

EVALUATION REPORT ON THE UNIT

AMAP - botAny and Modeling of Plant and
vegetation Architecture

UNDER THE SUPERVISION OF INSTITUTIONS AND RESEARCH BODIES:

Université de Montpellier - UM

Institut national de recherche pour l'agriculture,
l'alimentation et l'environnement - INRAE

Institut de recherche pour le développement -
IRD

Centre de coopération internationale en
recherche agronomique pour le
développement - CIRAD

Centre national de la recherche scientifique -
CNRS

EVALUATION CAMPAIGN 2025-2026

GROUP A



On behalf of the committee of experts:

Michele Morgante, Chairperson of the committee

For Hcéres:

Coralie Chevallier, Presidente

In accordance with articles R. 114-15 and R. 114-10 8° of the Research Code, evaluation reports drawn up by the committees of experts are signed by the chairpersons of these committees and countersigned by the president of Hcéres.

To facilitate the reading of the document, the terms used in this report to designate functions, occupations or responsibilities (expert, researcher, teacher researcher, professor, lecturer, engineer, technician, director, doctoral student, etc.) are generic and gender neutral.

This report is the outcome of an evaluation by a committee of experts the composition of which is specified below. The assessments it contains are an expression of the independent and collegial deliberation of the committee. The data within it are the certified accurate data extracted from the application forms submitted by the supervising bodies on behalf of the unit.

This version of the report is public under Article R. 114-23 of the Research Code. Sections of the report considered confidential, and responses to points of attention from supervisors are not included in it.

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HCÉRES SCIENTIFIC ADVISOR

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Ms Agnès Mignot, Université de Montpellier

UNIT CHARACTERISATION

- Name: botAny and Modeling of Plant and vegetation Architecture
- Acronym: AMAP Lab
- Label and number: UMR CNRS 5120, UMR IRD 123, UMR INRAE 931, UR CIRAD 51
- Number of axis: 3
- Composition of the executive team: Mr Raphaël Pélissier (DR IRD, Lab Director), Ms Alexia Stokes (DR INRAE, Deputy Lab Director), Mr Marc Jaeger (DR CIRAD, Deputy Lab Director) and Ms Héloïse Cambon (IE IRD, Lab Administrator)

SCIENTIFIC PANELS OF THE UNIT

SVE Sciences du vivant et environnement

SVE2 Productions végétales et animales (agronomie), biologie végétale et animale, biotechnologie et ingénierie des biosystèmes

THEMES OF THE UNIT

The unit is organized in a matrix-like structure around eleven research themes, with personnel that can contribute to a maximum of three themes. These themes, following recommendations from the 2015 evaluation committee have been grouped into three axes, each coordinated by one or two senior researchers. The axes are the Biodiversity Axis (Systematics, Biogeography, Ecology; understanding the processes underlying past, present and future plant diversity under the influence of global change), comprising four themes (Systematics and biogeography of extant and fossil plants; Biotic interactions, plant adaptation and ecosystem functioning; Dynamics and assembly of tropical forests; Ecology of disturbances in a changing world), the Biomass Axis (Plant and stand dynamics and production; understanding resource allocation and biomass distribution strategies in plants and vegetation), comprising four themes (Plant architecture and functioning; Functional biology and biomimetics; Applied ecology and ecosystem services; Remote sensing of tropical vegetation) and the Digital Plant Axis (Models, analyses and data from organs to ecosystems; developing methods and tools for the study and modelling of complex plant systems), comprising three themes (Biodiversity informatics and Artificial Intelligence in agroecological sciences; Functional Structural Plant Models; Modelling and analysis for tropical agronomy and ecosystems).

In addition to the three research axes, the unit has other organizational structures that are presented as support services and correspond to two scientific poles and one administrative pole. The two scientific poles are the Scientific Computing Pole (POLIS) that brings together and organises the Lab's material and human resources (permanent and contract staff) around scientific computing by area of expertise (code development, data, GIS, high-performance computing, statistics and systems administration) and the Technical and Experimental Support Pole (POLTEX) that coordinates operational support for the experimental, logistical and observational phases of the research projects by taking charge of technical tasks. The administration pole is the Administration and Communication Pole (POLADCOM) that covers the Administration and Finance Service (SAF) and the Information and Communication Service (Info-Com).

AMAP is also in charge of the scientific management or co-management of shared platforms such as:

The IRD Herbaria of French Guiana (CAY) and New Caledonia (NOU) that are secondary AMAP locations that house permanent technical staff (8 technicians and engineers in total).

Three digital platforms that are Capsis, which is a platform of forest stand dynamics modelling supported by INRAE and used in research and management, Pl@ntNet, which is a participatory botany platform stemming from an AMAP research project and OpenAlea, supported by Macs4Plants network between AMAP Lab and AGAP Institute, that hosts software and tools to model and simulate the plant architecture.

HISTORIC AND GEOGRAPHICAL LOCATION OF THE UNIT

AMAP Lab historically originates from scientific approaches developed in the Montpellier School of Plant Architecture that were the result of joint work carried out in the 1970s at the *Université des Sciences et Techniques de Languedoc*, Montpellier by Francis Hallé and at ORSTOM (ex-IRD) in French Guiana by Roelof Oldeman. Plant architecture is a method of morpho-anatomical description of plant structure and development that led to the formalisation of 23 archetypes (or architectural models) to account for the spatio-temporal organisation of the vegetative and reproductive organs and the structure-function relationships established during ontogeny. This observational approach quickly gave rise to mathematical modelling work in agronomy with the creation by Philippe de Reffye of the *Atelier de Modélisation de l'Architecture des Plantes* (AMAP) in the 1980s at CIRAD-GERDAT, which INRA joined in 1999. This initial nucleus, which forged the interdisciplinary culture of the AMAP collective, was extended to other disciplinary fields in the early 2000s with the arrival of teams of botanists,

ecologists and palaeobotanists from the CNRS, IRD and the University of Montpellier 2 to form, along with CIRAD and INRA, the AMAP Joint Research Unit (UMR), also called AMAP Lab, which was set up in 2001 and strengthened in 2009 when the IRD herbaria in French Guiana and New Caledonia were added. AMAP Lab now has five supervisory bodies (CIRAD, CNRS, INRAE, IRD, University of Montpellier) and has grown steadily in terms of personnel, from 35 permanent staff when it was set up in 2001 to 90 today. Bringing together a wide range of disciplines and research areas in the same place over time led to the emergence of innovative and structuring interdisciplinary approaches, which still forges a strong collective identity today.

AMAP Lab is housed by CIRAD in two buildings facing each other (PS1 and PS2) at *Parc Scientifique Agropolis, boulevard de la Lironde, Montferrier-sur-Lez*, covering a total area of 1,422 m². The two herbaria for which AMAP is responsible for scientific management are secondary AMAP sites, housing permanent technical teams, located on the IRD campuses of Nouméa in New Caledonia and Cayenne in French Guiana. The current space allocation is rather scarce in consideration of the increasing number of permanent and non-permanent staff. In light of this problem, AMAP has obtained from CIRAD the allocation of five additional offices in PS1. Remote working also means that offices are globally less overloaded. AMAP has also fitted out new technical premises: a microscopy lab separated from the histology lab, a lab devoted to architectural measurements, and rooms for the storage of samples and consumables. In addition, a lab dedicated to olfactometry experiments with the Asian hornet, which requires avoiding air turbulence, is rented on the CIRAD campus.

The plan to move AMAP to the CIRAD campus has been postponed until the end of the second phase of the EcoSite project in 2032, but the move is viewed as crucial because it would bring the whole lab together in a single building.

UNIT RESEARCH ENVIRONMENT

The AMAP unit benefits from being located in a pole of excellence for the disciplines in which it is active with many prestigious institutions that converge in the area and are active in research on agronomy, ecology and digital sciences.

AMAP has been involved in two regional labex, Agro (Agronomy and Sustainable Development) and CeMEB (Mediterranean Centre for Environment and Biodiversity), which have been since 2024 integrated into the University of Montpellier I-Site, and in a network labex focusing on French Guiana biodiversity, CEBA (Centre d'Étude de la Biodiversité Amazonienne), which has been extended until the end of 2025. AMAP is secondarily affiliated to the labex Numev (Digital Solutions, Materials and Models for the Environment and Life Sciences), which is now part of the I-Site. AMAP is affiliated with the Convergence Institute #DigitAg (Digital Agriculture), which will end in 2026. These programs support AMAP projects at the interface with digital sciences.

AMAP is part of the University of Montpellier I-Site that results from the I-Site Program of Excellence, accredited in 2017 for a 5-year probationary period and established in 2022. This project brings together sixteen research institutions on the Montpellier site with the goal of developing a research-intensive thematic university internationally recognised for its impact on societal issues such as food safety, environmental protection and human health. AMAP has undertaken to comply with the joint publication signature charter (citing the University of Montpellier as its main affiliation) and has benefited from c. 300 k€ of financial support from various calls. Since 2022, AMAP has been attached mainly to the AEB (Agriculture, Environment, Biodiversity) research division and secondarily to the MIPS (Mathematics, Computer Science, Physics, Systems) research division of the I-Site. Another relevant aspect of the I-Site structuring dynamics concerns the creation of the UAR MEEB (Research Support Unit Montpellier Ecology, Evolution, Biodiversity), which is intended to bring together the shared analytical platforms of the AEB division. At this stage, only two platforms are involved, GenSeq (Genotyping-Sequencing) and PACE (Platform for Chemical Analysis in Ecology), with AMAP mainly using PACE.

AMAP is also involved in regional, national and international research networks.

Regional research networks: Écologie de la santé Montpellier (One health approach in Montpellier conurbation), RESEDA (Stakeholders' network for Mediterranean flora conservation).

National research networks: GDR Sciences du Bois, GDR Ecostat, GDR FORTRAN (Forests in transition), GIP Recolnat (Natural science collections), Theia (Data centre on continental land surface observation).

International research networks: IUFRO (International Union of Forest Research Organizations), ESA-Biomass satellite mission, Geo-Trees (Forest Biomass Reference System), OFVI (One Forest Vision Initiative), LFBBA (Franco-Brazilian Laboratory on the Amazonian Biodiversity); ATDN (Amazonian Tree Diversity Network).

AMAP has a leading role in many IRD and CIRAD partnership programs with the Global South and is involved to varying degrees in several Research Programs (and Facilities) from the France 2030 Strategic State Investment Programs.

UNIT WORKFORCE: IN PHYSICAL PEOPLE AS OF 31/12/2024

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	6
Directeurs de recherche et assimilés	16
Chargés de recherche et assimilés	35
Personnels d'appui à la recherche	38
Sous-total personnels permanents en activité	95
Enseignants-chercheurs et chercheurs non permanents et assimilés	1
Personnels non permanents d'appui à la recherche	20
Post-doctorants	7
Doctorants	39
Sous-total personnels non permanents en activité	67
Total personnels	162

BREAKDOWN OF THE UNIT'S PERMANENT STAFF BY EMPLOYER: IN PHYSICAL PEOPLE AS OF 31/12/2024. NON-SUPERVISING EMPLOYERS ARE GROUPED ON THE HEADING "OTHERS".

Nom de l'employeur	EC	C	PAR
CIRAD	0	16	12
CNRS	0	5	3
INRAE	0	7	5
IRD	0	23	14
U Montpellier	5	0	0
Autres	1	0	4
Total général	6	51	38

GLOBAL ASSESSMENT

The research activities of the AMAP unit are organized along three axes, one dealing with biodiversity and understanding the processes underlying past, present and future plant diversity under the influence of global change, another with analysing plant and stand dynamics and understanding resource allocation and biomass distribution strategies in plants and vegetation, and the third one dealing with developing methods and tools for the study and modelling of complex plant systems). All axes appear to deal with scientifically highly relevant themes, even though a stronger focus on research in agroecology and agroforestry is deemed important for the future of the unit and highly requested by one of the supervising bodies.

In addition to the three research axes, the unit has other organizational structures that are presented as support services and correspond to two scientific poles (the Scientific Computing Pole (POLIS) and the Technical and Experimental Support Pole (POLTEX)) and one administrative pole (the Administration and Communication Pole (POLADCOM)). AMAP is also in charge of the scientific management of shared platforms such as the IRD Herbaria of French Guiana (CAY) and New Caledonia (NOU) that are secondary AMAP locations that house permanent technical staff. The objectives appear to be mostly in line with the priorities of the supervising bodies, and scientifically very relevant and ambitious.

The profile, resources and organisation of the unit are rated as being very good. The resources are excellent in terms of the financial resources and available equipments. However, there is a growing concern about decreasing technical staff resources and this represents a clear threat for the short-term development of the unit. The resources in terms of building infrastructures appear to be no longer adequate to support the future development of the unit and the relocation of the unit to a larger building should be a clear priority of management and supervising bodies. The management of the unit appears to have some weaknesses but the changes implemented in the future trajectory of the unit seem to go into the right direction of implementing harmonized management procedures and improving communication within the unit.

The attractiveness of the unit is excellent, as attested by the participation to or organization of national and international conferences, editorial activities, participation to the management and evaluation of research and the participation, as well as coordination, of scientific programs, which has been a clear strength of AMAP in the evaluation period. Great attractiveness as well as recognition and visibility have also been gained over time both nationally and internationally thanks to its unique competences that integrate plant biology and ecology with mathematical and computational sciences. This specificity of the unit should be maintained and reinforced by making mathematical and computational approaches ubiquitous in all research themes developed within the unit.

The unit productivity in terms of scientific results and publications is viewed as excellent and this also provides the unit with excellent attractivity both nationally and internationally. The scientific production is excellent both quantitatively and qualitatively and this has resulted also in the ability of the unit of attracting considerable funding at the national and international levels.

The level of involvement of AMAP research in society is viewed as very good. The unit has developed good non-academic interactions with industry and these activities could be improved to result for example in a larger number of PhD students being funded by industry. A greater focus on agroecology and agroforestry could also help to foster interactions with industry. The involvement with the general public and the civil society is considered to be excellent, thanks also to the huge impact of specific applications developed within the unit that combine the expertise in plant biology, namely botany, with that in informatics. The best example of this is the Pl@ntNet platform that reaches more than 20 million users, most of which are not scientists. Other examples of this type of interactions through software development aimed at the general public could be pursued to further improve the involvement of civil society.

The overall assessment of the activity of the unit over the evaluation period is excellent but there is room for improvement in a few critical areas to maintain and increase the attractivity of the unit.

DETAILS OF THE EVALUATION OF THE UNIT

A - CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

Regarding the scientific publications, AMAP meets the previous committee recommendations. AMAP maintains a strong publication dynamic, both in terms of quality and quantity. An impressive number of publications with AMAP's members are highlighted by the scientific community. Many review papers, as recommended in the previous evaluation, covering all AMAP's topics have been published. In spite of many communications in International Conferences and home-seminars, and the co-organization of a European Conference in 2022, AMAP has not hosted any international Conference during the evaluation period.

Following the guidelines of the previous committee report, the unit's management achieved the organization of the support resources into three poles. This new organization contributes to a better visibility and understanding of the objectives for the teams as well as for the researchers.

The loss of permanent technical support seems, however, to be unavoidable due to the mobility or resignations. Pooling competences with other labs to maintain shared platforms is being considered. However, reinforcing the capacity to develop or maintain softwares and applications is still on the agenda.

The scientific strategy of AMAP shifted to ecology and, to a lesser extent, to agroecology. AMAP favors collaboration with other laboratories rather than reinvesting in agronomy research. Following the guidelines of CIRAD and IRD, AMAP strengthened its collaboration with institutions from the Global South.

The Unit scientific policy reinforced the mathematical modelling and informatics collaborations. Priority is given to training through research, as evidenced by the number of PhD students (106, 61 of whom defended their PhD between 2019 and 2024) and PostDoc fellows (34). The Unit continues to be attractive since four teacher-researchers have joined the UMR during the present evaluation period.

During the evaluation period there were some difficulties with administrative support, due to departures and health-related leaves. The new recruitments have helped to address this shortage, but the situation remains critical. As the move to the new building is scheduled for 2032, the issue of cramped premises remains unsolved. The Unit has resorted to a new organization of the buildings as well as renting additional spaces. Some offices have been provided by CIRAD. AMAP remains attractive, as evidenced by an increasing trend in both permanent and non-permanent staff.

B - EVALUATION AREAS

When considering the references set in the research units' evaluation guidelines, the committee will see to it that outstanding elements that relate to the strengths and weaknesses of the unit are pinpointed. Each and every assessment must be backed up with observable facts, namely from elements submitted in the portfolio. The committee assesses whether the unit's performance is consistent with its profile of activities. Information in boxes is summarily drafted based upon evaluative elements described in the subsections on the strengths and weaknesses.

EVALUATION AREA 1: THE UNIT'S SCIENTIFIC OBJECTIVES, ORGANIZATION AND RESOURCES

Assessment of the unit's scientific objectives, organization and resources

The scientific objectives of the Unit can be qualified as excellent and they correspond to its very good organization in three thematic axes: Biodiversity, Biomass and Digital Plants. To maintain the structure and the level of activity of the Unit that includes excellent technical expertise, the members of the Unit have achieved a very good level of resources although it may be a challenge to maintain it for the near future in buildings that are too small and obsolete. Although the Unit has achieved a very good level of internal organization, there are not harmonized procedures of management that are difficult to handle due to the weak administrative support to the unit.

- 1/ The unit has set itself relevant scientific objectives and is organized accordingly.*
- 2/ The unit has resources adapted to its scientific objectives, profile of activities and research environment and mobilizes them.*
- 3/ The unit has premises, equipment and technical skills adapted to its scientific policy and research objects.*
- 4/ The unit's practices comply with the rules and guidelines set by its supervisory bodies in terms of human resources management, safety, environment and data protection as well as scientific assets.*

Context-related strengths and opportunities for the four references above

The strengths of the unit are the clear objectives they have set, the international recognition they have achieved and its relations with Global South research laboratories. AMAP is a relatively large research unit that has succeeded in replacing the retired scientists and technicians, essentially due to new posts created by institutions, mainly IRD and its ability to attract members of the different institutions. The staff has increased by 10% during the last four years and 40% are women. The unit has maintained its presence in French Departments outside metropolitan France, mainly Guiana and New Caledonia. In fact, more than one fourth of the unit resources are devoted to missions abroad. The financial resources nearly doubled during the evaluation period, reaching 3.6 millions euros in 2024, thanks to the performance of the AMAP's scientists in elaborating large competitive projects and obtaining grants at the national and international levels (coordination of the HORIZON GARDEN,

ECO2ADAPT et FIRE- ADAPT projects, of the ERA-NET CoForFunc and 3dForMod, of the MSCA ITN TERRE-CIRAD). An ERC starting grant has been obtained (DOPAMICS).

Context-related weaknesses and risks for the four references above

The main risks for the AMAP unit may come from lack of institutional support in the future in view of some retirements that may happen in key positions. The work they are doing depends very much on success in achieving competitive support from European and French funds. Future investments will be needed, at the scale of the UNIT or via shared facilities, in High Performance Computing and Data Management that are technologies that have a continuous and very rapid development. The unit will need to make important investments in order to maintain excellence in their technical platforms, especially in those related to agriculture digitalization. The unit works in buildings that need urgent renovation. Internal organization among different levels of staff could be revised as only the largest Themes held regular meetings during the period of evaluation, and there were no regular meetings of the Axes. The management procedures are not harmonized and the administrative staff cannot face this complexity. Communication and specific support towards the technical staff are insufficient. The buildings are obsolete and too small to support the increasing number of staff in relation to the excellent attractiveness of the unit.

EVALUATION AREA 2: THE UNIT'S SCIENTIFIC RESULTS, IMPACT AND ATTRACTIVENESS

Assessment of the unit's scientific results, impact and attractiveness

The unit produces excellent quality research, publishing in diverse disciplines, often in internationally renowned journals and with an interdisciplinary approach. Given the quality of these publications, the publication rate is very good, with three publications per researcher per year, about 50% of which as first/last author, 18% co-authored with PhD students, and 83% with international collaborators. The unit excels in calls for proposals and shows an excellent local, national and international attractiveness through recruitments, contributions to committees (Soc. Bot. Occ., ANSES, CSFD, IUFRO, ATBC...) and collaborations with the global South.

- 1/ The unit is recognized for its scientific achievements that meet quality criteria.*
- 2/ The research activities of the unit result in quality scientific production.*
- 3/ The unit participates in the coordination and management of its community.*
- 4/ The unit's scientific production respects the principles of scientific integrity, ethics and open science. It complies with the guidelines applicable in this field.*

Context-related strengths and opportunities for the four references above

The unit has built an excellent scientific recognition. Over 2019-2024, its annual budget ranged between 764 and 848 k€ from parent institutions and there were 2.6 M€ from external resources, especially European programs (H2020, ERC and MSCA) and French public calls (e.g. ANR, CNES, ADEME). This highlights the very good success rate of the unit to such calls. Five projects (including four European projects) whose budget is larger than 1 M€ are coordinated in AMAP. The unit is well embedded in Montpellier University's ecosystem (I-Site), which supports its international visibility. The unit has been remarkably attractive in recruiting, increasing its permanent staff by 10%, with half of the people hired having previous experience in the unit.

The teams encompass theoretical approaches, experiments, modelling, remote sensing, and machine learning. The theme on Disturbance ecology emerged in 2023 after new researchers joined the lab. In the Digital Plants axis, two topics have been enhanced to structure the activities: LiDAR data processing and Artificial Intelligence applied to images. The unit defined new directions of research for the next five years, relying on a large survey of the unit's members. This includes emerging topics in the unit like ecosystem functioning, plant-based solutions, and a deeper integration of artificial intelligence approaches.

The disciplinary fields in which AMAP is particularly involved are reflected in the unit's publications: Ecology (23% of the publications), Plant Sciences (21%) and Environmental Sciences (12%). Most are peer-reviewed in international non-predatory journals, showing the commitment of the unit to ensure irrefutability of its results. Four publications were published in journals of outstanding recognition (*Nature*, *Nature Communications*, *New*

Phytologist, *Biological Reviews*), with AMAP members as first, second and/or last authors and had a significant impact in their respective field, as measured by the number of citations received. These publications revisited paradigms dealing with root traits impact on ecosystems functioning, tree mortality, long-term evolution of tropical biodiversity, and ecological mapping models for forests, thus breaking grounds on both theoretical and methodological aspects.

The members of the unit gathered 19 prizes/awards (French Society for Botany, Royal Academy of Belgium, University of Oxford, University of Pretoria). Two PhD students also got awarded (My PhD thesis in 180s, Sub-Saharan Africa Young Talent Prize of Women in Sciences L'Oreal-Unesco, in 2022 and 2023).

Over 2019-2024, AMAP published 902 articles in peer-reviewed journals, approximately three per (teacher-) researcher per year, half of them signed as first and/or last author. The quality of these publications is very good, with a large number in highly recognized journals (e.g. *Nature*, *Nature Ecology & Evolution*, *New Phytologist*, *Global Change Biology*...).

The number of publications per post-doc is very good, between 2.9 (Digital Plant axis) and 9.3 (Biomass axis), reaching 4.3 for the Biodiversity axis. It is also good for the PhD students, with 2.1 for the Biodiversity axis, 2.2 for Digital Plants, and 3.2 for the Biomass axis. 18% (160) of the unit's publications were co-authored by PhD students, and 40% with collaborators from the Global South. The unit's members have a rich international network of collaborators, with 83% of the publications involving foreign scientists.

The unit has secondary sites abroad, favoring its management of platforms or datasets. AMAP is in charge of the scientific management of two Herbaria located in French Guiana and in New Caledonia, where eight permanent staff are hosted. The unit is also in charge of two digital platforms (Capsis for forest growth modelling and Pl@ntNet for botanical observations), both deeply rooted in participatory science. The unit is involved in the management of a third platform (OpenAlea), as well as in charge of the African network of orchid shade-houses, covering five countries. AMAP also took part in two regional labex (Agro and CeMEB), that were integrated in the University of Montpellier I-Site Program of Excellence in 2024. Members of the unit are involved in the steering committees of these former labex and of the recent I-Site.

The unit shows a very good national and international involvement, through coordinating programs with the Global South (LMI Dycofac, DP R2Fac) and partnership in international research networks (IRN LiStat, IUFR0, ESA-Biomass...). On the national scale, the unit is involved in three PEPR (ForestT, FairCarbon, and SoluBiod) and 3 PPR (Ocean and Climate, Agroecology, and Digital Science). It is also part of three GDR and one GIP, as well as the Theia Data and Services Center. Members of the unit co-organised the European Tropical Ecology Conference in Montpellier in June 2022.

The unit shows a clear international outreach, with 53 external foreign scientists and 22 external French scientists invited to give seminars. 106 PhD students and 34 post-docs were hired, four of these latter being awarded grants like MSCA, PAUSE and MOPGA. Among the 106 PhD students, 80% were (co-)supervised by AMAP HDR researchers, with a median duration of 42.6 months. 52% of the unit's (teachers-) researchers have the HDR. AMAP's members also gave 24 non-academic training sessions, illustrating their commitment to the dissemination of their work.

The unit shows a remarkable commitment to support ethics in science. More than 50% of the 87 datasets produced by the unit (2019-2024) were published via institutional repositories, ensuring their longevity and visibility, while making them findable via the national portal of research datasets. The unit invited speakers to present the Peer Community In initiative (PCI) and the DAFNEE at the 2023 General Assembly to stimulate free-of-charge and open publication by its members. The Lab Council voted to stop funding APC for non-academia friendly journals referenced in the DAFNEE database on the unit's operating budget. AMAP pays a specific attention to the use and distribution of codes generated by its members. The more than 30 softwares and source codes produced by the unit are openly distributed for research purposes and internal rules have been proposed to initiate a charter of values for scientific, human and environmental ethics. The platform dedicated to forest growth modelling (Capsis) provide personalized sessions to any user, ensuring his/her autonomy for potential further model developments, while the platform kernel is distributed under a free software license.

Context-related weaknesses and risks for the four references above

The unit faced difficulties in supporting some research topics. The Biomimetics theme created in 2015 and further developed in 2019 around the GrowBot project did not attract enough PhD and post-doc fellows and was thus shut down in 2023. It will be replaced by a new "Challenge" on nature-based solutions in the future project of the unit. Similarly, the Interactions theme (in Biodiversity Axis) is to be merged with a larger group in the future plan of the unit. These two examples highlight the strong reliance of some Themes on a small number of PIs, jeopardizing their resilience.

Although a flagship of the unit, activities of the current Digital Plants axis might be threatened by a decrease of the number of its members. Yet this axis has been awarded 9 out of the 19 Prizes and Awards of the unit. Similarly, expertise on botany and paleobotany could be decreasing in the unit, because of recent and most importantly of coming retirements and despite the recent hirings.

Out of the 900 publications of the unit over the evaluation period, only 12% associate members of at least two of the three Axes. 9% of the publications associated members of the Biomass and Biodiversity Axes, about 2.5% associated members of the Digital Plant and Biomass axis, and about 1% associated members of the Digital Plant and the Biodiversity Axes. Finally, 1% of the published articles associated members of the three Axes. Relatively to each Axis 'production, Digital Plants published about 23% of its publications with members of at least another axis, and Biodiversity about 19%; this figure reaches about 33% for the Biomass Axis.

There is a noticeable imbalance between Axes concerning the stay of invited senior scientists, as Digital Plants and Biomass hosted respectively only 1 and 0 of them over the period of evaluation. The six foreign scientists who spent more than two months in the unit were mostly welcomed by the Biodiversity axis (five out of six).

A non-negligible number (seven) of PhD students dropped out before completion. Half of them started in 2018 or 2019, and the other half in 2021, thus in a post-Covid context. To our knowledge, there are no dedicated actions (training, charter) to make the policy of authorship clearer to all members of the unit.

EVALUATION AREA 3: INCLUSION OF RESEARCH ACTIVITIES IN SOCIETY

Assessment of the inclusion of the unit's research activities in society

The research activities of the unit are overall very well included in society. Its implication in public and civil society is excellent mainly through its contribution to pl@ntNet which is a very effective showcase. Pl@ntNet has a huge impact and very good dynamics. This Involvement in civil society should be continued.

The committee found the relationship of the unit with industry good. Only five PhD were funded by companies during the evaluation period. The industry related budget is decreasing despite the importance of the unit research for agroforestry & agroecology.

1/ The unit stands out for the quality of its interactions with the cultural, and socioeconomic world.

2/ The unit develops products and services for the cultural, socioeconomic world.

3/ The unit shares its knowledge with the general public and participates in social debates.

Context-related strengths and opportunities for the three references above

The over 20 million users of Pl@ntNet and the valuable information gathered on all kinds of plants, rare, endemic or invasive make it a great tool to work on novel research questions and build new services. The technical knowledge acquired by managing such a large user base and a system with quite large data exchange (images) is a key to host or help hosting new applications from the laboratory or from partners. The team members have also built a software ecosystem with novel features or extensions (R access, API, spacial prediction) and promote local user communities with interest in specific questions (microprojects). The AMAP teams have had five contracts with private companies corresponding to 1.3 M€ (260 K€ on average) used mainly to fund three PhDs and two Post-docs. Two patents for a mobile application and five digital tools used for diagnostics and image analysis have been obtained. AMAP built four partnerships with non-governmental organisations to develop tools enabling forest management and diversity conservation. AMAP has partnerships with conservation and forest management NGOs including Nouméa herbarium, ONF-Guyane, Forest Health Department of the Ministry of Agriculture. Nine AMAP members have acted during the period as expert members in Scientific Councils or Committee in organizations of public interest. AMAP staff has largely contributed to academic training during the period teaching 6,500 hours in total. Laboratory members were invited or their work cited in hundreds of occasions by press media during the period providing their expertise to a large audience about how these tools work and how their services can be used daily.

Context-related weaknesses and risks for the three references above

Pl@ntNet is not the only application providing taxonomical information from a plant picture. It is one of the oldest and performs quite well in competitions but this could change in the future with evolutions in GAFAM strategies or the advent of novel technologies. For example, in the latest iOS version plant recognition is included in the camera app.

The answer provided by the Pl@ntNet team regarding the topic presented here above gave the evaluation committee valuable insights on the actual positioning and programmed trajectory of the application. It convinced the committee that the pl@ntNet near future should be reasonably safe.

ANALYSIS OF THE UNIT'S TRAJECTORY

The unit is moving from an organization that revolves around three axes and eleven research themes to a new organization based on six challenges and 21 specific aims, following what was perceived by the staff as a weakness, namely the difficulty understanding the relationships between axes and themes. While all the proposed challenges and aims appear to be very relevant scientifically, the committee shares some concerns about the fact that there may be an excessively thin spreading of resources in too many research directions. One of the distinctive features of the AMAP unit is the combination of biological approaches with mathematical, modelling and informatic ones. In the proposed new organization these last aspects (mathematics, modelling, informatics) appear to be largely restricted to Challenge 6, while the committee feels strongly that they should be more transversally and pervasively applied to all challenges.

While the unit sees the integration of artificial intelligence in their analysis and modelling toolbox, there is no specification of how the unit intends to deal with the revolution that artificial intelligence-based approaches will introduce into the way research activities are carried out and into the teaching approaches and how they plan on making all the research and technical staff fully equipped and ready to embark into these new approaches.

The changes to the management structure appear to provide improvements to the current structure, with the creation of a new animation cell. There are clear plans to recruit new human resources to adequately support the new scientific organization and overcome the effects of future retirements.

RECOMMENDATIONS TO THE UNIT

RECOMMENDATIONS REGARDING THE EVALUATION AREA 1: SCIENTIFIC OBJECTIVES, ORGANIZATION AND RESOURCES OF THE UNIT

The AMAP unit has reorganised according to three main topics that have an excellent activity. It has succeeded in having an international recognition and keeping activities mainly in Montpellier but also in other non-European sites such as Réunion, Martinique, Guyane and New Caledonia to fulfill the mission of IRD and CIRAD. The members of AMAP are working on topics that are in line with the main subjects such as loss of Biodiversity or the Dynamics of plant populations in tropical environments. They are also very active in producing tools for the general public such as Pl@ntNet. The main recommendation is to continue to work in these directions and trying to be successful in getting support for competitive and non-competitive grants. The unit works in buildings that need urgent renovation and do not provide sufficient space to host all activities. The committee strongly recommends that the unit, in order to maintain its attractiveness, works in close collaboration with the supervising bodies to accelerate as much as possible the move to a new and more spacious building.

RECOMMENDATIONS REGARDING THE EVALUATION AREA 2: THE UNIT'S SCIENTIFIC RESULTS, IMPACT AND ATTRACTIVENESS

The unit could reinforce its university component by increasing its number of university staff, and mix more the staff from various parents' institutions into teams, also to compensate a large number of retirements to come, e.g. among the CIRAD staff. Coming retirements will also jeopardize the administrative staff of the unit and efforts should be renewed to face this issue.

The committee noticed that an Animation Cell will be created in the future project of the unit, and encourages regular meetings of the staff members of each Challenge.

The Digital Plant axis could aim at a better recognition of its contributions, for example by suggesting some of its members to take a larger part to committees, panels and editorial boards.

Six of the seven PhD students who dropped out before completion were in the Biodiversity axis, thus a specific consideration should be given to this point. Also, a specific effort could be dedicated to obtain a larger number of PhD grants from Gaia (only two PhDs funded since 2019), which is the main doctoral school for the unit.

As the unit shows a clear commitment for the quality of life at work of its members, it might consider collecting feedbacks from the non-permanent staff (interns, PhD students, post-doc fellows...) about their experience during their stay in the unit. In addition, besides the proposed three-hour training on sexism and sexual violence, the unit might consider implementing trainings on cognitive bias about gender and science.

RECOMMENDATIONS REGARDING EVALUATION AREA 3: INCLUSION OF RESEARCH ACTIVITIES IN SOCIETY

AMAP research activities are very well included in society. The research unit provides valuable services on plant recognition to general public. Its expertise is also shared with private companies and public stakeholders. We recommend to go on with this strategy.

AXIS-BY-AXIS ANALYSIS

Axis 1: Biodiversity: Systematics, Biogeography, Ecology
Name of the supervisor: Mr Fabien Anthelme

THEMES OF THE AXIS

The main objective of the BIODIVERSITY axis is to study the taxonomic, morphological and functional aspects of plant biodiversity. This is analysed in terms of the past, present and future, as well as anthropogenic and natural ecological gradients. The BIODIVERSITY axis includes four themes: INTERACTIONS - Biotic interactions, plant adaptation and ecosystem functioning, SYSTE - Systematics and biogeography of extant and fossil plants, DyaFOR - Dynamics and community assembly of tropical forests, and DYSTEC - Disturbance Ecology in a changing World. While theme #1 is led by one person from CNRS, the other three are led by two to three people, with leadership shared between researchers from different supervising bodies (CNRS, INRAE and IRD).

CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

The recommendations in the previous report mainly focused on: i) increasing the number of PhD students and postdocs; ii) improving the quality of grant applications; and iii) stimulating the involvement of this axis's members in consultancy work and expert committees. The committee acknowledges that these recommendations have been fully addressed and will continue to be improved upon in the future. While the number of postdocs and students hosted by the BIODIVERSITY Axis for the period 2019–2024 increased compared to the previous one, with two HDRs defended in 2021 and 2023 and a further three in 2025, a potential further increase in PhD supervision in the near future is expected. Regarding grant applications, 52 grants were obtained (44% as coordinator), including EU Horizon Europe, Biodiversa+ and ERC Starting Grants. This highlights a more ambitious international approach to grant applications. Finally, several BIODIVERSITY Axis members act as institutional representatives (CIRAD and IRD) or as members of scientific councils in national and international organisations, demonstrating their commitment to sharing their expertise with the scientific community and organisations of public interests.

AXIS WORKFORCE: IN PHYSICAL PEOPLE AS OF 31/12/2024

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	4.5
Directeurs de recherche et assimilés	4
Chargés de recherche et assimilés	18.5
Personnels d'appui à la recherche	10.5
Sous-total personnels permanents en activité	37.5
Enseignants-chercheurs et chercheurs non permanents et assimilés	0
Personnels non permanents d'appui à la recherche	11.5
Post-doctorants	4
Doctorants	12.5
Sous-total personnels non permanents en activité	28
Total personnels	65.5

EVALUATION OF THE AXIS

Overall assessment of the axis

The BIODIVERSITY Axis is internationally recognised for its strong botanical and taxonomic expertise. The axis has set excellent scientific objectives, relies on excellent resources and has a good organization. Scientific results are excellent, with a strong publication record, significant contributions to databases, numerous ambitious projects, and a strong representation in both national and international organisations. The attractiveness of the axis is excellent at all levels, nationally and internationally. The involvement with industry is rather poor but with general public and civil society is excellent.

Context-related strengths and opportunities

One of the main strengths of the Biodiversity Axis is its highly efficient recruitment strategy. As the Biodiversity Axis grew by ten permanent positions, the recruitment of sixteen permanent staff between 2019 and 2024 largely offset the six departures from the Axis. This recruitment, representing 60% of AMAP recruitment across the three Axis, was based on external competitive recruitment in thirteen out of sixteen cases and has greatly enhanced the technical and research expertise of the Biodiversity Axis. During this period, the Biodiversity Axis also hosted 41 PhD students, eighteen postdoctoral researchers and 32 non-permanent support staff dedicated to science, as well as five foreign senior scientists for stays of more than three months. The number of non-permanent staff at the Biodiversity Axis in December 2024 was over 50% higher than at the start of the evaluation period, again highlighting the efficiency of the recruitment strategy and the strong attractiveness of this Axis.

Thanks to their strong botanical and taxonomic expertise, the members of the BIODIVERSITY Axis have made significant contributions to the description of new species and to regional, national and international lists of taxa and databases. They have also provided strong support to the IUCN criteria for the vulnerability status of biodiversity hotspots and taxa. In addition, the BIODIVERSITY Axis was highly successful in obtaining grants to develop its research. Indeed, 52 grants were obtained during the evaluation period, including prestigious EU Horizon Europe, Biodiversa+ and ERC Starting Grants totalling 3.5 million euros, two-thirds of which were managed as project coordinator.

Over the period, this Axis published many highly ranked papers, fulfilling the recommendation made in the previous evaluation report. These articles range from new species descriptions to new methodologies for studying plant-insect interactions and commenting on meta-analyses dealing with worldwide insect decline, as highlighted in the Portfolio. Many of these articles were published in journals with excellent or exceptional recognition. Finally, it should be noted that, during the evaluation period, a mean of four scientific publications per PhD student and two per postdoc were reported, demonstrating the significant investment of permanent staff in supervising and supporting the research of early career researchers. The involvement of the axis with the PI@ntNet platform and its more than 20 million users makes it an excellent example of interaction with the general public.

Context-related weaknesses and risks

As of December 2024, the BIODIVERSITY Axis comprised 37.5 full-time equivalent (FTE) permanent staff, divided into four themes. This axis will become a biodiversity challenge with four specific aims and 16 permanent staff remaining. It is unclear whether these specific objectives will result in the formation of four small research groups within this challenge. While there will be an animation cell, internal dynamics and animation will be mandatory across these four aims, which seem strongly interrelated.

Compared to the other two axes, there was a total lack of PhD theses or postdoctoral grants in association with non-academic partners during the evaluation period. According to the specific objectives, there are opportunities to establish partnerships with non-academic organisations, and efforts should be made to encourage greater engagement with the socio-economic sector.

Finally, it should be noted that while 19 PhD theses were completed during the evaluation period, six were abandoned, abandons due to various reasons including difficulties related to Covid. The committee hopes that a more in-depth analysis of this issue will be conducted to help prevent such a high failure rate in future.

ANALYSIS OF THE AXIS'S TRAJECTORY

According to the unit's trajectory, the Biodiversity Axis will evolve into a Biodiversity Challenge, remaining a pivotal AMAP research theme. The four specific aims to be developed in this Biodiversity challenge are ambitious and clearly defined. However, as specified in the previous section, these four ambitious specific aims will rely mainly on only sixteen permanent staff. It is difficult to clearly assess from the report whether these specific aims will be based on small homogeneous or heterogeneous research groups, or where the research topic concerning disturbance ecology, which successfully emerged from the Biodiversity Axis, will be developed within the planned challenges.

RECOMMENDATIONS TO THE AXIS

Based on the excellent research dynamics of the past five years, it is clear that strong attention should be paid to the human resources available to respond to the specific aims that will be developed in the Biodiversity Challenge. Thanks to the five HDRs that were recently defended and the attractiveness of the research topics presented, priority can be given to reinforcing the staff with PhD students and post-docs, as well as through strategic recruitment, in order to maintain botanical and taxonomic expertise and high-quality research.

Axis 2: Biomass: Dynamics and production of plants and plant communities
 Name of the supervisor: Mr Pierre Couteron

THEMES OF THE AXIS

The objectives of Biomass Axis are to understand resources allocation and biomass distribution strategies in plant and vegetation dynamics in response to environmental constraints. Three domains of research are investigated by the Biomass Axis: the growth, resource allocation and the shaping of structural and functional elements of plants, the individual plasticity in relation to environmental forcings and overall community dynamics and the role of vegetation in landscape structure and biogeochemical cycles.

The Biomass Axis includes four themes: BIOMIME - Functional biology and biomimetics, EASE - Applied ecology and ecosystem services, TETROFOR - Remote sensing of tropical vegetations, ARCHI - Plant architecture and functioning. The former is very small in size (only one member).

CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

The recommendations in the previous report focused on the current development of a new research theme. The Biomimetics theme, being recently created and of a small size in terms of staff, required particular attention. The past committee emphasized the importance of fostering communication and interaction between the different thematic axes.

The Biomass Axis anticipated that the GrowBot project could create an internal dynamic for advancing work on this topic. However, this expectation was not fulfilled and no new project has emerged to continue work on this topic. For the future, bioinspired research will be integrated into a broader scientific Challenge.

AXIS WORKFORCE: IN PHYSICAL PEOPLE AS OF 31/12/2024

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	1.5
Directeurs de recherche et assimilés	6.5
Chargés de recherche et assimilés	9.5
Personnels d'appui à la recherche	7
Sous-total personnels permanents en activité	24.5
Enseignants-chercheurs et chercheurs non permanents et assimilés	0
Personnels non permanents d'appui à la recherche	10.5
Post-doctorants	4
Doctorants	11
Sous-total personnels non permanents en activité	25.5
Total personnels	50

EVALUATION OF THE AXIS

Overall assessment of the axis

The Biomass Axis has very good scientific objectives and excellent resources. Its organization is very good, though the Biomime theme remains unbalanced in size. Scientific results are excellent, with high-quality publications, major roles in national and international projects, and significant contributions to PhD training. The axis has advanced into emerging fields such as remote sensing, LiDAR, and AI through strategic recruitment. Interaction with industry is very good (€600k in private funding), and the axis maintains very good ties with leading laboratories and civil society. The overall assessment for this axis is from very good to excellent.

Context-related strengths and opportunities

The Biomass Axis shows a very good rate of publication in excellent journals. During the evaluation period, the axis has published 355 papers. The median number of publications per permanent and non-permanent, excluding PhD students, is thirteen with a median absolute deviation of eight. Only one non-permanent researcher has no publication. The number of publications per scientist full-time-equivalent is 15.1 which is exceptional. Among all the published papers, 24 were published in journals with exceptional recognition and for six of them, members of the axis were first or last authors. Two books and 20 book chapters were also published. The axis also published a visible opinion paper in *Trends in Ecology & Evolution* regarding the incorporation of plant architecture into trait-based ecology. During the period, Biomass Axis members supervised or co-supervised 36 PhD students: a very good rate by considering the number of HDR members (ten). During the period, 27 PhD have been defended, one has abandoned and 30 papers were published with PhD students involved.

The international recognition of this axis is further highlighted by the numerous publications produced in collaboration with international partners, which have appeared in journals of exceptional visibility (two Nature Communications, two Nature Plants). The number of post-docs (eleven with two foreign ones) also attests of the very good attractiveness of the Biomass Axis.

The axis has developed several excellent collaborations at the national scale (one ANR project coordinated and two as partners) and at the international scale (two H2020 projects coordinated and three as partners, and when considering all European projects including also structural and development funds, 6 were coordinated and 19 as partners). The total number of projects obtained by axis's members during the period is 72, for a total of 4509K€ (~36k€ per year and per scientist FTE). The axis contribution to the lab budget is approximately 19% of the total funding. Three of the five biggest projects in terms of funding of AMAP were obtained by members of the axis.

The axis also coordinates important projects with developing countries, such as *One Forest Vision Initiative*, in line with its mission. The Biomass Axis is also involved in several local initiatives (two labex, one I-site).

During the evaluation period, the Biomass Axis has explored recent remote sensing and AI techniques to monitor vegetation properties at scale. To support this area of research the axis has investigated LiDAR acquisitions techniques and has enrolled permanent scientists with competences in this area (two CR-IRD).

Context-related weaknesses and risks

The axis is divided into four themes, with one of them being very small, the BIOMIME theme with only one permanent scientist. Despite an important project, an internal dynamic was not created and the theme remains undersized in comparison to other themes and the vulnerability in ensuring the ongoing research themes remains. In the portfolio, the choice of one item per theme did not emphasize the interactions between themes that appear to be not completely adequate.

The description of the themes that are developed in the axis does not fit very well with the name of the axis, Biomass. The axis should have a greater focus on agroforestry and agroecology research activities, as strongly requested also by one of the supervising bodies.

Regarding the attractivity, for the evaluated period, the axis did not host visiting scientists.

Finally, for the development of LiDAR techniques, there is a threat in developing and maintaining the needed processing chain with limiting human resources. This must be put in relation with the mentioned difficulties of the Digital Plant Axis to maintain software for other thematic axes.

The funding from private partners is adequate even though more interactions with private companies would be expected from this axis. No specific outreach actions for the involvement of civil society are presented by the axis.

ANALYSIS OF THE AXIS'S TRAJECTORY

The unit organization is modified for the next period into 6 *Scientific Challenges* in which the Biomass Axis will be distributed. From the report, it is difficult to clearly assess how the axis themes will be spread but Challenge 2, 4 and 5 correspond to the axis. Research in plant architecture has gained visibility in the new organization, being a now a clearly identified *Scientific Challenge*. The Biomime theme is integrated into the *Scientific Challenge on Applied Ecology and Plant Based Solutions*, but the question of human resources available to address these questions remains open. The new organization should foster interaction between the *Scientific Challenges*, with permanent staff affiliated to two of them. One possible risk concerns the excessive number of meetings for those seeking to participate in both *Scientific Challenges*.

RECOMMENDATIONS TO THE AXIS

The new organization is expected to foster stronger interactions across *Scientific Challenges*, supported by the affiliation of permanent staff to more than one *Scientific Challenge*. A potential point of attention will be to avoid overloading staff with excessive meetings or project contributions when engaging in multiple *Scientific Challenges* simultaneously. Furthermore, adequate support in terms of permanent resources must accompany research themes with limited human resources in order to safeguard the continuity of their activities. The committee recommends that agroecology and agroforestry research are given additional emphasis in the future research plans of the axis. This could also help to increase the level of interaction with private companies.

Axis 3: Digital plants: Models, Analyses and Data, from organs to ecosystems

Name of the supervisors: Mr Jean-Baptiste Durand & Mr Hervé Goeau

THEMES OF THE AXIS

The main objective of the Digital Plants axis is to develop and validate generic, quantitative approaches combining expert knowledge, field data, experiments, and mechanistic processes to address complex plant-related issues. When dealing with large, heterogeneous, or fragmented datasets, the axis aims to design methods for representing, identifying, and quantifying key markers from organ to stand level. It is structured into three themes: BIAS (Biodiversity Informatics & AI), FSPM (Functional Structural Plant Models), and MAGNET (Modelling for tropical agronomy and ecosystems).

CONSIDERATION OF THE RECOMMENDATIONS IN THE PREVIOUS REPORT

Two major recommendations were made. The first is to build on and further increase the high level of production and activity in terms of publications, software development and industry contacts. This involves ensuring that publication rates are not overly affected by software development activities. The development of a strategy to balance software development efforts and maintain a high level of scientific output in terms of publications was strongly recommended. This recommendation has been addressed by strengthening and diversifying human resources (recruitment of three research associates, including two HDRs and three Engineers).

The second recommendation is not to spread efforts across numerous small projects, given the limited number of scientists involved. This recommendation has not been followed, since the axis participated in 61 projects, for a mean budget per project of 72 k€.

Strategies have been put in place to strengthen and attract human resources and significant national and European funding. This funding enabled the recruitment of IT developers, doctoral students and post-doctoral researchers.

AXIS WORKFORCE: IN PHYSICAL PEOPLE AS OF 31/12/2024

Catégories de personnel	Effectifs
Professeurs et assimilés	0
Maitres de conférences et assimilés	0
Directeurs de recherche et assimilés	3,5
Chargés de recherche et assimilés	8
Personnels d'appui à la recherche	6,5
Sous-total personnels permanents en activité	18
Enseignants-chercheurs et chercheurs non permanents et assimilés	0
Personnels non permanents d'appui à la recherche	8,5
Post-doctorants	0
Doctorants	8,5
Sous-total personnels non permanents en activité	18
Total personnels	36

EVALUATION OF THE AXIS

Overall assessment of the axis

The Digital Plants Axis is excellently structured around three complementary and well-defined themes covering a broad range of plant modeling approaches. It is recognized for its high scientific quality, excellent organization, and effective management. Despite limited staff, the axis maintains excellent productivity and attractivity, develops innovative tools such as PI@ntNet and CAPSIS-Forest, secures major funding, and reinforces its leading position through strong interdisciplinary collaboration. The interactions with industry are very good and with civil society excellent. The overall assessment for the axis is excellent.

Context-related strengths and opportunities

The Digital Plants axis provides an excellent scientific environment and strong internal dynamics, offering highly favorable conditions for research and innovation. With a stable team of fifteen to eighteen permanent staff, it demonstrates remarkable productivity, averaging around three publications per researcher and two per PhD student per year in exceptional journals such as *Nature* and *Science*, reflecting the outstanding quality of both research and supervision. The training of seventeen PhD students and the involvement of six post-docs confirm its strong capacity to support early-career scientists and maintain academic vitality.

The axis benefits from excellent international collaborations (Yaoundé, French Guiana, Central Africa via the One Forest Vision Initiative), strengthening its visibility and scientific exchanges. Its innovation and transfer performances are equally impressive, with nine industrial partnerships securing 217 k€ and producing impactful applications such as PI@ntNet and CAPSIS-Forest. The coordination of twelve national and several international projects further demonstrates its institutional recognition and leadership in large-scale research initiatives.

Between 2019 and 2024, the axis managed a total budget of 4.4 M€, including 2.9 M€ from coordinated projects. Its scientific attractivity remains excellent, with 902 peer-reviewed publications, including 22 associated with software or source code, confirming its strong scientific and societal impact.

Context-related weaknesses and risks

The decline in human resources risks a loss of essential skills in agronomy, ecophysiology, software development, and plant architecture. The dispersion of themes and projects further limits internal collaboration. Funding is also challenging, as many AI projects target temperate zones rather than tropical contexts central to the unit's identity.

The MAGNET theme remains fragile due to the retirement dynamics in the next evaluation period, the limited number of researchers and of experts in stochastic modelling. Cross-cutting developments such as LiDAR or hybrid deep-learning/parsimonious methods also struggle to emerge. Historical software tools depend on single developers, creating continuity risks with upcoming retirements. Machine-learning approaches are difficult to valorize because they are highly problem-specific and less suited to publication in methodological journals.

Recruitment is still a challenge because attracting young mathematicians and computer scientists is difficult due to competition with the private sector. HDR accreditation remains challenging for young scientists, especially given the applied orientation of the axis. One of the most critical issues is the absence of senior AI experts holding HDR, which limits the supervision capacity and the development of ambitious AI programs. Finally, the lack of methodological research in machine learning and insufficient expertise in stochastic modelling restrict innovation, reduce adaptability of results, and limit the unit's scientific impact.

ANALYSIS OF THE AXIS'S TRAJECTORY

The trajectory of the Digital Plant (DP) Axis demonstrates a coherent evolution into what is now identified as Challenge 6, within a reorganized scientific framework consisting of six challenges. Initially structured around three primary themes (BIAS, FSPM, MAGNET) the DP Axis focused on addressing complex biological questions through the development of generic, quantitative methodologies, as well as tailored approaches for handling large-scale, fragmented, and heterogeneous data. These dual priorities reflected a balance between mechanistic understanding and data-driven insight, laying a strong foundation for tackling diverse plant systems.

With the establishment of Challenge 6, the DP Axis's scope has not only been preserved but also expanded and integrated into a broader, strategic vision. The challenge aims to develop new methods and tools for analysing, modelling, and simulating plant systems at multiple scales, from individual organs to ecosystems, with the goal of better understanding plant responses to environmental and anthropogenic changes. This marks a transition from a theme-based organizational model to a challenge-driven, interdisciplinary framework, emphasizing integration across applied mathematics, computer science, and botanical expertise. This new organisation (Challenge 6), structured around three clearly defined scientific objectives, seems better suited to addressing research questions on complex systems that require the development of models, field observation and a combination of the two.

RECOMMENDATIONS TO THE AXIS

To ensure the sustainability of historical software, it's essential to coordinate maintenance efforts, thoroughly document code, and plan for succession. Enhancing the impact of AI approaches requires interdisciplinary publications, open datasets, and internal methodological assessments. Supporting early-career researchers toward their HDR involves mentorship and co-supervision. Collaborations with countries in the Global South should be co-designed to include digital components from the outset. Given limited staffing, attractiveness should be reinforced through internships, postdoctoral positions, and targeted mobility programs. Interactions with industry should be enhanced, also through joint PhD programmes.

CONDUCT OF THE INTERVIEWS

DATES

Beginning: 06 November 2025 at 08:30

Ending: 07 November 2025 at 18:00

Interview conducted: on-site or remotely

PROGRAMME OF THE INTERVIEWS

November 6, 2025

8h30-9h00: Closed meeting of the committee of experts and Hcéres scientific advisor

Open sessions

9h00 - 9h15 Introduction (Hcéres Scientific Advisor) and presentation of the committee

9h15 - 10h00 The AMAP unit: presentation and past activities (Raphaël Pélissier)

10h00 - 10h45 Discussion with the committee

10h45 - 11h05 Break

11h05- 11h50 Axis 1: Biodiversity: Systematics, Biogeography, Ecology (*Fabien Anthelme*)

11h50 - 12h35 Discussion with the committee

12h35 - 14h00 Lunch break

14h00 - 14h45 Axis 2: Biomass: Dynamics and production of plants and plant communities (*Pierre Couteron*)

14h45 - 15h30 Discussion with the committee

15h30 - 15h50 Break

15h50 - 16h35 Axis 3: Digital plants: Models, Analyses and Data, from organs to ecosystems (*Jean-Baptiste Durand and Hervé Goeau*)

16h35 - 17h20 Discussion with the committee

17h20 - 17h40 Presentation of the AMAP' project (*Raphaël Pélissier*)

17h40 - 18h00 Discussion with the committee

November 7, 2025

Closed sessions

08h30 -09h00 Closed meeting of the committee of experts and Hcéres scientific advisor

09h00 - 09h30 Discussion of the committee with the permanent researchers, assistant professors, professors and research engineers (in the absence of the unit's direction and supervising bodies)

9h30 - 10h00 Discussion of the committee with the permanent technical staff (in the absence of the unit's direction and supervising bodies)

10h00 - 10h30 Discussion of the committee with the non-permanent staff (in the absence of the unit's direction and supervising bodies)

10h30 - 10h45 Break

10h45 - 11h15 Discussion of the committee with the axis leaders (in the absence of the unit's direction and supervising bodies)

11h15 - 11h45 Discussion of the committee with the supervising bodies (in the absence of the unit's direction) (CNRS: François Criscuolo, INRAE: Catherine Bastien and Cécile Robin, University of Montpellier: Jacques Mercier, IRD: Catherine Fernandez, CIRAD: Delphine Luquet)

11h45 - 12h15 Discussion of the committee with the present and future unit's direction (in the absence of the supervising bodies)

12h15 - 13h30 Lunch break

13h30 - 18h00 Closed meeting of the committee of experts and Hcéres scientific advisor

GENERAL OBSERVATIONS OF THE SUPERVISORS



**UNIVERSITÉ DE
MONTPELLIER**

MONTPELLIER
Le 6 janvier 2026

Monsieur Arnaud TOURIN
Directeur du Département d'évaluation de la recherche
HCERES
19 rue Poissonnière I 75002 PARIS

DRED
SERVICE DE LA COORDINATION DES STRUCTURES
ET DES MOYENS DE LA RECHERCHE
GERALDINE YVON
+33 (0)4 67 14 94 97
dred-srech@umontpellier.fr
163 rue Auguste Broussonnet
34 090 Montpellier
WWW.UMONTPELLIER.FR

OBJET : Rapport d'évaluation - DER-PUR270025785 - AMAP - botanique et Modélisation de l'Architecture des Plantes et des végétations

Monsieur le Directeur,

Je tiens à remercier le comité de visite HCERES pour la qualité de son rapport d'évaluation concernant l'unité de recherche AMAP - Botanique et Modélisation de l'Architecture des Plantes et des végétations - dirigée par Monsieur Raphaël PELISSIER.

Le directeur de l'unité, le CNRS, l'IRD et moi-même avons pris connaissance des recommandations formulées par le comité de visite.

Vous trouverez ci-après les observations de portée générale du directeur de l'unité.

Nous vous prions d'agréer, Monsieur le Directeur, nos salutations distinguées.

Agnès MIGNOT

Vice-présidente
Chargée de la recherche

Montpellier, 19th of October 2025

Obj.: Reply to the preliminary version of the HCERS evaluation report referred to as DER-PUR270025785-AMAP - botAnique et Modélisation de l'Architecture des Plantes et des végétations

To whom is concerned,

First of all, we would like to thank the HCERES committee for its in-depth analysis of AMAP's self-assessment report and the very positive evaluation of the results and trajectory of the unit. We are also grateful for the suggestions of improvement pointed out by the committee, especially in terms of organization and management of the unit, and for the useful recommendations provided regarding the scientific strategy.

However, we would like to point a misunderstanding we already pointed in the answers to the questions sent by the committee before the interview, and which concerns the general feeling of the committee that the new structure in 6 challenges proposed for the 2027-2032 period constitutes an increased risk of thematic dispersion and overlooks pivotal AMAP's research directions such as in mathematics and computer sciences, disturbance ecology, or agroecology and agroforestry.

The 2019-2024 project was basically organized into 11 research themes (or research groups), each coordinated by 1 to 3 co-PIs, that were secondarily grouped into 3 main axes (Biodiversity, Biomass, Digital Plants) to make the whole AMAP research program more understandable from outside. The scientific animation has therefore been effective, thought heterogeneous, at the grain of the 11 themes, while the animators of axes ensured a global coordination of the themes. We identified in the preparation phase of the new project that this 2-level structure was not optimal, especially in terms of top-down communication, since only the axes' animators were members of the lab Scientific Committee, so that the decisions taken there hardly percolated to all research groups. We therefore proposed two ways of improvement in the new project, first, by fostering existing communication channels (better diffusion of decision statements and minutes of meetings) and opening new ones (e.g. creation of an animation cell), second, by simplifying the scientific organization into 6 challenges instead of 11 themes. Each of the 6 challenges is led by two PIs that will be members of the new Scientific Committee. For the sake of clarity, the challenges are presented as organized around 3 to 4 specific aims in the self-assessment report (21 in total for the 6 challenges), but these specific aims do not define independent research groups within the challenges. On the contrary, we expect this new structure to increase interactions within the unit, since some of the challenges (e.g. Ecosystem functioning, Applied ecology and Nature-based solutions) mix researchers that were previously spread into different themes. We also kept the possibility for researchers to contribute to two different challenges, which should maintain active connections between the research groups, that moreover are more balanced in terms of work forces than the themes were.

The fact that the Digital Plant axis (one of the 3 axes of the current project) becomes one of the 6 challenges in the new project is not at all a desire to minimize its importance. This has been a strong feature of AMAP's research program for a long time that we still promote. But the DP axis was the smallest of the 3 axes (36 Full Time Equivalent against 50 and 65.5 for the Biomass and Biodiversity axes, respectively), and the Biodiversity axis grew massively, from 47 to 65.5 FTE, during the 2019-2024 period, mainly from external recruitments, which required a new equilibration in terms of visibility. This also explains that the new Biodiversity challenge only partly covers topics of the previous Biodiversity axis, putting emphasis on botany, taxonomy and systematics (which is also a means to give an increased support to these topics), while other research lines of the Biodiversity axis are made more visible through Challenge 3 (Ecology and fate of communities) and Challenge 5 (Applied ecology and Nature-based solutions). It also can be highlighted that the members of Challenge 6 (Digital Plants) significantly

contribute to methodological research topics in all the other challenges, maintaining an active connection between the numerical and biological research directions. For instance, specific aims in Challenges 2 and 4 are to develop *in silico* plant models and digital twins of plant systems, respectively, which corresponds to the research activities formerly conducted within the small FSPM theme. Finally, disturbance ecology and agroecology/agroforestry, which remain active research domains in AMAP, though supported by small research groups, both fall under Challenge 5 (Applied ecology and Nature-based solutions) of the new project to emphasise the fact that this research, more than the other research in AMAP, explicitly includes interactions with non-academic stakeholders, being either environment managers or the civil society. This organisation also reveals our desire to make our research activity relevant to the sustainability science domain more visible. In this last domain (agroecology and agroecology) the idea is also to strengthen the existing collaborations with local research units that focus on agronomy, plant health or agricultural practises, which are not topics we can develop in AMAP.

At last, we acknowledge that AMAP research program is large, but this diversity allows us to conduct an integrated research program on plants and vegetation, from the organ to the individual, community and biome, in anthropized or natural plants systems. We highlight that this is one of our strengths and we promote interconnections between these different scales in the daily lab life (via seminars, collective projects and initiatives).

With best regards,



Raphaël PELISSIER
Directeur
UMR AMAP

Evaluation of universities and schools
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19 rue Poissonnière
75002 Paris, France
+33 1 89 97 44 00

