAF - French law for the future of Agriculture, Food and Forestry
MNHN - French National Museum of Natural History
PNFB - French National Forest and Wood Programme
PRFB - Regional Forestry and Wood Programme
RDI - Research Development Innovation
RMT AFORCE - Mixed Technological Network devoted to the adaptation of forests to climate change
ONF - National Forests Office
OPESCT - French Parliamentary Office for the Evaluation of Scientific and Technological Choices
SEHS Network - Economic, Human and Social Sciences Network, created and managed by GIP ECOFOR

APPENDIX 1			
PNFB objectives and associated actions, according three main science-practice interaction types			
Objective A Increase harvesting and ensuring woodland renewal	Objective B Meet public expectations	Objective C Adapt to climate change	Objective D Develop synergies between forestry and industry And match actual market needs (jobs, added value, balance of trade)
Science-Practice interaction type 1 : developing observation and intelligent monitoring			
		To increase the resilience of forests and to tackle the risks (fire, storms, health,...) : <ul style="list-style-type: none"> • establishment of R&D plots for comparative plantations, workshop sites,... • development of technical tools to improve observations (remote sensing, molecular biology, ...) 	
<ul style="list-style-type: none"> • Knowing, preserving and promoting forest biodiversity : Initiate the implementation of an ongoing monitoring of the evolution of forest biodiversity 			
Science-Practice interaction type 2 : developing and making available knowledge and tools to inform on management choices and public policies			
		<ul style="list-style-type: none"> • assess and model the response of forest systems to future conditions • Develop silvicultural models incorporating a variety of climatic scenarios • Create a R&D centre for the preservation and development of forest genetic resources 	<ul style="list-style-type: none"> • Continue the research effort on the profitable use of hardwood species (technical performance, competitiveness with tropical species, development of new products to meet the expectations of the public, modernization of production tools and processes, etc.) ; • Develop research on the study and evaluation of wood material performance in comparison with other materials
<ul style="list-style-type: none"> • Development of an R&I Plan 2025 • Development of a programme on innovation and modernization of forest-wood industries through the national “investments for the Future” 			
<ul style="list-style-type: none"> • Setting up innovative technical itineraries and improve existing ones by in-situ experiments • Promoting results in forest management framework documents 			
<ul style="list-style-type: none"> • Coordination and renewal of existing training in the fields of forest management and logging, wood mobilization and wood technology, in connection with research 			
<ul style="list-style-type: none"> • In the field of biodiversity: improving the transfer of research results and naturalist inventories to foresters and managers. • Develop ecosystem services related evaluations,... 			
Science-Practice interaction type 3 : other actions promoting interactions between researchers and professionals of forest-wood sector			
		<ul style="list-style-type: none"> • At the European level : Implementation of R&D partnerships with the Mediterranean countries on the conservation, selection and transfer of genetic resources ; • Structuring the sharing of information between researchers, owners and managers 	<ul style="list-style-type: none"> • At the European level : RDI initiative on Hardwood species
<ul style="list-style-type: none"> • Mapping the abilities of the various actors in research, development and innovation (RDI) to identify overlaps and gaps • Promote synergies between these actors by encouraging them to work together on common themes where each one would bring its expertise 			